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Can we afford this? The capability to make financial decisions in individuals with and without cognitive impairment

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DOI:
[10.33612/diss.190019115](https://doi.org/10.33612/diss.190019115)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2021

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):
Bangma, D. (2021). *Can we afford this? The capability to make financial decisions in individuals with and without cognitive impairment*. [Thesis fully internal (DIV), University of Groningen]. University of Groningen. <https://doi.org/10.33612/diss.190019115>

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**Can we afford this? The capability to make financial decisions in
individuals with and without cognitive impairment**

Dorien Frederike Bangma

Publication of this thesis was financially supported by the University of Groningen (RUG) and the Graduate School of Behavioural and Cognitive Neuroscience (BCN).

The study described in Chapter 8 was financially supported by the internet fund of the Department of Psychology of the University of Groningen, the Netherlands. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Design: Mungkorn | www.vectorstock.com

Layout: Dorien Bangma

Printing: Ridderprint | www.ridderprint.nl

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 groningen

Can we afford this? The capability to make financial decisions in individuals with and without cognitive impairment

PhD thesis

to obtain the degree of PhD at the
University of Groningen
on the authority of the
Rector Magnificus prof. dr. C. Wijmenga
and in accordance with
the decision by the College of Deans.

This thesis will be defended in public on

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Geraldina Gaastra

This thesis is dedicated to my father,
Klaas Bangma

You would have been so proud

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PART

INTRODUCTION

I

CHAPTER

GENERAL INTRODUCTION

1

Financial decision-making (FDM) capability refers to the ability to manage or direct one's finances (Appelbaum et al., 2016). It is a complex construct, that not only involves the ability to count coins, pay bills or buy products (e.g., buying a bread in the local supermarket), but also more complex decisions such as investment decisions, buying or selling property and taking out health insurances. An adequate FDM capability is essential for adults to live independently. Problems within the context of FDM can have serious and tremendous consequences, such as debts, bankruptcy, poverty or financial abuse. The evaluation of the capability to make financial decisions is, therefore, of utmost importance to protect and assist individuals. Furthermore, adequate assessment can assist (clinical) decision-making about the necessity for support or empowerment when making financial decisions. This is especially important since in our current society independent living is expected and encouraged for as long as possible, also for vulnerable groups such as older individuals. Combined with the sensitivity of this topic and the complexity of the construct, the assessment of FDM should be conducted carefully and comprehensively.

The assessment of FDM

There are several methods available that can be used to assess behavioral constructs such as FDM, which can roughly be divided in direct and indirect assessments of behavior. *Indirect assessment* refers to the evaluation of information without the behavior of interest occurring during evaluation, such as reviewing financial reports, self-evaluation using self-report questionnaires or interviewing an informant who is able to make an evaluation of a person's financial capability (e.g., relatives or care practitioners) using proxy-report questionnaires (Appelbaum et al., 2016; Cone, 1978). Proxy-report questionnaires are the most frequently used tool when measuring activities of daily living including FDM (Loewenstein & Acevodo, 2010). Self- and proxy-report questionnaires are in general valid instruments to evaluate functional capability and are easy to administer and cost effective. Proxy-report questionnaires rely, however, on a reliable and independent informant who has a good insight in the capability of the participant (Sikkes & de Rotrou, 2014). Factors such as depression or caregiver burden can have a negative impact on the objectivity of the informant (Pfeifer et al., 2013; Schulz et al., 2013). Self-report questionnaires, on the other hand, rely on a person's self-evaluation of his or her financial capability. Self-reported cognitive decline tends to precede decline observed by an informant (Caselli et al., 2014). Self-report questionnaires require, however, an adequate self-insight, which can be affected because of various reasons which may lead to over- or underestimation of one's own capability (Demetriou et al., 2015; Graham et al., 2005; Howorth & Saper, 2003). In the context of the assessment of FDM, both self- and proxy report evaluations were found to lead to over- as well as underestimation of financial abilities in patients with Alzheimer's Diseases (AD) (Wadley et al., 2003), which underscores the necessity of an alternative approach for the assessment of the capability to make financial decisions.

Direct assessment refers to the direct observation and evaluation of the behavior of interest (Cone, 1978) and, in contrast to indirect assessment, results in a more objective estimation of someone's FDM capability. Ideally, the skills and manners of an individual are evaluated within a real-life setting. This way of assessment is, however, inefficient and time

consuming and consequently rather costly. As an alternative, performance-based tests are often applied which are a practical and adequate alternative for real life observations. Performance-based tests include the observation of an individual’s performance on tasks or activities administered and scored in an experimental or clinical setting using standardized scoring techniques (Moore et al., 2007; Nuijten et al., 2003). They provide a reliable and objective approach to evaluate FDM. Nevertheless, performance-based tests are not necessarily superior to indirect assessment methods of FDM. Both methods are related to and unique significant predictors of direct observations of everyday functioning (Schmitter-Edgecombe et al., 2011). Ideally, a combination of assessment methods should therefore be used to evaluate a person’s FDM capability (Appelbaum et al., 2016).

Conceptualization of FDM

Recently, a group of international experts formulated several recommendations for the assessment of FDM and argued that multiple components of FDM should be evaluated when drawing conclusions and formulating (clinical) recommendations regarding someone’s ability to deal with his or her finances (Appelbaum et al., 2016). They composed a conceptual model of FDM capability and stated that FDM or financial capability is determined by a person’s financial competence, financial performance as well as contextual factors (Figure 1.1). *Financial competence* can be described as the skills of an individual needed to make financial decisions and distinguishes financial knowledge and financial judgment. Financial knowledge involves both the declarative knowledge (i.e., ‘knowing what’) and procedural knowledge (i.e., ‘knowing how’) needed to adequately manage one’s finances. Financial knowledge is needed

to fulfill actions as counting coins, paying bills or budgeting. In research, terms such as ‘financial capacity’, ‘financial competence’ or ‘money management skills’ are used interchangeably when describing financial knowledge (e.g., Goverover et al., 2016; Kershaw & Webber, 2004; Marson, 2001; Marson et al., 2000; Webber et al., 2002). Financial judgment, on the other hand, involves the ability to make financial decisions. It includes the ability to identify and understand information, appreciate and reason about options and expressing a choice (Appelbaum & Grisso, 1988). *Financial performance* is defined as “the individual’s degree of success in handling financial demands in the context of the stresses, supports, contextual cues and resources in his or her actual environment” (Appelbaum et al., 2016, p. 25). Financial performance requires adequate financial knowledge and judgment, but also relies on the possession of certain abilities, such as impulse control or the ability to resist external pressure. It can be influenced by several contextual factors, which makes it difficult to examine financial performance and contextual factors separately.

Taken together, in order to draw careful and deliberate conclusions about the FDM capability of an individual, financial competence, financial performance as well as contextual factors need to be evaluated (Appelbaum et al., 2016; Engel et al., 2016). In the present thesis, a set of FDM tests and questionnaires are therefore composed focusing on financial competence, financial performances and contextual factors (see **chapter 2**).

Vulnerability for problems with FDM

Understanding the underlying psychological processes of decision-making can help to explain the vulnerability of some individuals for problems with (financial) decision-making. An important and widely accepted explanatory model in the field of decision-making is the dual processing theory (Evans, 2008; Kahneman, 2003). It suggests two simultaneously working systems of decision-making. The *affective/experiential processing of information*, also referred to as system 1, relies on our intuition and affect and is described as fast, automatic and subconscious (Evans, 2008; Kahneman, 2003; Peters et al., 2007). It is based on our personal experiences and the emotions related to these experiences. Adequate affective processing, personal knowledge and experience enhance the mechanisms of system 1 and may result in better decision-making. On the other hand, affective disorders (e.g., major depression or motivational dysregulation) seem to have a negative impact on the capability to make (financial) decisions (Bishop & Gagne, 2018; Peters et al., 2007). The *deliberative/analytic processing of information*, also referred to as system 2, relies on careful deliberation of options and is described as slow, effortful and conscious (Evans, 2008; Kahneman, 2003). This latter system is more dependent on cognitive control and relies on several cognitive functions (Evans, 2008). Intact cognitive functioning is therefore important when making (financial) decisions in a deliberative/analytic way. Both in the context of general decision-making and FDM, working memory, executive functioning and numeracy are consistently, but not exclusively, found to be related decision-making deficits (e.g., Chen et al., 2014; Czaja et al., 2017; Earnst et al., 2001; Martin et al., 2012; Niccolai et al., 2017; Reyna et al., 2009; Sherod et al., 2009). Therefore, individuals experiencing cognitive problems (e.g., as a result of a neurodegenerative or neurodevelopmental disease) might be vulnerable to experience difficulties with FDM.

Cognitive deficits, however, do not necessarily result in problems with (financial) decision-making due to a possible compensatory role of the affective/experiential processing of information. Both systems work simultaneously, are not superior to one another and might be situational dependent (Evans, 2008; Kahneman, 2003). Furthermore, contextual factors, as proposed in the conceptual model of Appelbaum et al. (2016), might be of influence such as age, gender, motivation or income. Contextual factors should, therefore, also been taken into account when studying FDM.

Outline of the thesis

The aim of the current thesis is to elaborate on currently available FDM research and to investigate if and how FDM can be measured more objectively in order to make (clinical) decisions about an individual's capability to make financial decisions. For this, with the use of systematic review and meta-analytic methods, an overview of studies using performance-based tests to evaluate (financial) decision-making will be provided. Furthermore, several studies presented in the current thesis aim to systematically and comprehensively study the FDM capability of individuals with and without cognitive dysfunctions using multiple tests and questionnaires that assesses financial knowledge, financial judgment and financial performance. In addition, the influence of several contextual factors and cognition on FDM will be evaluated. For this purpose, several new FDM tests and questionnaires have been developed. In **chapter 2** all (new) tests and questionnaires are introduced and information is provided about the administration and scoring of each test or questionnaire.

Subsequently, in the second part of the thesis, the focus lies on FDM in relation to normal and abnormal aging. Normal aging is accompanied by changes in cognition, and a decline in cognitive functioning may negatively affect FDM capability of older individuals (Denburg & Hedgcock, 2015). On the other hand, more knowledge and experience may enhance the FDM performances of older adults compared to younger individuals (Hess, 2015; Peters et al., 2007). The study presented in **chapter 3** evaluates the effects of normal aging on multiple aspects of FDM. Sometimes individuals, however, experience a degree of physical and cognitive problems not consistent with normal aging. Patients with neurodegenerative diseases (NDDs) experience more serious problems with cognition not associated with normal aging (American Psychiatric Association, 2013; Hardiman & Doherty, 2016). This makes these patients vulnerable for problems with FDM. In the review and meta-analyses presented in **chapter 4**, a comprehensive overview of the literature is provided focusing on FDM in patients with different NDDs in comparison to healthy controls. Only studies using performance-based tests of FDM are included. Furthermore, if possible, patients with different NDDs are compared and the association between FDM and disease severity, cognition, age, sex and level of education are evaluated. In **chapter 5** preliminary results are described of a study evaluating the performances of patients with Alzheimer's disease (AD), mild cognitive impairment (MCI) and Parkinson's disease (PD) in comparison to healthy controls on our FDM test battery.

The third part of the thesis focuses on adults with attention-deficit/hyperactivity disorder (ADHD). ADHD is historically described as a childhood disorder, characterized by problems with attention, hyperactivity and impulsivity (American Psychiatric Association, 2013). Now-

a-days, it is well known that the symptomatology and problems related to ADHD can persist into adulthood (Fayyad et al., 2007; Lara et al., 2009). Problems with decision-making are frequently described in children with ADHD, but are less clearly objectified in adults with ADHD (Groen et al., 2013; Mowinckel et al., 2015). Money management problems are, however, described in adults with ADHD (e.g., Altszuler et al., 2016; Barkley et al., 2006, 2008), but until recently no study was performed using performance-based tests to evaluate FDM capability in adults with ADHD. In **chapter 6** a systematic review is presented in which the performances of adults with ADHD on performance-based decision-making tests (including FDM) in comparison with the performances of healthy controls on these tests are evaluated. Within this chapter, the mechanisms underlying problems with decision-making are discussed, which potentially also underly FDM capability problems in adults with ADHD. The study presented in **chapter 7** describes the performances of a group of clinically diagnosed adults with ADHD on our FDM test battery compared to a healthy control group. Also, the personal financial situation, such as income and debts, of both groups are compared. In the study presented in the final chapter of the third part, the influence of current symptoms of ADHD on two aspects of FDM (i.e., impulsive buying and the use of specific financial decision styles) is further evaluated in a large community sample. In this study, as presented in **chapter 8**, the influence of symptoms of ADHD on these two aspects of FDM is evaluated using both group comparisons and regression analyses. Furthermore, the potential influence of personality traits, symptoms of depression and demographical factors on the relation between symptoms of ADHD and FDM is investigated.

To conclude, a critical discussion of the described studies, the FDM test battery and suggestions for the next steps in functional capability and FDM research are described in **chapter 9**. References, a summary in English and Dutch, acknowledgements, curriculum vitae and a list of publications can be found in the addenda at the end of the thesis.

CHAPTER

2

INTRODUCTION TO THE
FINANCIAL DECISION-MAKING
TESTS

As emphasized in **chapter 1**, it is important to evaluate FDM comprehensively by evaluating financial competence, financial performance and contextual factors, in order to draw careful and deliberate conclusions about the FDM capability of an individual. Most of the FDM instruments available, however, focus on only one of the components of FDM capability and/or do not investigate contextual factors. Furthermore, none of these tests were until recently available in Dutch and/or suitable for the Dutch financial situation. Therefore, a new test battery including eight FDM tests and questionnaires has been developed. Each test or questionnaire focuses on a specific aspect of FDM, covering the components of financial competence and financial performance/contextual factors (Figure 2.1). All tests and questionnaires are based on

Figure 2.1. Subdivision of eight tests and questionnaires (i.e., the Financial Competence Assessment Inventory (FCAI), the Financial Decision-Making Interview (FDMI), the Competence in Decision Rules (CDR), the Financial Decision Styles (FDS) questionnaire, the Temporal Discounting Task (TDT), the Impulsive Buying Questionnaire (IBQ), the Iowa Gambling Task (IGT) and the Financial Decision-Making on Intuition or Deliberation (FDM-I/D) test) into one of the components of financial decision-making capability as described by Appelbaum et al. (2016), i.e., financial competence, financial performance and contextual factors. This division, however, should be interpreted with some nuance, as there may also be (partial) overlap between the aspects, tests and/or questionnaires.

previously published procedures and translated and adapted for the Dutch population. In this chapter, information about the development, outcome measure(s) and administration of each test or questionnaire is described. Psychometric properties of the tests and questionnaires are described in **chapters 3, 7 and 8** and critically discussed in **chapter 9**.

FCAI-NL: Financial Competence Assessment Inventory – NL

The *Financial Competence Assessment Inventory - NL (FCAI-NL)* is a translated version of the original FCAI (Kershaw & Webber, 2008) and adapted in content for the Dutch financial situation. The test enables the evaluation of an individual's financial competence, measuring both financial knowledge and judgment. The FCAI-NL consists of an item instruction handbook with 38 theoretical, practical and contextual questions about finances (Figure 2.2). The FCAI-NL has a multidimensional approach and differentiates six subscales based on the six dimensions of financial competence as described by Kershaw and Webber (2004; Webber et al., 2002): 'Financial abilities' (i.e., ability and knowledge to perform everyday financial tasks such as budgeting and paying bills; e.g., *"Do you receive any bills, How do you recognize them?"* or *"What expenses do you need to allow for each pay period?"*), 'Financial judgment' (i.e., ability to set financial goals and identifying and understanding items on a bank statement and a health insurance brochure; e.g., *"Suppose you receive no income, but you own a sum of money (say €500,000), with which you had to support yourself, what would you do with it?"* or *"From this bank statement, can you tell whether there is sufficient money to pay the electricity bill?"*), 'Financial cognitive functioning' (i.e., basic financial literacy and numeracy skills; e.g., *"Please tell me the value of these coins and notes. How much do we have in total?"*), 'Financial management' (i.e., understanding of one's assets, income sources and bank protocols; e.g., *"Explain to me what Power of Attorney is."* or *"Tell me what 'assets' are."*), 'Debt management' (i.e., awareness of debts and the ability to successfully manage debts; e.g., *"Have you ever received any default notices"* or *"Have you ever had legal action against you for debt?"*) and 'Financial support resources' (i.e., the assistance-seeking skills of an individual in a financial context; e.g., *"Where would you go for financial advice and counselling?"*).

Figure 2.2. Material of the financial competence assessment inventory – NL, consisting of an instruction handbook (i.e., *FCAI item instructions*) and scoring form, Euro coins and fictitious paper money, fictitious energy bill, bank statements, blank form for internet banking (not in picture), health insurance policy, health insurance registration form (not in picture) and a lunch menu.

The FCAI is administered as a semi-structured interview. For each question, participants receive a score of 0 to 4 depending on the accuracy of the answer (0 = ‘*little or no awareness*’, 1 = ‘*rudimentary awareness*’, 2 = ‘*partial understanding*’, 3 = ‘*adequate understanding*’ and 4 = ‘*complete understanding*’). The assessment of accuracy should be made by a trained examiner using answer examples for each question as described in the item instruction handbook. Clarification of incomplete answers may be requested by the examiner by asking neutral questions without directing the answer. Five questions are formulated as yes/no questions and scored with 0 or 1 points, respectively. Several materials are needed for administration, such as a fictitious energy bill, bank statements, blank form for internet banking, health insurance policy, Euro coins and notes and a scoring form (Figure 2.2). No time limit is given for answering the questions. Total administration time of the FCAI-NL is between 25 and 45 minutes. For each subscale a score can be calculated based on the sum score of selected items. The total score of the FCAI-NL (maximum score of 134) represents the total on the six subscales and gives an indication of an individual’s overall financial competence. Higher scores indicate better performances.

FDMI: Financial decision-making interview

The *Financial Decision-Making Interview (FDMI)* evaluates financial judgment (in this thesis also referred to as decision-making capacity). The test evaluates the mental ability to make a decision related to financial issues. The FDMI is based on the MacArthur Competence Assessment Tool that is used to assess (medical) decision-making (Appelbaum & Grisso, 1988; Karlawish et al., 2013; Kim et al., 2001; Martin, Okonkwo, et al., 2008; Suto et al., 2005; Vellinga et al., 2005). Consistent with the principles of Appelbaum and Grisso (1988), the FDMI consists of five domains, i.e. the ability to identify a problem (‘Identification’), the ability to understand information and consider risks and benefits (‘Understanding’), the ability to reason about different options and make a reasoned decision (‘Reasoning’), the ability to appreciate and evaluate the effects of decisions (‘Appreciating’) and the ability to articulate a final choice (‘Communication’; Appelbaum & Grisso, 1988; Suto et al., 2005).

The FDMI consists of two vignettes in which a main character is confronted with a relatively complex hypothetical financial problem (i.e., [1] Kees has a broken car and needs to decide whether he wants to repair or sell his car, and [2] Bart and Sophie who need to make a decision about selling their current house and buying a new house). The first vignette is based on one of the vignettes described in the study of Suto et al. (2005), the second vignette is a fictional story written for the FDMI. Each vignette is presented to the participant in oral and written form. After the presentation of the vignette, participants are asked to answer questions related to the five domains of decision-making capacity using the principles of a semi-structured interview. Questions are, e.g., “*About what does Kees have to make a decision and why?*” (i.e., Identification), “*Imagine Kees decides to have the car repaired. Are there any advantages and disadvantages of this decision?*” (i.e., Understanding), “*What do you think Kees will decide to do? And why do you think he will decide to do that?*” (i.e., Reasoning), “*Who will be affected by this choice?*” (i.e., Appreciating). For each domain, participants receive a score of 0, 1 or 2 based on the degree of completeness of the answer(s). Communication is scored by the

examiner based on the ability of the participant to communicate about the problem and the available options on a scale from 0 to 2. For each domain, specific requirements are described for achieving a particular score. The domain of Understanding consists of three questions; therefore, an average score is calculated based on the answers on these three questions and rounded downwards. The procedure is identical for both vignettes. The scores on each domain of both vignettes are added which results in a total score for each domain (maximum score of 4 for each domain). An overall total score is calculated as the sum based on all domains (maximum score of 20). The administration time of the FDMI is approximately 10-15 minutes for each vignette, which results in a total administration time of 20-30 minutes.

CDR: Competence in Decision Rules test

The *Competence in Decision Rules (CDR)* test is used to evaluate the ability to use specific rules or criteria to form a decision, e.g., when selecting a product that needs to meet certain specifications. The CDR is a Dutch variant of the Applying Decision Rules subtest of the Adult Decision-Making Competence battery (Bruine de Bruin et al., 2007; Parker & Fischhoff, 2005). The CDR is a literal translation of the original version, but slightly adjusted in order to make the test more suitable for the Dutch population (i.e., typical Dutch names for main characters in each question) and current time (i.e., the original version refers to DVD players instead of televisions).

In the CDR, participants need to choose between five televisions using specific decision rules. The televisions are equally priced, but differ in their technical specifications (i.e., picture quality, sound quality, programming options and reliability of the brand). Each specification is scored on a five-point Likert scale, namely (1) a 'very low' rating, (2) a 'low' rating, (3) an 'average' rating, (4) a 'high' rating and (5) a 'very high' rating. To make correct decisions in this test, participants are required to analyze the specifications of each television and to balance all pros and cons of a specific television based on the given preferences of the character in a scenario. In total, the CDR consists of ten hypothetical scenarios with increasing complexity. An example of a scenario of the CDR is *'Emma wants the television with the highest average rating. However, she also wants to make sure that she buys a television that obtained the best rating on sound quality'*. In most scenarios, one television meets the preferences of the character and is the correct answer (six scenarios). However, it is also possible that none of the televisions meet the preferences of the character (one scenario) or that multiple televisions meet the preferences of the character (three scenarios). Participants are informed about the different answer options by presenting three practice scenarios prior to the actual test. A completely correct answer on each scenario is rewarded with one point (maximum total score of 10 points). Only on the last scenario, 0.5 points can be obtained if two out of three correct televisions are identified.

For this test a booklet that includes the different scenarios and a scoring sheet are required. Both are provided to the participant and answers are written down by the participant. Participants need to write down an answer on the scoring sheet before continuing to the next question. The CDR has no time limit. The administration time of the CDR is approximately 10-15 minutes.

FDS: Financial decision styles questionnaire

The *Financial Decision Style (FDS) questionnaire* evaluates the extent to which decision-making styles are used in an FDM situation. A decision-making style can be defined as “the learned habitual response pattern exhibited by an individual when confronted with a decision situation” (Scott & Bruce, 1995, p. 820). The FDS is inspired by the General Decision-Making Style (GDMS) questionnaire (Loo, 2000; Scott & Bruce, 1995; Spicer & Sadler-Smith, 2005). Questions of the GDMS have been translated and reformulated in such a way that the general decision situation concerns a financial decision. Similar to the GDMS, the FDS differentiates five decision-making styles corresponding the five-factor model of decision-making by Scott and Bruce (1995): a ‘rational’ decision style characterized by rational considerations and the evaluation of options (e.g., *‘I make financial decisions in a logical and systematic manner’*), an ‘intuitive’ style characterized by relying on feelings or emotions (e.g., *‘When I make financial decisions, I tend to rely on my intuition’*), a ‘dependent’ style characterized by the requirement of advice of others (e.g., *‘I rarely make important financial decisions without consulting other people’*), an ‘avoidant’ style characterized by avoiding and postponing decisions (e.g., *‘I postpone financial decision-making whenever possible’*) and a ‘spontaneous’ style characterized by impulsivity and spontaneous decisions without prior consideration (e.g., *‘I often make financial decisions in the spur of the moment’*). One statement of the GDMS was not included in the FDS (i.e., *‘I often make impulsive decisions’*), because the statement was not exclusively related to the spontaneous style and also correlated with the intuitive style (Scott & Bruce, 1995). The FDS consists, therefore, of 24 statements. For each statement, the participants must indicate to what extent this corresponds with their habitual manners when making a financial decision. Answers are scored on a five-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Each decision style is reflected by 4 or 5 statements and for each of the five decision styles a total score can be calculated by adding the scores on these 4 or 5 statements.

The FDS is a self-report questionnaire. The use of a specific decision style may be situational dependent, therefore, participants are asked to choose their answers based on financial decisions *in general* (e.g., when shopping or paying bills). Administration time of the FDS is approximately 5-10 minutes.

TDT: Temporal discounting test

The *Temporal Discounting Task (TDT)* is used to evaluate the concept of temporal discounting, which suggests the reduction of the subjective value of an option over time (Green et al., 1994, 1996). A strong temporal discounting tendency complicates decision-making with implications for the future (e.g., choosing between spending or saving money). The TDT is based on previously published procedures (e.g., Barkley et al., 2001; Green et al., 1994, 1996; Scheres et al., 2010) and consists of eighteen hypothetical scenarios. In each scenario, participants are offered a relatively high amount of money, which they can receive later in time. More specifically, they have to wait for a certain period of time (i.e., ‘one week’, ‘one month’ or ‘one year’, depending on the scenario) before they receive a relatively high amount of (hypothetical) money (i.e., €100, €500 or €1000, depending on the scenario). Simultaneously with this offer,

participants receive another offer: They can also choose a lower amount of money which they can receive earlier in time. Participants are requested to indicate the lowest amount of money they would accept today or after a relatively short delay (i.e., ‘in one week’ or ‘in one month’, depending on the scenario) instead of receiving the relatively high amount of money after a longer delay (e.g., ‘Which amount of money would you accept today instead of receiving €100 in one month?’). To visualize the options, participants receive a table with several offers/options (Figure 2.3). Participants also have the option to renounce the lower offer and to choose to wait until they can hypothetically receive the original offer. If participants choose a lower offer, their choice will be checked by offering them one lower option from the table, to ensure their choice is the lowest offer that they would accept. For example (Figure 2.3), if a participant chose to receive €80 today instead of €100 in one month, the examiner asks “If I offer you €80 today, you would accept this money instead of €100 in one month, is this correct? But if I offer you today €75 instead of €100 in one month, which of these options would you choose”. If the participant indicates that in this latter offer, he or she would not accept €75, €80 will be indicated as the lowest amount of money he or she would accept. If the participant decides to also accept €75, the procedure will be repeated and lower options will be offered to the participant until he or she no longer accepts the offer.

Six different time-interval combinations are used (i.e., ‘today vs. one week’, ‘today vs. one month’, ‘today vs. one year’, ‘one week vs. one month’, ‘one week vs. one year’ and ‘one month vs. one year’). Each time interval is presented once with €100, €500 or €1000 as the highest offer. In half of the scenarios the offers on the tables are offered in ascending order (e.g., from €1 to €95) and in the other half of the scenarios the offers on the tables are presented in descending order (e.g., from €95 to €1). The offers are presented in increments of five euros (i.e., in the €100 condition) or ten euros (i.e., in the €500 and €1000 condition), with exception

Figure 2.3. One of the eighteen scenarios of the Temporal Discounting Task, including the option of receiving €100 euro in one month or a (lower) offer which can be received today. The participants are asked to indicate the lowest offer that he/she would accept today instead of the relative high offer later in time.

of the lowest offer (i.e., €1 for the €100 condition and €5 for the €500 and €1000 conditions). The sequence in which the eighteen scenarios are presented is the same for each participant.

The lowest accepted offer is the answer on each of the scenarios. All answers are converted to a percentage of the amount of money participants could receive after a relatively long delay (e.g., score 80% is given if €80 is accepted instead of €100 later in time). Different summary scores can be calculated depending on the variable of interest (e.g., different delay lengths or different amounts of money). In current thesis, an overall average score has been used based on all eighteen scenarios. Higher scores are indicative for a lower sensitivity to temporal discounting and, therefore, reflect a better capability to make decisions with implications for the future. The total administration time of the TDT is 15-25 minutes.

IBQ: Impulsive buying questionnaire

The *Impulsive Buying Questionnaire (IBQ)* is used to investigate the tendency to buy on impulse or making sudden unplanned purchases (Rook, 1987). Impulsive buying tendency is defined as “the degree to which an individual is likely to make unintended, immediate and unreflective purchases” (Jones et al., 2003, p. 506). Two related and partly overlapping models of impulsive buying underly the IBQ. First, the ‘rational model of impulsive buying’ by Beatty and Ferrell (1998) describes eight precursors to predict impulsive buying tendency. In this model, an impulsive purchase depends on available time, available money, shopping enjoyment, impulse buying tendency, negative affect, in-store browsing, positive affect and the urge to buy impulsively. Impulse buying, however, also correlates with the lack of planning and deliberation (Verplanken & Herabadi, 2001) and seems to have an emotional component (Rook, 1987). These important components are lacking in this rational model of impulsive buying. Therefore, based on the work of Beatty and Ferrell (1998), a second model of impulsive buying is suggested (Youn, 2000; as cited in Coley & Burgess, 2003). In this second model, impulsive buying is described as a function of affect (i.e., the irresistible urge to buy, positive buying emotion and mood management) and cognition (i.e., cognitive deliberation, unplanned buying and disregard for the future). Both models show considerable overlap and similar questions are used in questionnaires developed based on these models. However, in the second model, more emphasis is placed on the emotions and feelings of the impulsive buyer and less attention is paid to the actual impulsive buying behavior and the external factors that contribute to whether or not a person will buy on impulse (e.g., available money). In the IBQ, therefore, items on affect and cognition are combined with items related to external factors that contribute to impulsive buying behavior. The items included in the IBQ are originating from the questionnaires of Beatty and Ferrell (1998) and Coley and Burgess (2003). As a result, the IBQ differentiates three components, i.e., an affective, a cognitive and a situational component of impulsive buying. The affective component refers to emotions and feelings that lead to impulsive buying behavior (e.g., *‘I always buy it if I really like it’*) and the cognitive component refers to thoughts of and the urge to buy on impulse (e.g., *‘When I go shopping, I buy things that I did not intend to purchase’*) (Coley & Burgess, 2003). The situational component describes the available time and money that contribute to the ability to execute impulsive purchases (e.g., *‘I cannot afford unplanned purchases’*) (Beatty & Ferrell, 1998).

Participants are asked to indicate for each statement whether they *in general* apply to them. All items are rated on a four-point scale, which ranges from 1 (*strongly disagree*) to 4 (*strongly agree*). However, some items are formulated contra-indicatively and the score of these items need to be mirrored (i.e., 4 (*strongly disagree*) to 1 (*strongly agree*)). Sum scores are calculated for the affective, cognitive and situational component. Since the combination of the two models is still experimental, the situational component is not part of the total score of the IBQ, which represent the overall tendency to buy on impulsive (i.e., the sum of the affective and cognitive component). Higher scores are indicative for a stronger tendency to buy on impulse. The IBQ is a self-report questionnaire and the administration time of the IBQ is approximately 5-10 minutes.

IGT: Iowa gambling task

The *Iowa Gambling Task (IGT)* is a widely used test and was developed to assess real-life decision-making (Bechara et al., 1994). The IGT is frequently used as a measure of risk-taking and/or gambling behavior, however, the IGT seems to primarily assess emotional decision-making in healthy individuals (Buelow & Suhr, 2009). Emotional decision-making in the context of the IGT can be described as an unconscious urge or feeling based on previous experience and emotional stage which has an influence on decision-making (Bechara et al., 1997; Buelow & Suhr, 2009).

A computerized, Dutch version of the IGT has been used (Figure 2.4; Grasman & Wagenmakers, 2005). In this task, participants have to choose cards from four decks of virtual cards. Each deck is associated with certain gains and losses. The number of cards in each deck is unlimited. The goal of the task is to gain as much money as possible and to minimize losing money. Participants play with hypothetical money, but are asked to consider this money as real. Two decks are considered disadvantageous and two decks are considered advantageous. The disadvantageous decks 1 and 2 (the two left-sided decks) lead to relatively high gains (i.e., €100) but also to relatively high losses (i.e., between €100 and €1250; Figure 2.4a). Decks 3 and 4, the advantageous decks, result in relatively low gains (i.e., €50) but also in relatively low losses (i.e., between €50 and €250; Figure 2.4b). Only minimal instructions are given to the participants. Besides the instructions on the computer (Figure 2.4c), participants receive more detailed instructions by the examiner. Participants are beforehand not informed about the advantageous and disadvantageous decks and the rules of winning and losing. They therefore have to learn from trial and error which decisions are most advantageous. During the task, participants receive feedback about the amount gained or lost and the total amount of money they have. Furthermore, the gains and losses can be tracked by a green and by a red bar that increase when money is gained or lost, respectively (Figure 2.4). In total, participants have to choose a card 100 times, however, the participants are not informed about the number of cards they have to choose beforehand. A total netscore, i.e., the number of times a participant chose the advantageous decks minus the number of times the participant chose the disadvantageous decks, over 100 trials is calculated. Furthermore, the netscore can be divided in five parts of 20 trials to assess the effect of feedback and risky decision-making (Brand et al., 2006). The administration time of the IGT is approximately 15-20 minutes.

Figure 2.4. Screen shots of the Iowa Gambling Task (in Dutch). The disadvantageous decks 1 and 2 (the two left-sided decks) lead to relatively high gains (i.e., €100) but also to relatively high losses (i.e., between €100 and €1250; picture a). Decks 3 and 4, the advantageous decks, result in relatively low gains (i.e., €50) but also in relatively low losses (i.e., between €50 and €250; picture b). Participants receive instructions at the beginning of the task (picture c).

FDM-I/D: Financial Decision-Making on Intuition or Deliberation test

The *Financial Decision-Making on Intuition or Deliberation test (FDM-I/D)* is used to assess intuitive and deliberative decision-making. The test is based on previous studies assessing the theory that (especially in complex decision situations) individuals make better decisions when decisions are based on feelings or intuition than when their decisions are made consciously and deliberately (Dijksterhuis, 2004; Dijksterhuis et al., 2006; Mikels et al., 2011).

The FDM-I/D is a computer test, developed and presented using E-Prime software (Schneider et al., 2002). In the FDM-I/D, participants are presented with information about attributes of four options of four hypothetical products (i.e., sequentially a boat, an apartment, a car and a flight ticket which are presented in separate trials). The attributes of each option are either positively or negatively formulated. Participants are asked to choose the option most people would consider as ‘the best’ option (Figure 2.5a). In each trial, the four options are designed in such a way that one option is the best product with 75% positive attributes. For two options the positive and negative attributes are equally represented and the last option has only 25% positive attributes. Each option is shown consecutively for 10 seconds and thereafter the four options are shown at once for another 10 seconds (Figure 2.5b).

The trials differ from each other using two different manipulations (2x2 design). With regard to the first manipulation, the trials are designed in such a way that the participant needs to make his or her decision either in an intuitive manner or in a deliberative manner. During two trials (i.e., boat and apartment) participants are distracted for 2.5 minutes before they have to make a decision by performing a Go-NoGo test immediately after the presentation of the attributes (Figure 2.5c). Because of the Go-NoGo test, participants are unable to think about the options and need to make a decision based on their intuition (i.e., the ‘intuitive approach’). In the other two trials (i.e., flight ticket and car), participants are instructed to make their decision after deliberatively thinking about the positive and negative attributes during a period of 2.5 minutes (i.e., the ‘deliberative approach’; Figure 2.5d). With regard to the second manipulation, two trials (i.e., boat and flight ticket) are considered relatively simple since each option is described with only four attributes. The other two trials (i.e., apartment and car) are considered relatively complex since each option is described with eight attributes. Consequently, there are four conditions in the FDM-I/D, i.e., simple intuitive approach (i.e., boat), complex intuitive approach (i.e., apartment), simple deliberative approach (i.e., flight ticket) and complex deliberative approach (i.e., car).

For each product, participants receive 0 points if they choose the best option, -25 points if they choose one of the options with 50% positive attributes and -50 points if they choose the option with only 25% positive attributes. Different scores can be calculated depending on the manipulation of interest, e.g., total scores can be calculated for decisions made after either the intuitive approach or the deliberative approach by adding the scores on the intuitive approach trials and deliberative approach trials, respectively. The FDM-I/D is, however, only used in the study described in **chapter 3** and is currently no longer included in the FDM test battery, due to the fact that now-a-days the validity of the underlying theory and comparable tests has been questioned and disproved (Nieuwenstein et al., 2015).

PART

II

FINANCIAL DECISION-MAKING
CAPABILITY IN RELATION TO
NORMAL AND ABNORMAL AGING

CHAPTER

3

THE EFFECTS OF NORMAL AGING
ON MULTIPLE ASPECTS OF
FINANCIAL DECISION-MAKING.

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PLoS ONE (2017)

Abstract

Objectives: Financial decision-making (FDM) is crucial for independent living. Due to cognitive decline that accompanies normal aging, older adults might have difficulties in some aspects of FDM. However, an improved knowledge, personal experience and affective decision-making, which are also related to normal aging, may lead to a stable or even improved age-related performance in some other aspects of FDM. Therefore, the present explorative study examines the effects of normal aging on multiple aspects of FDM.

Methods: One-hundred and eighty participants (range 18-87 years) were assessed with eight FDM tests and several standard neuropsychological tests. Age effects were evaluated using hierarchical multiple regression analyses. The validity of the prediction models was examined by internal validation (i.e., bootstrap resampling procedure) as well as external validation on another, independent, sample of participants ($n = 124$). Multiple regression and correlation analyses were applied to investigate the mediation effect of standard measures of cognition on the observed effects of age on FDM.

Results: On a relatively basic level of FDM (e.g., paying bills or using FDM styles) no significant effects of aging were found. However more complex FDM, such as making decisions in accordance with specific rules, becomes more difficult with advancing age. Furthermore, an older age was found to be related to a decreased sensitivity for impulsive buying. These results were confirmed by the internal and external validation analyses. Mediation effects of numeracy and planning were found to explain parts of the association between one aspect of FDM (i.e., competence in decision rules) and age; however, these cognitive domains were not able to completely explain the relation between age and FDM.

Conclusion: Normal aging has a negative influence on a complex aspect of FDM, however, other aspects appear to be unaffected by normal aging or improve.

Introduction

During adulthood, most people make financial decisions. Some of these decisions are age or life stage dependent, such as buying a house or saving for retirement, while other decisions occur throughout adulthood, such as buying groceries and paying bills. Financial decision-making (FDM) is thus necessary in multiple situations and is crucial for independent living.

FDM requires the integrity of cognition (Glimcher, 2014) and appears to be vulnerable to cognitive changes and dysfunctioning of especially the prefrontal cortex (Kennerley & Walton, 2011; Krawczyk, 2002). Consequently, it is not surprising that impairments in FDM are found in patients with different brain pathologies, such as patients with Alzheimer's disease, mild cognitive impairment and Parkinson's disease (Kershaw & Webber, 2008; Loewenstein et al., 1989; Marson et al., 2000; Martin et al., 2013; Pereira, Yassuda, et al., 2010; Pirogovsky et al., 2014; Triebel et al., 2009). Normal aging is, however, also accompanied by structural and functional changes of the prefrontal cortex (Dennis & Cabeza, 2008; Maillet & Rajah, 2013). These age-related changes might result in a decreased memory, attention and executive functioning (Braver & West, 2008; Denburg & Hedgcock, 2015) and consequently in deficits of FDM in older individuals.

Previous studies have shown that deliberative information processing is essential for decision-making. Deliberative information processing can be defined as a rational manner of manipulating information that is needed to come to a decision (e.g., Peters et al., 2007). Deliberative information processing is thought to rely strongly on working memory capacity and related cognitive functions (Evans, 2008). Indeed, previous research indicates that deliberative information processes are less efficient with advancing age due to an age-related cognitive decline in processing speed, short- and long-term memory, working memory, attention, inhibition and reasoning (Braver & West, 2008; Denburg & Hedgcock, 2015; Salthouse, 1996; Salthouse & Meinze, 1995). As a result, older adults evaluate less information before making a decision (Mather, 2006) and have more difficulties with rather complex decision-making (Bruine de Bruin et al., 2007, 2012) than younger individuals. Furthermore, in the context of FDM, also numeracy abilities, independent of age, education level and other cognitive functions, are thought to play an important role (Chen et al., 2014; Reyna et al., 2009; Sherrod et al., 2009; Wood & McHugh, 2013).

Besides deliberative information processes, affective processes were also found to play a role in decision-making (e.g., Loewenstein et al., 2001, 2015). Affective processing relies on personal experience and prior learning on how to deal with certain decision-making situations (Peters et al., 2007). Not only integral affect (i.e., the feelings or emotions towards a problem or decision), but also incidental affect (i.e., the emotional status, unrelated to the problem or decision, while making a decision) are related to affective processing and have an influence on decision-making (Peters et al., 2007). It has been suggested that these affective processes remain unaffected or even improve with advancing age (Li et al., 2004; Mikels et al., 2013; Peters et al., 2007). Furthermore, also personal experience in and knowledge about (financial) decision-making (e.g., the experience with paying bills or buying or selling property) expand with advancing age (Hess, 2015; Peters et al., 2007). Affective processing and personal

knowledge and experience might, therefore, compensate for a decreased deliberative cognitive processing in older adults resulting in similar or even better decision-making with advancing age (Mather & Knight, 2005; Meyer et al., 1995). It can thus be concluded that normal aging may have negative effects as well as positive influences on (financial) decision-making.

So far, only a few studies focused on FDM. These studies primarily examined an older (demented) population and investigated relatively basic aspects of FDM, such as the ability to recognize coins, count money and pay bills (e.g., Kershaw & Webber, 2008; Loewenstein et al., 1989; Marson et al., 2000). FDM, however, also includes buying or selling property, saving for retirement and taking out health insurances. Furthermore, unfitting behavior in a financial context, such as impulsive buying and gambling, can lead to major consequences for an individual's financial situation. Therefore, to gain a comprehensive overview of an individual's FDM skills and abilities it is of utmost importance to not only assesses the simple aspects of FDM but also to study more complex aspects of FDM.

The aim of the present explorative study is to determine the effects of normal aging on multiple aspects of FDM. Therefore, based on previously published procedures, a test battery was developed encompassing eight FDM tests measuring eight aspects of FDM (i.e., financial competence, (financial) decision-making capacity, financial decision styles, ability to apply rules, decisions with implications for the future, impulsive buying tendency, emotional decision-making and intuitive and deliberative decision-making). It is expected that an advancing age results in a decreased performance in aspects of FDM that rely strongly on deliberative information processing (e.g., the ability to apply rules) due to an age-related cognitive decline that accompanies normal aging (Braver & West, 2008; Denburg & Hedgcock, 2015; Salthouse, 1996; Salthouse & Meinz, 1995). However, it is also expected that other aspects of FDM, that rely more on knowledge or affective processing, are not affected by aging (e.g., financial competence) or even improve with advancing age (e.g., impulsive buying or intuitive decisions) due to an age-related increase in knowledge and experience with FDM or an improved affective decision-making in older adults (Hess, 2015; Li et al., 2004; Mikels et al., 2013; Peters et al., 2007). Furthermore, since this is an explorative study, it is important to determine whether or not our results are due to statistical errors and can be replicated. Therefore, the validity of the prediction models will be examined by internal validation (i.e., bootstrap resampling procedure) as well as external validation on another, independent, sample of participants. Finally, the association between cognitive functions and the different aspects of FDM and the possible mediating effect of cognition on the relation between age and FDM are investigated.

Materials and Methods

Participants – sample 1

One hundred and ninety-one adults participated in this study. Participants were recruited through advertisement in a local newspaper and via social contacts of the researchers (i.e., family members and acquaintances of the researchers and of included participants were

informed about the study via word-of-mouth, email or social media). Eleven participants with evidence for psychiatric or neurological conditions were excluded: five participants showed high scores on a depression rating scale (Beck Depression Inventory-II-NL > 19; Roelofs et al., 2013), two participants obtained low scores on a dementia rating scale (Mini Mental State Examination < 24; Folstein et al., 1975) and four participants reported having a neurological or psychiatric condition which might have a negative impact on cognition (e.g., brain tumor and Lyme disease). The remaining 180 participants (sample 1) were on average 49.58 years old (range 18 – 87 years; Table 3.1) and obtained on average 15.15 years of education. Slightly more females (57.2%) than males were included in sample 1 (Table 3.1).

Participants – sample 2

A second sample (n = 124) was included to evaluate the external validity of possible age effects. The recruitment procedure (i.e., via contacts of the researchers, recruited by word-of-mouth, e-mail or social media) as well as the inclusion and exclusion criteria (e.g., no evidence for a psychiatric or neurological condition) were similar to the first sample. None of the participants in sample 1 were also included to sample 2. Both samples were comparable with regard to the age range. However, the average age of the second sample was significantly lower than in the first sample (Table 3.1). Furthermore, the second sample obtained on average two more years of education than the first sample. The samples did not differ significantly on other demographic characteristics (Table 3.1).

Ethics statement

The Ethical Committee Psychology of the University of Groningen, Groningen, The Netherlands, and the Medical Ethical Committee of the University Medical Center Groningen, Groningen, The Netherlands, approved this study. Participants were informed about the content of the research prior to assessment. Furthermore, they were informed that participation was

Table 3.1. Demographic characteristics of samples 1 and 2.

	Sample 1	Sample 2	Group differences (p-value)
n	180	124	
Age range	18 - 87	19 - 87	
Age <i>M(SD)</i>	49.58 (18.37)	41.28 (17.73)	< .001 ^a
Age groups			< .001 ^b
< 30	20.6 %	37.9 %	
30 – 39	12.2 %	14.5 %	
40 – 49	11.1 %	5.6 %	
50 – 59	22.2 %	27.4 %	
60 – 69	21.7 %	7.3 %	
> 70	12.2 %	7.3 %	
Female	57.2 %	58.9 %	.775 ^c
Education <i>M(SD)</i>	15.15 (3.78)	17.04 (3.60)	< .001 ^a
In employment	61.1 %	67.7 %	.237 ^c
Income range	25.000 – 35.000	25.000 – 35.000	.198 ^b

Note. Age and education in years. Average annual gross income range in Euro. ^a One-way ANOVA,

^b Mann-Whitney U test, or ^c Pearson’s chi-square tests.

voluntary and that they were able to withdraw at any time. All participants signed a written informed consent prior to assessment.

Procedure and Measurement

The assessment in sample 1 consisted of eight FDM tests and several standard neuropsychological tests. All tests were performed consecutively and in a fixed order with an approximate duration of 3.5 hours (see Appendix 3-1 for an overview of the sequence of tests). The fixed sequence of tests was chosen to minimize the interference between cognitive tests. One break of at least fifteen minutes was included, however, participants could ask for as many breaks as needed to minimize the effects of fatigue. Questionnaires were completed at home prior to assessment. Each participant was tested individually. The data of sample 2 was collected in the context of another study and in this study only FDM tests were used.

Tests measuring financial decision-making

The *Financial Competence Assessment Inventory - NL (FCAI-NL)* is an in Dutch translated and updated version of the original FCAI task developed by Kershaw and Webber (2004, 2008). The FCAI-NL provides information about strengths and weaknesses regarding an individual's ability and knowledge to perform actions that are needed to execute financial transactions on a relatively fundamental level (further described as 'financial competence'; Kershaw & Webber, 2004; Webber et al., 2002). The original FCAI appeared to be suitable for different age and patient groups (Kershaw & Webber, 2004, 2008). The FCAI-NL consists of six different subscales based on the six dimensions of financial competence (Kershaw & Webber, 2004, 2008): 'Financial abilities' (e.g., the ability to understand the information that is presented on bills), 'Financial judgment' (e.g., identifying and understanding items on a bank statement), 'Financial cognitive functioning' (e.g., writing a cheque), 'Financial management' (e.g., understanding banking protocols), 'Debt management' (e.g. awareness of own debts) and 'Financial support resources' (e.g., assistance seeking skills). In total, the FCAI-NL contains 38 questions varying between theoretical questions, practical assignments and questions about the financial situation of the participant. For each question, participants receive a score between 0 (*no awareness*) and 4 (*complete understanding*) depending on the accuracy of the answer, with the exception of yes/no questions (score of 0 or 1 points, respectively). The total score of the FCAI-NL (maximum score of 134) is based on the sum of the six subscales and gives an indication of an individual's overall financial competence.

The *Financial Decision-Making Interview (FDMI)* is a newly developed test used to determine the mental ability or capacity to make a decision related to financial issues (i.e., (financial) decision-making capacity). Decision-making capacity consists of five domains (Appelbaum & Grisso, 1988; Suto et al., 2005), i.e., the ability to identify a problem ('Identification'), to understand information and consider risks and benefits ('Understanding'), to reason about different options and make a reasoned decision ('Reasoning'), to appreciate and evaluate the effects of decisions ('Appreciating') and to articulate a final choice ('Communication'). The principle of the FDMI is based on the MacArthur Competence Assessment Tool and on previously published procedures that were used to assess (medical)

decision-making (Appelbaum & Grisso, 1988; Karlawish et al., 2013; Kim et al., 2001; Martin, Okonkwo, et al., 2008; Suto et al., 2005; Vellinga et al., 2005). In the FDMI, two vignettes with a complex hypothetical financial problem are presented in oral and written form. After the presentation of the vignette, participants are asked to answer questions related to the five domains of decision-making capacity. For each answer, participants receive a score of 0, 1 or 2 based on the degree of completeness. The scores on both vignettes are combined and one overall total score (maximum score of 20) is calculated as well as total scores for each subscale (maximum score of 4).

The *Financial Decision Style (FDS)* questionnaire is used to evaluate the manners individuals apply in FDM situations (i.e., financial decision styles; Harren, 1979; Scott & Bruce, 1995). The FDS is based on the General Decision-Making Style questionnaire (Scott & Bruce, 1995) which is a self-report questionnaire with good construct validity (Loo, 2000; Spicer & Sadler-Smith, 2005). The FDS consists of 24 questions and differentiates five decision-making styles (Scott & Bruce, 1995), i.e., (1) a ‘rational’ style characterized by the evaluation of options (e.g., ‘I make financial decisions in a logical and systematic manner’), (2) an ‘intuitive’ style which allows individuals to rely on feelings or emotions (e.g., ‘When I make financial decisions, I tend to rely on my intuition’), (3) a ‘dependent’ style characterized by the requirement of advice of others (e.g., ‘I rarely make important financial decisions without consulting other people’), (4) an ‘avoidant’ style characterized by avoiding and postponing decisions (e.g., ‘I postpone financial decision-making whenever possible’) and (5) a ‘spontaneous’ style characterized by impulsivity (e.g., ‘I often make financial decisions in the spur of the moment’). For each question, participants are asked to rate on a scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) to what extent each situation applies to them. A total score is calculated for each financial decision style.

Competence in Decision Rules (CDR) test is a subtest of the Adult Decision-Making Competence battery (Bruine de Bruin et al., 2007; Parker & Fischhoff, 2005) and assesses the ability to make financial decisions based on specific rules or criteria, such as selecting a product that meets certain requirements. The CDR contains ten scenarios with increasing complexity during which participants need to indicate which of five televisions (the original version referred to a DVD-player) they would buy using different decision rules. For example, ‘Emma wants the television with the highest average rating. However, she also wants to make sure that she buys a television that obtained the best rating on sound quality’. All televisions are equally priced, but vary in their technical specifications (e.g., picture quality and brand reliability). To make correct decisions in this test, participants are required to analyze the specifications of each television and to balance all pros and cons of a specific television based on the given rule. A total score is calculated based on the total number of correctly answered scenarios (maximum score is 10).

The *Temporal Discounting Task (TDT)* consists of eighteen different hypothetical scenarios and is used to assess decisions with implications for the future, such as choosing between spending or saving money. A critical characteristic of these decisions is that the subjective value of an option decreases over time (i.e., temporal discounting (TD); Green et al., 1994). During each scenario of the TDT participants have to indicate the lowest amount of

money they would accept today or after a relatively short delay instead of receiving a relatively high amount of money later in time (e.g., ‘Which amount of money would you accept today instead of receiving €100 in one year?’). Six different time intervals are used (i.e., ‘today vs. one week’, ‘today vs. one month’, ‘today vs. one year’, ‘one week vs. one month’, ‘one week vs. one year’ and ‘one month vs. one year’), which are combined with an amount of money participants can receive after a delay (i.e., €100, €500 or €1000). All answers are converted to a percentage of the amount of money participants can receive after a relatively long delay. Subsequently, one average score is calculated based on all six time-intervals. A high score is indicative for a decreased sensitivity to TD and, therefore, the ability to make decisions with implications for the future.

The *Impulsive Buying Questionnaire (IBQ)* is used to investigate the tendency to buy on impulse, which can be described as the irrepressible tendency to perform a sudden unplanned purchase (Rook, 1987). The IBQ assesses the affective, cognitive and situational components of impulsive buying (Beatty & Ferrell, 1998; Coley & Burgess, 2003; Verplanken & Herabadi, 2001). The affective component refers to emotions and feelings that lead to impulsive buying behavior; the cognitive component refers to thoughts of and the urge to buy on impulse. A situational component, i.e., the availability of time and money that are needed to execute an impulsive purchase, also appears to be involved (Beatty & Ferrell, 1998). The situational component is, however, still experimental and therefore not part of the total IBQ score. All questions (e.g., ‘When I go shopping, I buy things that I did not intend to purchase’ or ‘I always buy it if I really like it’) are rated on a four-point scale, which ranges from 1 (*strongly disagree*) to 4 (*strongly agree*). Sum scores are calculated for the affective, cognitive and situational component. Furthermore, a total score is calculated reflecting the overall tendency to buy on impulse. Scores are reversed so that high scores represent low levels of impulsive buying tendency.

A computerized version of the *Iowa Gambling Task (IGT)* (Bechara et al., 1994; Grasman & Wagenmakers, 2005) was developed to assess real-life decision-making, however, seems to assess primarily emotional decision-making in healthy individuals (Buelow & Suhr, 2009). Emotional decision-making in the context of the IGT can be described as an unconscious urge or feeling based on previous experience and emotional stage which has an influence on decision-making (Bechara et al., 1997; Buelow & Suhr, 2009). Participants have to choose cards from four decks and each deck is associated with certain gains and losses. The disadvantageous decks A and B lead to relatively high gains but also to relatively high losses. Decks C and D, the advantageous decks, result in relatively low gains but also in relatively low losses. Participants are not explicitly informed about the rules of winning and losing. They therefore have to learn from trial and error which decisions are most advantageous. A total netscore, i.e., the number of times a participant chose the advantageous decks minus the number of times the participant chose the disadvantageous decks, over 100 trials is calculated. Furthermore, the netscore will be divided in five parts of 20 trials to assess the effect of feedback and risky decision-making (Brand et al., 2006).

The *Financial Decision-Making on Intuition or Deliberation test (FDM-I/D)* is a computer test based on previous published procedures (Dijksterhuis et al., 2006; Mikels et al.,

2011) and is used to assess intuitive and deliberative decision-making. This test is based on the theory that individuals who were distracted before they had to make a complex decision made significantly better decisions compared to individuals who made their decisions consciously and deliberately (Dijksterhuis, 2004; Dijksterhuis et al., 2006; Mikels et al., 2011). During the FDM-I/D participants are presented with information about attributes of four options of a hypothetical product (i.e., a boat, an apartment, a car and a flight ticket) of which they have to choose the best option. The attributes are either positively or negatively formulated and the options per product are designed in such a way that one option is the best product with 75% positive attributes. For two options the positive and negative attributes are equally represented, and the last option has only 25% positive attributes. During two trials (i.e., boat and apartment) participants were asked to base their decision on their intuition; i.e., participants are distracted for 2.5 minutes before they have to make a decision by performing a Go-NoGo test immediately after the presentation of the attributes. In the other two trials (i.e., car and flight ticket) participants are instructed to make their decision after deliberatively thinking about the positive and negative attributes during a period of 2.5 minutes. Participants received 0 points if they choose the best option, -25 points if they choose one of the options with 50% positive attributes and -50 points if they choose the option with only 25% positive attributes. A total score is calculated for intuitive-based and deliberative-based decisions by adding the scores on the intuitive-based trials and deliberative-based trials, respectively.

Neuropsychological tests

A neuropsychological assessment was performed to assess a wide range of cognitive functions, such as memory, attention, executive functions, psychomotor speed and numeracy. Several standardized, reliable and valid neuropsychological tests were used to assess these cognitive functions. Verbal short-term memory was examined with the Digit Span forward of Wechsler Adult Intelligence Scale IV (*WAIS-IV – Digit Span forward*; Wechsler, 2008, 2012) and with the immediate recall of the Dutch version of the Rey Auditory Verbal Learning Test (*RAVLT immediate recall*; van der Elst et al., 2005). Verbal long-term memory was assessed with the *RAVLT delayed recall*; van der Elst et al., 2005). Psychomotor speed was assessed using the Trail Making Test – Part A (*TMT A*; Reitan, 1958) and the Stroop Color-Word Test – Word Card (*Stroop card 1*; van der Elst et al., 2006b). Selective attention was examined with the D2 Test of Attention (Brickenkamp, 2007; Brickenkamp & Zillmer, 1998) (target measures: *D2 Concentration Performance* and *D2 Total Correct*). The following tests were used to assess different aspects of executive functioning: response inhibition – Color-Word Card/Color Card of the Stroop Color-Word Test (*Stroop card 3-2*; van der Elst et al., 2006b); cognitive flexibility – Trail Making Test – Part B divided by Trail Making test – Part A (*TMT B/A*; Reitan, 1958); *Semantic alternating fluency test* (i.e., alternating between names of places and clothes during 1 minute (Bouma et al., 2012) and *Phonemic alternating fluency test* (i.e., alternating between words starting with the letters K and O during 1 minute (Bouma et al., 2012); planning – Tower of London Test (*TOL*); working memory – *WAIS-IV Digit Span backward* and *WAIS-IV Digit Span sorting* (Wechsler, 2008, 2012); divergent thinking – *Semantic fluency test* (categories ‘Animals’ and ‘Professions’; each during 1 minute; Luteijn & Barelds, 2004) and *Phonemic*

fluency test (categories words starting with a ‘D’, ‘A’ and ‘T’; Schmand et al., 2008); 1 minute for each letter). Finally, mathematical reasoning and numeracy were assessed with the *WAIS–IV Arithmetic* (Wechsler, 2008, 2012).

Data analyses

Statistical Package for the Social Sciences 23 was used for data analyses.

Effects of age. To determine the effects of age on the performance on the FDM tasks, thirteen hierarchical multiple regressions were performed on sample 1 using total scores of the FDM tasks as dependent variables. In the first step (method: enter) demographic variables that might be of influence on FDM were included as independent variables, i.e., gender, years of education, employment status and annual year income. Age in years was included as an independent variable in the second step (method: enter). Results of step two will be presented, unless otherwise stated. Normality was violated regarding the TDT total score; therefore, an arcsine transformation for percentage data was used for the TDT (i.e., $2 * \arcsine \sqrt{X_i/100}$; Cohen et al., 2003). When significant effects of age on FDM were found and a summary or total score was used as dependent variable (i.e., FCAI, FDMI, IBQ and IGT) the hierarchical multiple regression analysis was repeated including the different subscales or components as dependent variables. A p-value $\leq .05$ was considered statistically significant.

Internal and external validity. When significant effects of age on FDM were found, the internal and external validity of these results were examined. To determine the internal validity, bootstrap analyses were performed to control for overoptimism (Steyerberg et al., 2001, 2003). In the bootstrap resampling procedure, 1,000 random samples of the original sample size were drawn with replacement from sample 1. Bootstrap 95% Confidence Intervals (CI) were estimated for the regression coefficients (b-values) as a measure of accuracy of the original regression analyses. When the 95% CI of the bootstrap analyses did not include the value of zero, the internal validation was considered satisfactory. To examine the external validity of the significant results, the hierarchical multiple regression analyses, including bootstrap analyses for significant results, were repeated using sample 2. The b-values of the hierarchical multiple regression analyses and the bootstrap analyses in the second sample were compared to the 95% CI of the conducted bootstraps on sample 1 to evaluate the external validity of the found age effects (Bleeker et al., 2003; Steyerberg et al., 2003). When b-values of sample 2 were within the 95% CI of the bootstrap of sample 1, the external validity was considered to be sufficient.

Mediating effect of cognition. To investigate a possible mediating effect of cognition on the relation between age and FDM, a four steps procedure by Baron and Kenny (1986) was followed. Step one is described above, i.e., the investigation of the relation between age and FDM. For step two, thirteen additional hierarchical multiple regression analyses (method: enter) were performed to determine the relation between cognition and participants’ performance in FDM tests. Dependent variables were the total scores of each FDM test. Independent variables were the participants’ performances on the different standard neuropsychological measures. When standard neuropsychological measures are found to significantly relate to aspects of FDM, additional hierarchical multiple regression analyses (step

three) will be performed to determine the effects of age on these measures of cognition. For both step two and three, we controlled for demographic variables (i.e., gender, years of education, employment status and annual year income) and a Bonferroni correction was applied to control for alpha-error growth in multiple testing (i.e., $p < .0038$ and $p < .017$ were considered significant for step two and three, respectively). When significant results were found in step two and three, additional hierarchical regression analyses (step four) were performed to investigate the effects of age and FDM while controlling for demographic variables and standard measures of cognition. A significant reduction in the relation between age and FDM, as determined by the Sobel test, is indicative of a mediating effect of cognition.

Finally, correlation analyses (Pearson) were used to determine the coherence between the FDM tests and to further explore the relation between FDM tests and standard neuropsychological measures. Bonferroni correction was applied to control for alpha-errors and $p < .001$ was considered significant.

Results

Age effects on FDM

No significant effects of age were found on the total scores of the FCAI-NL and FDMI and on the application of financial decision-making styles (FDS; Table 3.2). However, with regard to the FCAI-NL years of education ($b = 0.79$ [0.35, 1.23], $p = .001$) as well as gross annual year income ($b = 1.4$ [0.19, 2.60], $p = .023$) were found to be significant predictors. Number of years of education was also a significant predictor of the total score of the FDMI ($b = 0.11$ [0.04, 0.19], $p = .003$) and years of education and gross annual year income were both significant predictors of the 'intuitive style' of the FDS ($b = -0.167$ [-0.30, -0.03], $p = .015$ and $b = -0.432$ [-0.81, -0.06], $p = .025$, respectively). None of the other FDS styles (i.e., rational, dependent, avoidant and spontaneous) could be predicted by any of the control variables. Furthermore, no significant effects of age, or of any of the control variables, were found on the FDM-I/D, neither for deliberative decisions nor for intuitive decisions (Table 3.2).

The number of years of education significantly predicted the CDR performance ($b = 0.17$ [0.98, 0.25], $p = < .001$). However, age was found to be a significant additional predictor of the performance on the CDR, explaining 15.1% of variance; a finding that is supported by both the internal and external validation analyses (Table 3.2). Negative effects of age were also found on the IGT. The total netscore of the IGT was significantly predicted by age, explaining 7.1% of variance. Specifically, the second, fourth and fifth trial of the IGT were significantly predicted by age (Table 3.2). No significant effects of age were found for the first and third trial of the IGT and the control variables did not predict the performance on the IGT. The internal validation analyses partly supported these results. However, the results could not be replicated in the external validation analyses (Table 3.2).

Gender and gross annual year income were found to explain 27.2% of variance of scores on the IBQ ($b = -5.55$ [-8.32, -2.78], $p < .001$ and $b = 1.20$ [0.15, 2.25], $p = .026$, respectively). Women had lower IBQ scores, indicating a stronger impulsive buying tendency, than men. However,

age was also a significant predictor of the IBQ, explaining an additional 3.4% of variance. Further investigation of the three IBQ components indicates that the relation of age is particularly evident for the affective component. Again, gender explained a large proportion of the variance (i.e., 25.7%; $b = -3.27 [-4.70, -1.85]$, $p < .001$) of the IBQ affective component, but age was an additional significant predictor of this component and explained 6.3% of the variance. Both the internal as well as external validation analyses support the effects of age on the IBQ (Table 3.2). The cognitive and situational components of the IBQ were not significantly influenced by age. Regarding the TDT, no relation was found with any of the control variables, but 5.8% of the variance was explained by age (Table 3.2). The internal validation analyses support this finding, but these age effects lack external validity since these results could not be replicated in sample 2 (Table 3.2).

Mediating effect of cognition

After controlling for gender ($\beta = -0.15$, $p = .018$) and years of education ($\beta = 0.15$, $p = .015$), standard measures of cognition explained additional and significant variance of the performance on the CDR ($\Delta R^2 = .40$, $\Delta F(17, 142) = 8.77$, $p < .001$). Numeracy (Arithmetic) was the strongest predictor of the performance on the CDR ($\beta = 0.27$, $p < .001$), followed by planning (TOL) and working memory (Digit Span backward) ($\beta = 0.19$, $p = .003$ and $\beta = 0.16$, $p = .023$, respectively). The remaining twelve regression models focused on the effects of cognition on each of the FDM tests did not reach statistical significance ($.056 \leq p \leq .915$).

For numeracy (WAIS-IV Arithmetic), planning (TOL) and working memory (WAIS-IV Digit Span backward) the relation with age was investigated. Age was significantly negatively related to planning (TOL; $\Delta R^2 = .14$, $\beta = -0.49$, $p < .001$) and numeracy (WAIS-IV Arithmetic; $\Delta R^2 = .05$, $\beta = -0.30$, $p = .002$), whereas no significant relation was found between age and working memory (WAIS-IV Digit Span backward) ($\beta = -0.15$, $p = .120$).

A mediation analysis was therefore performed for the relation between age and the CDR controlling for TOL and WAIS-IV Arithmetic. The results indicate that, after controlling for these measures of cognition, the strength of the relation between age and the CDR decreases but remains significant ($\beta = -0.30$, $p < .001$ after controlling for TOL and WAIS-IV Arithmetic compared to $\beta = -0.50$, $p < .001$ in the original analysis). According to the Sobel test, the decrease in the association between age and CDR can be explained by a mediating effect of both numeracy (WAIS-IV Arithmetic, $p = .003$) and planning (TOL, $p = .012$).

Related to these findings, only a few weak correlations between standard neuropsychological measures and FDM tasks were found (see Appendix 3-2). Correlation analyses performed to determine the coherence between different FDM tests showed also only weak to negligible correlations (see Appendix 3-3).

Table 3.2. Results of multiple hierarchical regression analyses of sample 1 and sample 2.

	Sample 1				Bootstrap of sample 1				Sample 2				Bootstrap of sample 2			
	Control variables ^a		Age		Bias	SE	95%CI	b	ΔR^2	p (ΔF)	Age	ΔR^2	p (ΔF)	Bias	SE	95%CI
	R^2	p (F)	b	ΔR^2												
FCAI-NL total	.163	<.001*	-0.015	.000	.791	-	-	-	-	-	-	-	-	-	-	-
FDMI total	.091	.003*	-0.008	.005	.358	-	-	-	-	-	-	-	-	-	-	-
FDS rational	.022	.488	0.003	.000	.848	-	-	-	-	-	-	-	-	-	-	-
FDS intuitive	.080	.002*	0.021	.008	.237	-	-	-	-	-	-	-	-	-	-	-
FDS dependent	.028	.361	-0.018	.005	.354	-	-	-	-	-	-	-	-	-	-	-
FDS avoidant	.012	.747	0.019	.007	.310	-	-	-	-	-	-	-	-	-	-	-
FDS spontaneous	.035	.233	-0.019	.010	.196	-	-	-	-	-	-	-	-	-	-	-
CDR total	.211	<.001*	-0.066	.151	<.001*	0.001	0.010 [-0.085, -0.044]*	-0.070	.150	<.001*	<0.001	0.017 [-0.101, -0.035]*	-	-	-	-
TDT total	.048	.088	0.006	.058	.001*	<0.001	0.002 [0.002, 0.010]*	-0.001	.001	.770	-	-	-	-	-	-
IBQ total	.272	<.001*	0.120	.034	.011*	0.002	0.042 [0.035, 0.209]*	0.169	.062	.006*	<0.001	0.040 [0.041, 0.198]*	-	-	-	-
Affective	.257	<.001*	0.086	.063	<.001*	0.001	0.023 [0.042, 0.132]*	0.085	.048	.016*	<0.001	0.038 [0.012, 0.163]*	-	-	-	-
Cognitive component	.215	<.001*	0.030	.007	.246	-	-	-	-	-	-	-	-	-	-	-
Situational component	.061	.044	-0.011	.015	.119	-	-	-	-	-	-	-	-	-	-	-
IGT netscore total	.017	.572	-0.619	.071	<.001*	0.011	0.174 [-0.959, -0.280]*	-0.040	.000	.878	-	-	-	-	-	-
Netscore trial 01 - 20	.018	.566	-0.035	.005	.343	-	-	-	-	-	-	-	-	-	-	-
Netscore trial 21 - 40	.042	.129	-0.112	.027	.032*	0.002	0.054 [-0.213, 0.004]	-0.056	.005	.453	-	-	-	-	-	-
Netscore trial 41 - 60	.015	.656	-0.057	.007	.275	-	-	-	-	-	-	-	-	-	-	-
Netscore trial 61 - 80	.018	.565	-0.171	.067	.001*	-0.002	0.052 [-0.279, -0.067]*	-0.020	.001	.790	-	-	-	-	-	-
Netscore trial 81 - 100	.027	.336	-0.252	.120	<.001*	0.001	0.052 [-0.353, -0.146]*	0.018	.000	.816	-	-	-	-	-	-
FDM I/D 'intuition'	.036	.217	-0.146	.014	.132	-	-	-	-	-	-	-	-	-	-	-
FDM I/D 'deliberation'	.043	.126	-0.113	.009	.223	-	-	-	-	-	-	-	-	-	-	-

Note. **CDR** = Competence in Decision Rules; **FCAI-NL** = Financial Competence Assessment Inventory - NL; **FDMI** = Financial Decision-Making Interview; **FDM-I/D** = Financial Decision Making on Intuition or Deliberation; **FDM-I/D** = Financial Decision Making on Intuition or Deliberation Test; **FDS** = Financial Decision Styles; **IBQ** = Impulsive Buying Questionnaire; **IGT** = Iowa Gambling Task; **TDT** = Temporal Discounting Task.

^a Control variables included were gender, education (in years), income and employment status.

ΔR^2 = R^2 change (i.e., added variance when including age); p(ΔF) = p-value F change.

* significant with $p < .05$.

Discussion

The objective of this explorative study was to determine the effects of normal aging on different aspects of FDM. Based on previously published procedures in the field of (medical) decision-making, a comprehensive test battery was developed reflecting eight aspects of FDM. It was expected that some more cognitive demanding aspects of FDM were negatively influenced by normal aging due to age-related cognitive decline (Braver & West, 2008; Denburg & Hedgcock, 2015; Salthouse, 1996; Salthouse & Meinz, 1995), while other aspects remained relatively stable or even improved due to an age-related increase of knowledge and experience or an improved affective decision-making in older adults (Hess, 2015; Li et al., 2004; Mikels et al., 2013; Peters et al., 2007).

When looking at the different aspects of FDM, no effects of normal aging were found on relatively basic aspects of FDM, i.e., financial competence and (financial) decision-making capacity. These results suggest that the (mental) ability or capacity and knowledge to perform actions that are needed to execute financial transactions on a relatively basic level are relatively stable across the adult life span. Furthermore, no or only relatively weak associations were found between financial competence, (financial) decision-making capacity and measures of cognition, suggesting that financial competence and (financial) decision-making capacity are not related to performances on measures of cognition. However, it is also possible that an age-related improvement in affective processing and an increased knowledge and experience with regard to these relatively basic aspects of FDM compensate for an age-related decline in cognition (Mather & Knight, 2005; Meyer et al., 1995). This hypothesis cannot be evaluated on the basis of the present data and therefore needs further investigation. Interestingly, most studies that examined the capacity to make decisions within a medical context, e.g., about different treatment options, among patients with mental disorders (Grisso & Appelbaum, 1995; Hindmarch et al., 2013), medical disorders (Karlawish et al., 2013; Martin, Okonkwo, et al., 2008) or elderly with and without cognitive impairments (Kim et al., 2001; Vellinga et al., 2005), suggest that a poorer decision-making capacity is related to cognitive dysfunctioning. None of the studies, however, examined the effects of normal aging on the capacity to make decisions by using a life-span perspective. Furthermore, so far, only two studies focused on decision making capacity in a financial context and found that patients with mild cognitive impairments or Alzheimer's disease (Lui et al., 2013) and patients with intellectual disabilities (Suto et al., 2005) have more difficulties with financial decision-making capacity compared to a healthy comparison group. Also the FCAI, measuring financial competence, has been shown to be able to distinguish individuals with cognitive impairments from individuals without cognitive impairments (Kershaw & Webber, 2008). These studies suggest that financial competence and (financial) decision-making capacity are sensitive to more severe cognitive dysfunctions and, therefore, might be impaired in patients with, e.g., mild cognitive impairments or Alzheimer's disease. In the present study, however, no evidence for effects of normal aging on these relatively basic aspects of FDM were found.

Also regarding the use of decision-making styles in FDM situations no significant effects of normal aging were found. To our knowledge, the present study is the first study investigating

decision-making styles in the context of FDM. Previous research on more general decision-making styles indicated that the use of intuitive and avoidant styles decreases with advancing age (Loo, 2000). The results of the present study, however, suggest that this does not apply to decisions in a financial situation. Also no significant effects of age were found for deliberative and intuitive FDM. It was expected that older adults would become better in making intuitive decisions since they rely more on the affective processes (Peters et al., 2007). However, no evidence for this expectation was found. Since a recently published meta-analysis including 61 studies concluded that there is no evidence for previous suggestions that intuitive decisions in complex situations lead to better decisions than deliberative decisions (Nieuwenstein et al., 2015), intuitive and deliberative decision-making were not directly compared in the present study.

With increasing age, the tendency to buy on impulse seems to decrease. Particularly the affective component of impulsive buying behavior appears to be sensitive to the effects of normal aging. Both the internal and external validation analyses support these findings. The results suggest that with advancing age individuals are less prone to feelings of temptation or immediate satisfaction when buying something, which is consistent with improved affective processes (Li et al., 2004; Mikels et al., 2013; Peters et al., 2007) and a better impulse control or emotion-regulation that accompanies aging (Orgeta, 2009). Related to the improved impulse control with advancing age, it was found in sample 1 that with advancing age individuals are less sensitive to immediate rewards (TD); these results could, however, not be confirmed in sample 2. The results of previous studies on the effect of aging on TD are also mixed, with some studies demonstrating an increased sensitivity to TD with advancing age, while others show no effects of normal aging on TD (e.g., Green et al., 1994, 1996; Löckenhoff et al., 2011; Read & Read, 2004; Whelan & McHugh, 2009). It has been hypothesized that income might have an effect on TD (Green et al., 1996) and mediate the age effects. Also other financial resources, such as financial reserves, might be of influence on the association between normal aging and TD.

Inconsistent findings between sample 1 and 2 were also found for emotional decision-making measured with the IGT. An age-related decline was found in sample 1 for emotional decision-making. This was particularly evident for the last parts (i.e., the last forty trials) of the task, which are suggested to assess risky decision-making (Brand et al., 2006). This age effect is in accordance with previous research (Beitz et al., 2014; Denburg et al., 2005; Fein et al., 2007). However, the internal validation analyses only partly supported these findings and results could not be replicated by the external validation analysis, i.e., no age effects on the IGT were found in sample 2. A possible explanation for these discrepant findings might be that the two samples included in the present study differed with regard to number of years of education. Indeed, several studies showed that performance on the IGT might be affected by level of education (Davis et al., 2008; Fry et al., 2009).

Nevertheless, the present study did find strong evidence that the ability to apply rules during an FDM situation (i.e., CDR) decreases with advancing age. This result indicates that when (financial) decisions need to be made based on specific preferences or rules, older adults have more difficulties with applying these preferences or rules than younger individuals. Both

the internal and external validation analyses support this finding. Previous research suggested that this decline in FDM can be attributed to a decrease in deliberative processes and executive functioning (Braver & West, 2008; Bruine de Bruin et al., 2012; Denburg & Hedgcock, 2015; Peters et al., 2007), in particular inhibition (Del Missier et al., 2010) and working memory (Del Missier et al., 2013). Indeed, in the current study 40% of variance of the performance on the CDR was explained by numeracy, planning and working memory, indicating that the ability to apply rules is a complex and cognitively demanding aspect of FDM. Furthermore, numeracy and planning appear to mediate the effects of aging on the CDR, however, these cognitive functions cannot completely explain the relation between age and this aspect of FDM. Furthermore, no evidence was found for a compensation effect of affective decision-making or experience for the performance on the CDR. Taken together, these results indicate that besides an age-related cognitive decline, also other variables are related to age-related difficulties in (financial) decision-making based on preferences and rules.

In summary, normal aging appears to have a differential effect on various aspects of FDM. Regarding relatively basic aspects (i.e., financial competence, (financial) decision-making capacity, financial decision styles and the quality of intuitive and deliberative decisions) no evidence for effects of normal aging were found. On the other hand, an aspect of FDM that has been associated with affective processes (i.e., impulsive buying tendency) seems to improve with advancing age. Furthermore, a more complex aspect of FDM (i.e., the ability to apply rules) appears to deteriorate with advancing age. Whether or not normal aging has an effect on FDM with implications for the future and emotional decision-making remains inconclusive. The possible influence of third variables (i.e., personal finances and level of education) needs further investigation in order to provide more insight into the effects of normal aging on these aspects of FDM.

When exploring the associations between performances on neuropsychological tests and FDM tests only weak and non-significant associations were found (see Appendix 3-2). This indicates that standard neuropsychological tests cannot be used to evaluate one's ability to make financial decisions, which emphasize the importance of the development of reliable FDM measurements. However, it must be noted that we might have failed to reveal existing effects (beta-errors) due to a conservative method to control for alpha-error growth in multiple testing (i.e., Bonferroni correction). Furthermore, the inclusion of a healthy sample without distinct cognitive dysfunctions may also account for the lack of coherence between cognition and aspects of FDM due to small inter-individual differences or ceiling effects within the sample. A sample of individuals with distinct cognitive impairment might show stronger relations between aspects of FDM and measures of cognition. Finally, when exploring the associations between the different FDM tests, it was found that all correlations were of a weak to negligible size (see Appendix 3-3). This shows that there is no or only little overlap between the tests which supports the assumption of the existence of multiple independent aspects of FDM.

A limitation of the current study is that the education level of our sample was slightly higher than the average education level in The Netherlands. This problem of representativeness of samples is, unfortunately, a common problem that is difficult to counter in scientific research with humans (Henrich et al., 2010). Second, the eight aspects of FDM might not reflect all FDM

situations an individual may encounter in daily life. Furthermore, in spite of the theoretical classification of different FDM aspects and the weak correlations found between FDM tasks, it is possible that in some cases certain tasks relate to similar constructs or aspects of FDM. A third limitation of the present study is that the convergent validity could not be evaluated since there are hardly any additional FDM tests available. In addition, the ecological validity of the FDM tests was not examined so far by exploring the associations between the performances on the FDM tests and real-life FDM problems. Fourth, it must be noted that the effects of age on FDM might have been confounded by the fixed sequence of test administration and differences in the assessment procedure of sample 1 and 2 (Appendix 3-1). However, by using the same sequence of FDM tests in sample 1 and 2 and providing participants the opportunity for as much breaks as needed the effects of the test administration order were likely kept on a minimum. Finally, the role of financial experience and knowledge was not taken into account sufficiently.

Nevertheless, by investigating multiple aspects of FDM, a better understanding of age-related differences in FDM was obtained. Normal aging influences some aspects of FDM, while other aspects appear to be unaffected by normal aging. Age-related decline in FDM, which is possibly related to normal age-related changes in the prefrontal networks (Dennis & Cabeza, 2008; Maillet & Rajah, 2013), seems to be mediated by age-related changes in executive functions (Braver & West, 2008; Denburg & Hedgcock, 2015), particularly in planning and numeracy. However, also working memory was found to be predictor of FDM. Improved affective decision-making and an age-related increase of knowledge and experience in older individuals (Hess, 2015; Li et al., 2004; Mikels et al., 2013; Peters et al., 2007) might result in stable or improved FDM with advancing age. In future research the role of motivation during complex FDM situations, such as applying decision rules, needs further investigation since an older age has been associated with a lack of motivation for difficult or complex (decision-making) situations (Bruine de Bruin et al., 2015). Furthermore, it would be interesting to further explore individual differences in FDM by focusing on the effects of gender, financial resources and level of education, since it is generally known that demographic characteristics have an effect on neuropsychological test performances (van der Elst et al., 2006a, 2006b, 2006c) and might have a mediating or moderating influence on the effects of age on FDM. In addition, studying FDM in patient groups, such as patients with neurodegenerative disorders, attention-deficit/hyperactivity disorder or traumatic brain injury, is of utmost importance since it can be expected that these patients experience problems with FDM in daily life due to more severe impairments in cognition (e.g., Barkley et al., 2008; Dreer et al., 2012; Earnst et al., 2001; Lui et al., 2013; Martin et al., 2013; Sherod et al., 2009) than found in healthy (older) adults. Finally, it is relevant to relate the current FDM tests to everyday situations and problems in FDM to determine the ecological validity of the different FDM tests.

Appendices

Appendix 3-1. Sequence of tests in sample 1 (and 2).

Questionnaires (e.g., Financial Decision Styles questionnaire* and Impulsive Buying Questionnaire*) were completed at home prior to assessment.

Start of assessment

- Short demographic characteristics questionnaire (e.g., age, gender, education)
- Mini-Mental State Examination (MMSE)
- Financial Competence Assessment Inventory (FCAI)*
- Rey Auditory Verbal Learning Test (RAVLT) – Immediate recall
- Tower of London (TOL)
- Trail Making Test (TMT)
- D2 Test of Attention (D2)
- Rey Auditory Verbal Learning Test (RAVLT) – Delayed recall and recognition

*Optional break***

- Financial Decision-Making Instrument (FDMI)*
- Competence in Decision Rules (CDR) test*
- Semantic fluency

*Mandatory break (15-20 min.)***

- Iowa Gambling Task (IGT)*
- Emotion Focused Financial Decision-Making (EF-FDM)*

*Optional break***

- Wechsler Adult Intelligence Scale IV – Arithmetic
- Phonemic fluency
- Wechsler Adult Intelligence Scale IV - Digit Span
- Temporal Discounting Task (TDT)*
- Semantic and Phonemic alternating fluency
- Stroop Color-Word Test (STROOP)

End of the assessment

*The Financial Decision-Making tasks were assessed in sample 2 in the same sequence as in sample 1.

**Besides the mandatory and optional breaks, participants could receive as many breaks as needed between the tests upon request.

Appendix 3-2. Correlations between FDM tests and standard neuropsychological measurements (Pearson).

	FCAI-NL	FDMI	CDR	IBQ	IGT	TDT	FDS				FDM-I/D		
							Rational	Intuitive	Dependent	Avoidant	Spontaneous	Intuition	Deliberation
RAVLT immediate	.13	.17	.42*	-.31*	.17	.04	-.06	-.01	.09	-.03	.18	.19	-.02
RAVLT delayed	.12	.06	.37*	-.31*	.19	-.05	-.11	.02	.13	.03	.15	.18	.02
TMT-A	-.05	.02	-.29*	.22	-.14	.11	.16	-.00	-.20	.002	-.23	-.07	.03
TMT B/A	-.05	-.15	-.07	.06	-.13	-.02	.01	.07	.08	.05	.01	-.01	.06
Stroop card 1	-.01	.01	-.32*	.27*	-.12	.10	.17	.02	-.16	-.02	-.18	-.08	.14
Stroop card 3/2	-.05	-.12	-.40*	.14	-.21	-.01	.10	.04	-.08	-.03	-.12	-.12	.05
TOL	.15	.19	.50*	-.02	.29*	.01	.15	-.07	.04	-.06	.06	.08	.10
D2 CP	.21	.16	.49*	-.13	.22	-.09	-.04	-.07	-.00	-.10	.10	.06	-.10
D2 Correct	.16	.04	.43*	-.10	.21	-.11	-.07	-.04	-.02	-.11	.11	.04	-.08
Digit Span forward	.15	.18	.36*	.03	.22	.003	.15	-.10	.02	-.04	-.02	.17	-.05
Digit Span backwards	.16	.20	.47*	.02	.20	.01	.08	-.06	-.01	.03	.04	.11	.07
Digit Span sorting	.13	.22	.47*	-.16	.23	-.06	-.01	-.15	.01	-.12	.15	.18	.10
Semantic fluency	.22	.24*	.28*	-.07	.15	-.01	-.17	-.07	.11	.02	.11	.12	-.17
Phonemic fluency	.16	.09	.30*	-.06	.16	.003	.003	-.08	.06	.02	-.08	.15	-.07
Semantic Alternating	.13	.18	.31*	-.01	.18	.10	-.01	-.21	.03	-.03	-.03	.04	-.04
Phonemic Alternating	.17	-.01	.34*	-.11	.22	-.01	-.07	.03	.16	.02	.03	.12	-.02
WAIS-IV Arithmetic	.33*	.16	.58*	.08	.24*	.11	.13	-.23	-.09	-.11	-.01	.03	.10

Note. **CDR** = Competence in Decision Rules; **D2 CP** = D2 Concentration Performance; **FCAI-NL** = Financial Competence Assessment Inventory – NL; **FDMI** = Financial Decision-Making Interview; **FDM-I/D** = Financial Decision-Making on intuition or deliberation; **FDS** = Financial Decision Styles; **IBQ** = Impulsive Buying Questionnaire; **IGT** = Iowa Gambling Task; **RAVLT** = Rey Auditory Verbal Learning Test; **TDT** = Temporal Discounting Task; **TMT** = Trail Making Test; **TOL** = Tower of London; **WAIS-IV** = Wechsler Adult Intelligence Scale IV.
* p < 0.001.

Appendix 3-3. Correlations between FDM tests (Pearson).

	FCAI-NL	FDMI	CDR	IBQ	IGT	TDT	FDM-I/D	
							Intuition	Deliberation
FDMI	.20	-	-	-	-	-	-	-
CDR	.32*	.21	-	-	-	-	-	-
IBQ	.07	-.05	-.10	-	-	-	-	-
IGT	.10	.19	.34*	-.08	-	-	-	-
TDT	.14	.06	-.06	.35*	-.02	-	-	-
FDM-I/D 'Intuition'	-.04	.04	.13	-.07	.10	-.02	-	-
FDM-I/D 'Deliberation'	-.09	.14	.15	-.12	.13	.09	.03	-
FDS Rational	.24	.02	.13	.39*	.03	.20	-.10	.07
FDS Intuitive	-.11	-.19	-.21	-.28*	.04	-.09	-.08	-.14
FDS Dependent	-.11	-.02	-.03	-.18	.15	-.01	.15	.08
FDS Avoidant	-.13	.02	-.08	-.15	-.03	.004	-.12	.08
FDS Spontaneous	-.11	.08	.02	-.55*	.06	-.19	-.00	-.04

Note. **CDR** = Competence in Decision Rules; **FCAI-NL** = Financial Competence Assessment Inventory – NL; **FDMI** = Financial Decision-Making Interview; **FDS** = Financial Decision Styles; **IBQ** = Impulsive Buying Questionnaire; **IGT** = Iowa Gambling Task; **FDM-I/D** = Financial Decision-Making on intuition or deliberation; **TDT** = Temporal Discounting Task.

* $p < 0.001$.

CHAPTER

4

HOW WELL DO PEOPLE LIVING WITH NEURODEGENERATIVE DISEASES MANAGE THEIR FINANCES?

A meta-analysis and systematic review
on the capacity to make financial
decisions in people living with
neurodegenerative diseases.

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*Neuroscience and Biobehavioral
Reviews (2021)*

Abstract

Objectives: Self and proxy reported questionnaires indicate that people living with a neurodegenerative disease (NDD) have more difficulties with financial decision-making (FDM) than healthy controls. Self-reports, however, rely on adequate insight into everyday functioning and might, therefore, be less reliable.

Methods: The present study provides a comprehensive overview and meta-analysis of studies evaluating FDM in people living with an NDD. For this, the reliability of performance-based tests to consistently identify FDM difficulties in people living with an NDD compared to healthy controls is evaluated. Furthermore, the associations between FDM and disease severity, performances on standard measures of cognition and demographics are evaluated.

Results & Conclusion: All 47 included articles, consistently reported lower performances on performance-based FDM tests of people living with an NDD (including Alzheimer's disease, mild cognitive impairment, frontotemporal dementia, Parkinson's disease, multiple sclerosis or Huntington's disease) compared to healthy controls. The majority of studies, however, focused on Alzheimer's disease and mild cognitive impairment (k=38). FDM performance appears to be related to cognitive decline, specifically in working memory, processing speed and numeracy.

Introduction

The ability to make financial decisions in one's own self-interest is essential for an independent life. Difficulties with financial decision-making (FDM) may lead to financial insecurity, poverty or financial abuse (Lai & Karlawish, 2007; Manthorpe et al., 2012; Okonkwo et al., 2008) and the (early) detection of deficits in FDM is, therefore, of utmost importance. The legislation regarding the mental capacity to make financial decisions differs between countries. In England and Wales, for example, but also in the Netherlands, the law presumes that a person has the capacity to make financial decisions unless this person is deemed to lack this capacity. This means that people with unrecognized or undetected deficits in the capacity to make financial decision can continue to make such decisions even though they may need support. The capacity, or competence, to make financial decisions is an umbrella term that includes not only practical skills and abilities (e.g., counting coins), but also the ability to judge and make (complex) decisions (American Bar Association Commission on Law and Aging and American Psychological Association [ABA/APA], 2008). FDM encompasses various cognitive functions (Glimcher, 2014) and appears to rely on the integrity of the frontal cortex (Kennerley & Walton, 2011). Cognitive functions found to be related to decision-making in general include working memory, executive functioning and numeracy (Chen et al., 2014; Martin et al., 2012; Reyna et al., 2009).

Neurodegenerative diseases (NDDs; e.g., Alzheimer's disease (AD), Parkinson's disease (PD) or Huntington's disease (HD)) are characterized by a progressive decline of cognition and neuropsychiatric disturbances (American Psychiatric Association, 2013; Hardiman & Doherty, 2016), which makes people living with an NDD particularly vulnerable for difficulties with FDM. Indeed, research using self or proxy reported questionnaires showed that people living with an NDD have more difficulties in 'financial skills' or 'financial management' than healthy controls (Pérès et al., 2008; Wadley et al., 2003; Wicklund et al., 2007). Even years prior to the diagnosis of AD (Pérès et al., 2008) and HD (Beglinger et al., 2010), people living with these conditions report more difficulties with FDM compared to healthy controls.

Self-report questionnaires, however, rely strongly on an adequate insight into everyday functioning and might, therefore, be less reliable (Wadley et al., 2003). Furthermore, people living with an NDD with comorbid depression tend to report significantly more problems with cognitive functioning in everyday life than people living with an NDD who are not depressed, even when no effects of depression on the performances on performance-based neuropsychological tests are found (Koerts et al., 2012; Marino et al., 2009; Middleton et al., 2006). Finally, previous research has shown that questionnaires often do not give a good reflection of what is measured with performance-based standardized neuropsychological tests (Fuermaier et al., 2015; Koerts et al., 2012; Toplak et al., 2013). In contrast to self or proxy reported questionnaires, performance-based tests directly examine an individual's performance on tasks or during activities using standardized scoring procedures (Engel et al., 2016; Moore et al., 2007). Performance-based tests are frequently administered in an experimental or clinical environment and provide a practical and adequate alternative for real life observations (Moore et al., 2007). Therefore, in order to ascertain in a reliable and valid manner to what extent people

living with an NDD can make financial decisions, performance-based FDM tests need to be used.

The aim of the present study is to provide a comprehensive overview and meta-analysis of studies evaluating FDM in people living with an NDD. For this, an evaluation of the reliability of performance-based tests to consistently identify FDM difficulties in people living with an NDD compared to healthy controls will be conducted. If possible, the performances on tests of FDM between groups with different NDDs will also be compared. Furthermore, the influence of disease severity and disease progression on FDM will be explored as well as the associations between FDM and performances on standard measures of cognition and demographic variables (i.e., age, sex and education).

NDDs are a heterogeneous group of disorders and the NDDs that are considered in the present systematic review and meta-analysis were selected based on prevalence rates. Since it is beyond the scope of this systematic review to describe all NDDs in detail, a short description of the NDDs that are considered in the present study will be provided. The first disorder that is considered is AD. AD is the most common NDD (Reitz et al., 2011) and is typically characterized by a progressive loss of functional independence and a gradual decline of memory. In addition, cognitive domains such as executive and visuospatial functions are often affected in people living with AD. Mild cognitive impairment (MCI) is often considered to be a prodromal stage of AD (or of other dementia's) and was, therefore, also taken into account in the present systematic review. MCI is diagnosed when there are concerns about a change in cognition, when impairments are present in one or more domains of cognition, while there is a preservation of functional independence and when the cognitive impairments are sufficiently mild that the person is not demented (Albert et al., 2011). The second most common NDD is PD which was, therefore, also taken into account in the present systematic review. PD also has a progressive decline and the diagnosis is based on the presence of motor symptoms such as rigidity, bradykinesia and tremor. Non-motor symptoms, including cognitive impairment in the domains of executive functions, attention, and visuospatial functions, are, however, also often present which can result in PD dementia (PDD) as the disease progresses (Hely et al., 2008; Litvan et al., 2011). Another common type of NDD that is closely related to PD is dementia with Lewy bodies. Dementia with Lewy bodies is also characterized by impairments in executive functions, attention, and visuospatial functions, resulting in dementia, and by motor symptoms such as bradykinesia, rigidity and tremor. However, within the context of dementia with Lewy bodies, and in contrast to PDD, dementia precedes or occurs simultaneously with the occurrence of motor symptoms (McKeith et al., 2005). Frontotemporal dementia (FTD) refers to a group of conditions which are predominately characterized by neurodegeneration of the frontal and temporal cortices. FTD is a common cause of dementia under the age of 65. The two core conditions within the context of FTD are the behavioral variant of FTD and primary progressive aphasia. The behavioral variant of FTD is characterized by changes in behavior, personality and emotion and by impairments in executive function and social cognition (Rascovsky et al., 2011), while impairments in language are the hallmark of primary progressive aphasia (Gorno-Tempini et al., 2011). Since there is a significant clinical overlap between the behavioral variant of FTD and amyotrophic lateral sclerosis (Lomen-Hoerth, 2011;

Rascovsky et al., 2011), the latter was also included in the search terms. Two other NDDs that are considered in the present study are progressive supranuclear palsy and HD. People living with progressive supranuclear palsy typically show eye movement abnormalities, parkinsonian features, personality changes and cognitive impairment in the domains of executive function and attention (Litvan et al., 1996). HD is an autosomal dominant NDD that is characterized by involuntary movements, cognitive impairment in domains such as executive functions, attention and social cognition, and psychiatric features, including anxiety, aggression, disinhibition and anti-social behavior (Ross & Tabrizi, 2011). The final condition that was considered in the present systematic review was multiple sclerosis (MS). MS is an inflammatory demyelinating disorder. However, it has been argued that a degenerative process is at the root of the disease (Stys et al., 2012). Furthermore, it has been suggested that MS has a prodromal period which is similar to NDDs (Wijnands et al., 2017). MS is a common disorder in young adults and often has a progressive course. However, the condition can also develop in a relapsing remitting manner. People living with MS often show fatigue and impairments in the domains of memory, executive functions, attention and psychomotor speed (Chiaravalloti & DeLuca, 2008). The NDDs that are considered in the present systematic review and meta-analysis are thus relatively common and are accompanied by significant cognitive and psychiatric impairments, all of which can have a tremendous impact of everyday functioning, including FDM. More rare conditions such as prion diseases and corticobasal degeneration were not included in the present systematic review and meta-analysis.

Materials and Methods

Study selection procedure

Available literature from four databases (i.e., Medline, PsychINFO, Pubmed and Web of Knowledge) was explored until December 31st, 2019, according the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Moher et al., 2009). Primary keywords were related to NDDs, such as ‘Parkinson’s disease’, ‘mild cognitive impairment’ or ‘dementia’. Secondary keywords were related to FDM, including ‘finances’, ‘financial capability’ or ‘money management’ (for a complete list of key words see supplementary material). Keywords needed to be present in the title or abstract. Additional articles were identified through reference lists of selected articles and a recently published review focusing on currently available instruments that can be used to assess financial skills (Engel et al., 2016). Only peer-reviewed articles written in English were included. After removal of duplicates, 1612 unique articles were identified of which 129 were on topic (Figure. 4.1). Studies were included in the review when they (a) included a group of people living with an NDD and a healthy control group or when they had a longitudinal design and (b) used a standardized performance-based test of FDM (i.e., primary tests) or a performance-based general decision-making or functional capacity test with an FDM subscale (i.e., secondary tests). Studies that included a mixed group (e.g., a ‘dementia group’) or primarily focused on gambling or risk-taking tasks were excluded. Forty-seven studies met the inclusion criteria (Table 4.1; Figure 4.1; Appendix 4-2).

Figure 4.1. Prisma flow diagram according to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Moher et al., 2009).

Table 4.1. Characteristics of included studies.

Characteristic	k	Characteristic	k
Total included studies	47	Number of studies per group^a	
Studies including > 1 NDD group	15	AD	25 (17)
Year of publication		MCI	26 (16)
≤ 2000	5	FTD	3 (3)
2001 – 2010	13	PD	7 (5)
≥ 2011	29	MS	3 (3)
Study design		HD	1 (-)
Case-control	39	Number of participants examined per study	
Longitudinal	6	1-25	18
Both	2	26-50	14
Assessment of cognition		51-75	8
Yes	29	76-100	4
No	18	> 100	3

Note. AD = Alzheimer's disease; FTD = frontotemporal dementia; HD = Huntington's disease; k = number of studies; MCI = mild cognitive impairment; MS = Multiple sclerosis; NDD = neurodegenerative disorder; PD = Parkinson's disease. ^a Numbers in parentheses are the number of studies included in the meta-analyses.

Identified financial tests and outcome measures

The included studies used one or more performance-based tests assessing FDM. A brief description of the primary and secondary FDM tests used is given below, in alphabetical order. For a more detailed description of each test and their administration procedure we refer to the original article(s) in which the respective test has been described.

Primary FDM tests.

1. The *Actual Reality test* (AR test; Goverover et al., 2010; Goverover & DeLuca, 2015) simulates the online purchase of a cookie bouquet and evaluates money management skills, such as planning and budgeting. Performances are evaluated based on (1) 'staying within price range', (2) 'correct use of credit card', (3) 'choosing an appropriate cookie bouquet', (4) 'efficient pace' and (5) 'correct response to unexpected events'. The total score is calculated based on the sum of these five goal-directed actions, with lower scores indicating better money management skills. The AR test is used in one study included in the review (i.e., Goverover et al., 2016).
2. The *Advanced Finances Test* (AFT; Heaton et al., 2004) evaluates the ability to manage finances using tasks involving depositing a check, paying bills and calculating checkbook balance. A total score can be calculated, with higher scores indicating a better ability to manage finances. The AFT is used in two studies included in the review (i.e., Pirogovsky et al., 2012; Sheppard et al., 2017).
3. The *Financial Assessment and Capacity Test* (FACT; (Black et al., 2007) evaluates FDM capacity in elderly individuals. The FACT includes nine domains related to the conceptual model of Appelbaum and Grisso (1988), i.e., (1) 'memory', (2) 'reading/writing', (3) 'calculation/attention', (4) 'daily financial tasks', (5) 'general financial knowledge', (6) 'understanding assets', (7) 'financial insight', (8) 'financial confidence', and (9) 'rational beliefs about money'. Scores on all domains separately

and an overall total score can be calculated, with higher scores indicating a better FDM capacity. The FACT is used in one study included in the review (i.e., Gill et al., 2019).

4. The *Financial Competence Assessment Inventory* (FCAI; Kershaw & Webber, 2008) assesses current financial competence using theoretical questions and functional tasks focused on financial abilities. The FCAI includes six domains, i.e., (1) 'everyday financial abilities', (2) 'financial judgement', (3) 'estate management', (4) 'cognitive functioning related to financial tasks', (5) 'debt management', and (6) 'support resources'. Scores on all domains separately and a total score based on the sum of all domains can be calculated. Additionally, items can be recoded in four subscales based on the conceptual model of Appelbaum and Grisso (1988), i.e., (i) 'understanding', (ii) 'appreciation', (iii) 'reasoning', and (iv) 'expressing a choice'. Higher scores indicate a better knowledge and understanding of financial competence. The FCAI is used in two studies included in this review (i.e., Gill et al., 2019; Kershaw & Webber, 2008).
5. The *Financial Capacity Instrument* (FCI; Marson et al., 2000) assesses financial knowledge and skills using tasks of different levels of complexity, such as counting coins and preparing bills. Depending on the version used, a maximum of nine domains can be differentiated with the FCI: (1) 'basic monetary skills', (2) 'financial concepts', (3) 'cash transactions', (4) 'checkbook management', (5) 'bank statement management', (6) 'financial judgment' (or 'identifying fraud'), (7) 'bill payment', (8) 'knowledge of personal assets' (or 'estate arrangements'), and (9) 'investment decision-making'. Scores can be determined for each domain separately and total scores can be calculated using different combinations of the described domains. The most frequently used combinations are a total score based on the sum of all domains, sometimes except domain 8 since this latter domain is considered to be still experimental, and a total score based on domains 2, 3, 5 and 7. One study (Gerstenecker et al., 2018) extracted four new domains of the FCI using factor analysis, i.e., (1) 'basic monetary knowledge and calculation skills', (2) 'financial judgment', (3) 'financial conceptual knowledge', and (4) 'financial procedural knowledge'. Higher scores indicate a better financial capacity. The FCI is used in twenty-two studies included in this review (i.e., Clark et al., 2014; Earnst et al., 2001; Gerstenecker et al., 2016, 2018, 2019; Gerstenecker, Hoagey, et al., 2017; Gerstenecker, Myers, et al., 2017; Griffith et al., 2003, 2007, 2010; Lassen-Greene et al., 2017; Marson et al., 2000; Martin et al., 2013, 2019; Martin, Griffith, et al., 2008; Niccolai et al., 2017; Okonkwo et al., 2006, 2009; Sherod et al., 2009; Stoeckel et al., 2013; Tracy et al., 2017; Triebel et al., 2009).
6. The *Financial Capacity Instrument – Short Form* (FCI-SF; Tolbert et al., 2019) assesses complex financial abilities and is a modified shorter version of the FCI. Five domains, i.e., (1) 'mental calculation', (2) 'financial conceptual knowledge', (3) 'single checkbook/register task', (4) 'complex checkbook/register task', and (5) 'using bank statement' are included. Scores can be determined for all five domains separately and a total score based on the sum of these five domains can be calculated, with higher scores indicating a better financial capacity. The FCI-SF is used in one study included in this review (i.e., Tolbert et al., 2019).

7. The *Financial Competency Questions* (FCQ; Bassett, 1999) evaluates a participants' understanding of financial issues related to the use and maintenance of a checking account by asking five questions. Questions require a yes or no answer and an explanation of the given answer. For each question a score is given by the examiner ranging from 0 to 5. The outcome measure is the total score on the five questions, with higher scores indicating a better understanding of financial issues. The FCQ is used in one study included in this review (i.e., Bassett, 1999).
8. The *Legal Capacity for Property Law Transactions Assessment Scale* (LCPLTAS; Giannouli et al., 2018) evaluates financial knowledge and skills by using tasks and questions focused on financial issues. The LCPLTAS is based on the theoretical model of the FCI (Marson et al., 2000) and adapted for the Greek population. The test defines seven domains, i.e., (1) 'basic monetary skills', (2) 'cash transactions', (3) 'bank statement management', (4) 'bill payment', (5) 'financial conceptual knowledge', (6) 'financial decision making', and (7) 'knowledge of personal assets'. The total score is based on all domains. Furthermore, scores on all domains separately can be calculated. Higher scores on this scale indicate better financial knowledge and skills. The LCPLTAS is used in two studies included in this review (i.e., Giannouli et al., 2018; Giannouli & Tsolaki, 2019). Furthermore, a pilot version of the LCPLTAS was presumably used in another included study (Giannouli & Tsolaki, 2014).
9. The *Numerical Activities of Daily Living – Financial* (NADL-F; Arcara et al., 2019) test is developed to evaluate independent financial functioning. The NADL-F builds on the conceptual model of Marson et al. (2000) and is based on previously published tests such as the FCAI (Kershaw & Webber, 2008) and the FCI (Marson et al., 2000). However, the NADL-F is redesigned for the socio-cultural context in Italy. The NADL-F consists of seven domains, i.e., (1) 'counting currencies', (2) 'reading abilities', (3) 'item purchase', (4) 'percentages', (5) 'financial concepts', (6) 'bill payment', and (7) 'financial judgments'. A sum score for each domain can be calculated, with higher scores indicating a better independent financial functioning. The NADL-F is used in one study included in this review (i.e., Arcara et al., 2019).
10. The *Semi-Structured Clinical Interview for Financial Capacity* (SCIFC; Marson et al., 2009) assesses financial capacity using a semi-structured interview with theoretical questions and practical performance-based items. The SCIFC is based on the theoretical model of Marson et al. (2000) and the FCI. Compared to the FCI, however, the SCIFC is briefer and easier to administer. The SCIFC consists of eight domains, i.e., (1) 'basic monetary skills', (2) 'financial conceptual knowledge', (3) 'cash transactions', (4) 'checkbook management', (5) 'bank statement management', (6) 'financial judgment', (7) 'bill payment', and (8) 'knowledge of personal financial assets and estate arrangements'. Scores on each domain and a total score based on the sum of domain 1 to 7 can be calculated (domain eight is considered to be experimental and is, therefore, not included in the total score). Higher scores indicate a better financial capacity. The SCIFC is used in one study included in this review (i.e., Marson et al., 2009).

Secondary tests.

11. The subscale ‘money management’ of the *Assessment of Capacity for Everyday Decision-Making* (ACED; Lai et al., 2008; Lai & Karlawish, 2007) evaluates everyday financial management activities and financial management approaches. Using standardized rating criteria, scores on four decision-making abilities can be described which are based on the conceptual model of Appelbaum and Grisso (1988), i.e., (1) ‘understanding’, (2) ‘appreciation’, (3) ‘reasoning’, and (4) ‘expressing a choice’. A total score can be calculated as the sum of four domains, with higher scores indicating better financial decision-making abilities. The subscale ‘money management’ of the ACED is used in one study included in this review (i.e. Lui et al., 2013).
12. The subscale ‘FDM’ is one of two subscales of the *Decision-Making Competence Assessment Tool* (DMCAT; Finucane & Gullion, 2010). Using tasks closely resembling the real-world setting, the DMCAT was developed to assess decision-making in older adults. The FDM subscale includes six items in which mutual funds must be chosen according to prespecified preferences. A total score can be calculated based on the number of correct answers, with higher scores indicating better FDM. The subscale ‘FDM’ of the DMCAT is used in one study included in this review (i.e., Duke Han et al., 2015).
13. The subscale ‘financial skills’ (also named ‘dealing with finances’) of the *Direct Assessment of Functional Status* (DAFS; Loewenstein et al., 1989; Pereira, Oliveira, et al., 2010) can be used as a measure of financial abilities and is described as one of the functional activities of daily living. The subscale consists of items related to identifying and counting currency and higher order financial abilities. Scores on five domains can be determined, i.e., (1) ‘identifying currency’, (2) ‘counting currency’, (3) ‘writing a check’, (4) ‘balancing a checkbook’ and (5) ‘make change for a purchase’, although not all studies included the fifth domain. Furthermore, a total score can be calculated based on all domains. The subscale ‘financial skills’ of the DAFS is used in four studies included in this review (i.e., Lima-Silva et al., 2015; Loewenstein et al., 1989, 1995; Pereira, Yassuda, et al., 2010).
14. The subscale ‘money management’ of the *Independent Living Scale* (ILS; Loeb, 1996) can be used to evaluate money management abilities such as counting money, performing calculations or paying bills. A total score of items associated with the subscale can be calculated, with higher scores indicating better money management abilities. The subscale ‘money management’ of the ILS is used in one study included in this review (i.e., Bangen et al., 2010).
15. The subscale ‘bill payment’ of the *Neuropsychological Assessment Battery* (NAB; White & Stern, 2003) is a task that simulates actions that are required when paying an utility bill, such as identifying information or filling out a check. A total score can be calculated as the sum of correct responses, with higher scores indicating better bill payment performances. The subscale ‘bill payment’ of the NAB is used in one study included in this review (i.e., Kenney et al., 2019).

16. The subscale ‘money usage’ of the *Numerical Activities of Daily Living* (NADL; Semenza et al., 2014) can be used to evaluate financial capacity as a function of (basic) mathematical abilities. The NADL assesses basic aspects of mathematical abilities and their impact on daily life, including the use of money. A score can be calculated based on the number of reasonably estimated prices (e.g., estimating the price of a car), with higher scores indicating better financial mathematical capacity. The subscale ‘money usage’ of the NADL is used in one study included in this review (i.e., Benavides-Varela et al., 2015).
17. The subscale ‘money-related skills’ of the *Structured Assessment of Independent Living Skills* (SAILS; Mahurin et al., 1991) evaluates FDM as part of a larger instrument that can be used to directly evaluate everyday activities. The subscale ‘money-related skills’ consists of five money-related activities, including counting money, making change, understanding a monthly utility bill, writing a check and understanding a checkbook. A total score, based on all five activities, can be calculated for the subscale with higher scores indicating better money-related skills. The subscale ‘money-related skills’ of the SAILS is used in one study included in this review (i.e., Mahurin et al., 1991).
18. The subscale ‘finances’ of the *University of California, San Diego* (UCSD) *performance-based skills assessment* (Patterson et al., 2001) assesses financial skills using two tasks, i.e., (1) counting coins and making change and (2) make out a check. A total score can be calculated based on the number of correct elements achieved on both tasks. Higher scores indicate better financial skills. The subscale ‘finances’ of the UCSD performance based skills assessment is used in two studies included in this review (i.e., Pirogovsky et al., 2014, 2013).
19. The subscale ‘money management’ of the *University of Miami computer-based functional assessment battery* (UMCFAB; Czaja et al., 2017) evaluates money management abilities using a computer-based replication of an Automatic Teller Machine (ATM). The performance-based ATM requires individuals to perform money related actions, such as checking the balance in their savings account, transferring money or withdrawing cash from their savings account. Different scores can be calculated, i.e., ‘total correct answers’, ‘total incorrect answers’, ‘task completion time’ and ‘an efficiency/rate score based on total correct answers divided by task completion time’. The subscale ‘money management’ of the UMCFAB is used in one study included in this review (i.e., Czaja et al., 2017).

Study analysis

Content analysis. A content analysis approach was applied to the included studies. The results were organized and extracted in table format for each disorder separately displaying demographics and disease characteristics of the included samples. In addition, primary outcome measures and the most important results of each paper relevant for the research questions at hand are described (Table 4.2). Some studies describe the use of participants from the same study cohort, i.e., from the *Cognitive Observations in Seniors Study* (COINS; Clark et al., 2014; Gerstenecker et al., 2016, 2018, 2019; Gerstenecker, Hoagey, et al., 2017; Niccolai et al., 2017)

or the *Measuring Independent Living in the Elderly Study* (MILES; Lassen-Greene et al., 2017; Okonkwo et al., 2009, 2006). However, despite the same study cohort has been used, there is insufficient evidence that the same sample has been used in these studies and, therefore, these studies are treated and described as separate studies in the content and meta-analysis. Two studies focused on people living with PD (Pirogovsky et al., 2013, 2014). However, these studies did use the same sample and are, therefore, considered and described as one study within the present systematic review. Of longitudinal studies, baseline data (if applicable) are used for cross-sectional comparisons. However, one research group performed a follow-up at one-year (Martin, Griffith, et al., 2008; Triebel et al., 2009), two-years (Clark et al., 2014; Gerstenecker et al., 2016) and six-years (Martin et al., 2019) of the same sample and, therefore, only the baseline data of people living with AD and people living with MCI as described in Martin et al. (2019) was used to evaluate cross-sectional data. In the content analysis, group differences were considered significant when $\alpha < .05$, independent of the used alpha level in the original study. Two studies, however, did not describe the p-values of their group comparisons and used a more conservative alpha level to evaluate significance (Marson et al., 2000; Tracy et al., 2017). Potential significant results using a less conservative p-value could, therefore, not be determined for these studies and included in this systematic review. Correlations were interpreted as weak when $r = .30$, moderate when $r = .50$ and strong when $r = .70$ (Fritz et al., 2012).

Meta-analysis. In addition, a meta-analysis was performed for each NDD group separately when more than one of the included studies focused on a particular group. In the meta-analyses, the total scores (i.e., sum of domains or items) of the FDM tests were used. Therefore, studies that did not report total scores (Arcara et al., 2019; Czaja et al., 2017; Gerstenecker et al., 2018; Giannouli & Tsolaki, 2014; Marson et al., 2000; Okonkwo et al., 2006, 2009) and studies that did not provide means and/or standard deviations for total scores (Mahurin et al., 1991; Marson et al., 2009; Sheppard et al., 2017) were excluded from the meta-analysis. Furthermore, two studies did not include a healthy control group (Gerstenecker et al., 2016; Loewenstein et al., 1995) and were, therefore, not used in the meta-analysis. Regarding longitudinal studies, only the baseline results were used for the meta-analysis. Furthermore, only the most recent published study was used in the meta-analysis of the two PD studies that presumably used the same sample (Pirogovsky et al., 2013, 2014). In total, thirty-one studies were included in the meta-analysis (Table 4.1; Figure 4.1). When studies included more than one subgroup (e.g., MCI converters and MCI non-converters) and/or used more than one FDM test or total score, a combined fixed effect size was calculated (Borenstein et al., 2009). Using Comprehensive Meta-Analysis software version 2.2.064 the pooled mean effect size (method: random) was calculated for each group. Hedges' g was considered small when $g = .20$, medium when $g = .50$ and large when $g = .80$ (Fritz et al., 2012). Funnel plot asymmetry was tested with a regression method to evaluate publication bias (Egger et al., 1997). Finally, heterogeneity was evaluated by calculating the I^2 value. I^2 values of 25%, 50% and 75% were interpreted as low, moderate and high heterogeneity, respectively (Higgins et al., 2003).

Results

Alzheimer's Disease (AD)

Twenty-five studies investigated FDM in people living with AD (Table 4.2a), evaluating 1086 people living with AD in total. Participants' average age ranged from 66.9 to 83.0 years (weighted average = 74.8 years). Most studies included people living with AD who were in a mild and/or moderate stage of the disease, two studies also included a group of people in a severe stage of AD (Giannouli et al., 2018; Giannouli & Tsolaki, 2014). Seven studies, however, did not specify the stage of the disease (Gill et al., 2019; Kershaw & Webber, 2008; Lima-Silva et al., 2015; Loewenstein et al., 1989, 1995; Mahurin et al., 1991; Pereira, Yassuda, et al., 2010).

All cross-sectional studies on AD reported significantly lower performances on performance-based tests of FDM in people living with AD compared to healthy controls (Table 4.2a). This corresponds to the overall large pooled mean effect size for the difference between people living with AD and healthy controls that was found in the meta-analysis ($g = 2.69$ [2.15; 3.23], $SE = 0.27$, $p < .001$ based on 17 studies; Figure 4.2). Significant heterogeneity was found ($Q(16) = 246.6$, $p < .001$, $I^2 = 93.5\%$). More than half of the studies that were included in the meta-analysis used the FCI ($n = 9$). Studies using the FCI reported a significantly lower overall effect size ($g = 2.17$ [1.40; 2.94], $SE = 0.39$, $p < .001$) compared to the studies using FDM tests other than the FCI ($g = 3.33$ [2.49; 4.16], $SE = 0.43$, $p < .001$; $Q(1) = 4.00$, $p = .045$). The effect size of three studies using FDM tests other than the FCI are, compared to the other studies, relatively high ($g = 9.63$ (Giannouli et al., 2018), $g = 5.02$ (Kershaw & Webber, 2008) and $g = 4.03$ (Lima-Silva et al., 2015); Figure 4.2). Nevertheless, the overall effect size remained large and significant when these studies are excluded ($g = 2.05$ [1.77; 2.33], $SE = 0.14$, $p < .001$ based on 14 studies). The difference between studies using the FCI compared to the remaining studies is, however, no longer significant after excluding these studies ($n = 5$, $g = 1.80$ [1.35; 2.25], $SE = 0.23$, $p < .001$; $Q(1) = 1.86$, $p = .173$). The funnel plot showed significant asymmetry ($p = .015$; Figure 4.3) with a slight right skewed distribution. After removal of the three studies with relatively high effect sizes, the funnel plot asymmetry was no longer significant ($p = .476$).

The content analysis of the included studies that described the stage of the disease of included participants indicates that relatively simple aspects of FDM (e.g., 'identifying currency' and 'naming coins') seem to be intact in people living with mild AD, since no differences between people living with mild AD and healthy controls were found regarding these specific domains in some of the studies (Griffith et al., 2003; Loewenstein et al., 1989; Marson et al., 2000, 2009). However, other studies did find significantly lower performances in people living with mild AD, compared to healthy controls, on similar domains of FDM (Gerstenecker et al., 2019; Gerstenecker, Hoagey, et al., 2017; Martin, Griffith, et al., 2008). Furthermore, overall FDM performance (reflected by total scores) was significantly lower in people living with mild AD compared to healthy controls in all studies that included people living with mild AD. Four studies (Giannouli et al., 2018; Giannouli & Tsolaki, 2014; Marson et al., 2000, 2009) divided the included participants in multiple subgroups based on disease severity which enabled the comparison of people living with AD in different disease stages.

These studies indicate that when the disease progresses to more moderate or severe stages, people living with AD show difficulties with all aspects of FDM compared to healthy controls and performed significantly worse on FDM tests than people living with mild AD.

Longitudinal studies. Significant deterioration of FDM over a one-year period was observed in people living with AD in three independent follow-up studies (Clark et al., 2014; Loewenstein et al., 1995; Martin, Griffith, et al., 2008). Decline was found for all domains of FDM, measured with the DAFS (Loewenstein et al., 1995) and the FCI (Clark et al., 2014; Martin, Griffith, et al., 2008), with the exception of ‘knowledge about assets and estate’ (experimental domain of the FCI; Martin et al., 2008). Although the differences between baseline and follow-up were significant in all studies, the clinical relevance of the observed decline is unclear, since the differences in scores after a one-year period were sometimes less than one point on subscales with scoring ranges from 0 – 3 or 0 – 8, depending on the subscale (Loewenstein et al., 1995). Clark and colleagues (2014) defined significant decline as a drop of more than 10 points on the FCI compared to a previous assessment. According to this definition, at a follow-up of one-year, almost half of the people living with AD (45.5%) that were included in the study showed a significant decline on the FCI compared to baseline; after two-year follow-up an additional 20% of participants showed decline compared to the assessment at one-year follow-up. It has to be taken into account, however, that only eleven and five participants, respectively, were assessed after the one-year and two-year follow-up.

The association between FDM and cognition in patients with AD. A summary of the cognitive functions that were evaluated in relation to FDM can be found in Table 4.3. Significant moderate to strong positive correlations between FDM performances and global cognition, as measured with, e.g., the Mini-Mental State Examination or Dementia Rating Scale, are found in people living with AD (Griffith et al., 2007; Kershaw & Webber, 2008; Martin, Griffith, et al., 2008; Stoeckel et al., 2013). Two studies, however, did not find significant correlations between financial competence and global cognition (Bassett, 1999; Sherod et al., 2009). When looking at specific cognitive domains, it was found that a slower processing speed was significantly related to lower scores on FDM tests of people living with AD (Bassett, 1999; Sherod et al., 2009). According to Bassett (1999), processing speed even predicted 81.3% of variance of the performance of people living with AD on a FDM test (i.e., FCQ). However, another study that focused on processing speed, as well as on other measures of cognition, found that only 10% of variance of the performances on the FCI of people living with AD could be explained by processing speed (Sherod et al., 2009). In this latter study, 46% of variance was explained by numeracy and 9% of variance of the FCI performance could be explained by verbal short-term memory. Other studies also reported significant correlations between FDM and numeracy (Earnst et al., 2001; Kershaw & Webber, 2008), verbal memory (Bassett, 1999; Sherod et al., 2009) and working memory (Earnst et al., 2001; Kershaw & Webber, 2008). One study, however, failed to find a significant association between FDM and memory (Stoeckel et al., 2013). Inconclusive results are found with regard to the association between FDM and attention and executive functions (Sherod et al., 2009; Stoeckel et al., 2013) in people living with AD. Furthermore, no significant association was found between

visuospatial abilities and FDM in people living with AD (Sherod et al., 2009; Stoeckel et al., 2013).

Influence of age, sex, education and symptoms of depression in patients with AD. In general there are no indications that age has an influence on FDM in people living with AD, since no significant correlations were reported (Bassett, 1999; Mahurin et al., 1991; Martin, Griffith, et al., 2008). Nevertheless, significant differences between people living with AD and people living with FTD on an FDM tests (i.e., FACT total score and FCAI appreciation scale) were no longer significant when controlling for age (Gill et al., 2019), assuming some influence of age. Giannouli et al. (2018) reported that years of education are a better predictor of financial capacity as examined with the LCPLTAS than classic neuropsychological measures and other demographic factors in a dementia sample (i.e., a mixed sample of people living with AD and people living with other types of dementia). The number of years of education was also a significant predictor of performances on seven out of eight FCI domains in people living with AD (Martin, Griffith, et al., 2008). These associations could, however, not be confirmed by two other studies (Bassett, 1999; Mahurin et al., 1991). Sex was found to be a significant predictor of one out of eight FCI domains (Martin, Griffith, et al., 2008). No significant correlations were found between performances on FDM tests and scores on depression questionnaires (Mahurin et al., 1991; Martin, Griffith, et al., 2008).

Mild Cognitive Impairment (MCI)

Twenty-six studies investigated FDM in people living with MCI. In total, 1727 people living with MCI were included in these studies and the average age of people living with MCI ranged from 68.0 to 84.3 years (weighted average = 72.9 years). In most studies, participants were diagnosed with single- or multiple-domain amnesic MCI (Table 4.2b). However, not all studies reported the subtype of MCI of the participants that were included (Arcara et al., 2019; Benavides-Varela et al., 2015; Clark et al., 2014; Duke Han et al., 2015; Gerstenecker et al., 2016; Kenney et al., 2019; Lassen-Greene et al., 2017; Martin et al., 2019; Triebel et al., 2009). Some studies used a mixed MCI group including both single- and/or multiple-domain amnesic and non-amnesic MCI (Bangen et al., 2010; Okonkwo et al., 2006; Pereira, Yassuda, et al., 2010) and three studies divided their sample in people living with MCI who progressed to AD and people living with MCI who showed no progression at follow-up (e.g., MCI converters vs. MCI non-converters, respectively; Bangen et al., 2010; Clark et al., 2014; Triebel et al., 2009).

All cross-sectional studies on MCI reported that participants showed significantly lower total scores on tests of FDM compared to healthy controls (Table 4.2b). Some aspects of FDM appear to remain intact in people living with MCI, although results are mixed. Most consistently, studies reported difficulties with ‘financial conceptual knowledge’, ‘checkbook management’, ‘bank statement management’ and ‘bill payment’ in people living with MCI compared to healthy controls (Gerstenecker et al., 2016, 2019; Gerstenecker, Hoagey, et al., 2017; Giannouli et al., 2018; Griffith et al., 2003; Martin et al., 2019; Okonkwo et al., 2006). The domains ‘basic monetary skills’ and ‘financial judgment’ of the FCI seem to remain relatively intact in people living with MCI (Gerstenecker et al., 2016, 2019; Gerstenecker, Hoagey, et al., 2017; Griffith et al., 2003). Furthermore, people living with MCI appear to have

no difficulties with ‘expressing a choice’ when making financial decisions (Lui et al., 2013), but need more time than healthy controls to complete a FDM task (Lassen-Greene et al., 2017; Okonkwo et al., 2006). In a computer-based simulation task, people living with MCI were found to have more difficulties than healthy controls with the use of an ATM (Czaja et al., 2017).

As expected, and in accordance with the findings mentioned above, an overall medium to large pooled mean effect size was found in the meta-analysis when comparing the performances of people living with MCI and healthy controls on tests of FDM ($g = 0.95 [0.78; 1.11]$, $SE = 0.08$, $p < .001$ based on 16 studies; Figure 4.2). Significant heterogeneity was, however, found ($Q(15) = 55.2$, $p < .001$, $I^2 = 72.8\%$). More than half of the studies on MCI used the FCI ($n = 9$) and for these studies a significantly larger pooled mean effect size was found ($g = 1.09 [0.92; 1.25]$, $SE = 0.09$, $p < .001$; $Q(1) = 8.80$, $p = .003$) compared to the seven studies using FDM tests other than the FCI ($g = 0.70 [0.52; 0.89]$, $SE = 0.10$, $p < .001$). The funnel plot showed a significant asymmetry ($p = .005$; Figure 4.3).

One study (Bangen et al., 2010) compared people living with amnesic MCI, people living with non-amnesic MCI and healthy controls and only found significant differences between people living with amnesic MCI and healthy controls, while other group comparisons were not significant. These findings are consistent with another study comparing people living with different subtypes of MCI (Pereira, Yassuda, et al., 2010). Interestingly, based on binary logistic regression, the ‘money management’ subscale of the ILS was a significant contributor in the prediction of the subtype of MCI (i.e., amnesic or non-amnesic MCI; Bangen et al., 2010).

Longitudinal studies. Over time, people living with MCI showed a significant deterioration on multiple domains of FDM (Clark et al., 2014; Gerstenecker et al., 2016; Lassen-Greene et al., 2017; Martin et al., 2019; Niccolai et al., 2017; Pereira, Oliveira, et al., 2010; Triebel et al., 2009). In one study (Triebel et al., 2009), after a one-year follow-up, 18% of participants converted from MCI to AD and showed a stronger deterioration than MCI non-converters on overall FDM (i.e., total score) and, more specifically, on ‘checkbook management’ of the FCI. Furthermore, deterioration was found in people living with MCI after two-years for ‘checkbook management’, ‘bank statement management’, ‘bill payment’ and ‘investment decision making’ of the FCI (Gerstenecker et al., 2016). Two other studies also reported significant deterioration after two-years in FDM performances in people living with MCI (Clark et al., 2014; Niccolai et al., 2017). Clark et al. (2014) demonstrated that MCI converters showed more often a significant decline on the FCI (i.e., a decline of more than 10 points) after one as well as after two-year(s) follow-up compared to MCI non-converters. However, statistics for group comparisons were not reported. MCI converters may already have more difficulties with some aspects of FDM at baseline compared to MCI non-converters (Triebel et al., 2009), however, two other studies did not support this finding (Clark et al., 2014; Pereira, Oliveira, et al., 2010). Furthermore, baseline performances of people living with MCI could not predict the deterioration after two years (Niccolai et al., 2017). Lassen-Greene et al. (2017) explored the performances on the FCI in more detail and reported that in people living with MCI only the accuracy of performances, not the speed of processing, deteriorates over a three-years period. Finally, Martin et al. (2019) performed a three and six-years follow-up using

the FCI. Comparing the performances at baseline, three-years follow-up and six-years follow-up, they found a significant deterioration over time on the FCI total score and on all domains separately in people living with MCI, while no deterioration was observed in healthy controls.

The association between FDM and cognition in patients with MCI. Also in people living with MCI, a decreased performance on tests of global cognition was found to be associated with decreased performances on tests of FDM (Arcara et al., 2019; Bangen et al., 2010; Duke Han et al., 2015; Gerstenecker et al., 2016; Table 4.3). General cognition, defined as the average of performances on nineteen tests of cognition, predicted 14% of variance of performance on an FDM test (Duke Han et al., 2015). When exploring different aspects of cognition in more detail, it appears that especially processing speed is related to FDM in people living with MCI since mild to strong correlations were found between measures of processing speed and FDM (Czaja et al., 2017; Duke Han et al., 2015; Griffith et al., 2010; Niccolai et al., 2017). Also numeracy was found to be significantly related to FDM in people living with MCI (Griffith et al., 2010; Niccolai et al., 2017; Sherod et al., 2009), explaining 37.6 to 55.0% of variance of performances on tests of FDM (Niccolai et al., 2017; Sherod et al., 2009). Furthermore, significant correlations were found between FDM and attention (Griffith et al., 2010; Okonkwo et al., 2006), visuospatial memory (Niccolai et al., 2017), visuomotor abilities (Benavides-Varela et al., 2015), language (Niccolai et al., 2017) and executive functions (Okonkwo et al., 2006; Sherod et al., 2009; more specifically working memory (Duke Han et al., 2015), cognitive flexibility (Czaja et al., 2017) and abstract reasoning (Benavides-Varela et al., 2015)) in people living with MCI, although results are mixed.

Influence of age, sex, education and symptoms of depression in patients with MCI. Some studies found evidence that a higher age was associated with lower performances on FDM tests in people living with MCI (Duke Han et al., 2015; Lassen-Greene et al., 2017; Lui et al., 2013; Tolbert et al., 2019). Age can, however, not fully explain the differences that were found between people living with MCI and healthy controls regarding FDM since some studies controlled for age in their group analyses and still found significant differences between groups on tests of FDM (Arcara et al., 2019; Benavides-Varela et al., 2015; Duke Han et al., 2015; Griffith et al., 2010; Martin et al., 2019; Triebel et al., 2009). Furthermore, more years of education was related to a better performance on a measure of FDM in people living with MCI (Lui et al., 2013; Niccolai et al., 2017; Tolbert et al., 2019). Sex was not related to FDM performances of people living with MCI (Tolbert et al., 2019). Niccolai et al. (2017) finally reported that higher scores on a depression rating scale were related to a faster deterioration of FDM performances in people living with MCI over a two-years period. However, Arcara et al. (2019) did not find a significant association between financial capacity (measured with the NADL-F) and symptoms of depression in a mixed group of people living with MCI, healthy controls and people living with other neurological diseases.

Comparison of AD and MCI

Thirteen studies included people living with AD as well as people living with MCI, which allowed a direct comparison between these groups regarding their performances on tests of FDM. When comparing people living with AD and people living with MCI, it was found that

people living with AD in the mild as well as in the moderate and severe stages, have more difficulties with FDM (i.e., total scores) than people living with MCI (Clark et al., 2014; Gerstenecker et al., 2018, 2019; Gerstenecker, Hoagey, et al., 2017; Giannouli et al., 2018; Giannouli & Tsolaki, 2014; Griffith et al., 2003; Lui et al., 2013; Marson et al., 2009; Martin et al., 2019; Pereira, Yassuda, et al., 2010; Sherod et al., 2009; Tolbert et al., 2019). This is in accordance with the significantly larger pooled mean effect size that was found for the comparison between people living with AD and healthy controls compared to the pooled mean effect size of the comparison between people living with MCI and healthy controls ($Q(I) = 48.4, p < .001$; Figure 4.2).

Studies exploring the different aspects of FDM in more detail by examining the domains of the FCI, LCPLTAS or ACED, consistently reported that people living with AD showed more difficulties than people living with MCI on almost all domains of FDM (Gerstenecker et al., 2018, 2019; Gerstenecker, Hoagey, et al., 2017; Giannouli et al., 2018; Giannouli & Tsolaki, 2014; Griffith et al., 2003; Lui et al., 2013; Marson et al., 2009; Martin et al., 2019; Tolbert et al., 2019). However, Marson et al. (2009) and Giannouli et al. (2018) reported that while people living with moderate AD do show more difficulties with ‘basic monetary skills’ compared to people living with MCI, no differences were found on this domain of FDM between people living with mild AD and people living with MCI. Furthermore, some studies found no differences in performances between people living with mild AD and people living with MCI on the domains ‘financial judgments’ (Gerstenecker, Hoagey, et al., 2017; Griffith et al., 2003; Martin et al., 2019) and ‘knowledge of personal assets’ of the FCI (Griffith et al., 2003) and ‘bill payment’ of the LCPLTAS (i.e., means of the different groups differed < 2 SD; Giannouli et al., 2018).

Biological imaging techniques and FDM in patients with AD and patients with MCI

Five of the included studies also evaluated metabolic, molecular and structural imaging techniques in people living with AD and/or people living with MCI. Firstly, Griffith et al. (2007) investigated the relation between the metabolism of the posterior cingulate gyrus and FCI total score in people living with mild AD, using Proton Magnetic Resonance Spectroscopy. They mainly focused on the N-acetylaspartate/Creatine (NAA/Cr) ratio and the choline-containing compounds/Creatine (Cho/Cr) ratio. A decrease in NAA/Cr ratio indicates neuronal tissue loss or damage; an increase in Cho/Cr ratio indicates an increased demyelination (Schuff et al., 2006). After controlling for global cognition (i.e., Dementia Rating Scale total score), a mild to moderate positive correlation between NAA/Cr ratio and FDM and a moderate negative correlation between Cho/Cr ratio and FDM were found in people living with mild AD. However, after the exclusion of one potential outlier the negative correlation between Cho/Cr and FCI was no longer significant. A second study (Griffith et al., 2010) explored the association between bilateral gray matter volumes of five regions of interests in people living with mild AD (i.e., the medial frontal cortex, the dorsolateral frontal cortex, the precunei, the angular gyri and the hippocampi) and FDM using Magnetic Resonance Imaging (MRI). A higher FCI total score was significantly, but moderately, associated with a larger volume of all regions of interest, except the hippocampi. Multiple regression, however, was used to control

for the overlap or connections between brain areas. The results indicated that only the volume of the medial frontal cortex was a significant predictor of FDM in people living with mild AD, i.e., predicting 35% of variance of the FCI total score. The association between white matter connectivity (using MRI based diffusion tensor imaging) and FDM was determined in a third study (Gerstenecker, Hoagey, et al., 2017). In people living with MCI, a greater degeneration of the white matter (i.e., a reduction of fractional anisotropy) in areas related to the precuneus, lateral and medial occipital, lateral temporal and lateral prefrontal cortices was related to lower performances on the FCI. In people living with mild AD, a decreased white matter integrity (i.e., increased axial diffusivity λ_1 and mean diffusivity of λ_1 , λ_2 and λ_3) in similar regions as found in people living with MCI was related to lower FDM performances. In healthy controls, no relation between white matter connectivity and FDM was found. In a fourth study, Pereira, Yassuda et al. (2010) investigated AD biomarkers (i.e., the concentrations of Total Tau, Phospho-Tau₁₈₁ and Amyloid β_{1-42} in the cerebrospinal fluid) in nineteen people living with MCI and related these concentrations to performances on a measure of FDM (i.e., the DAFS subscale ‘dealing with finances’). The results showed that higher concentrations of Total Tau and Phospho-Tau₁₈₁ were associated with lower performances on the tests of FDM in people living with MCI, whereas overall functional capacity (i.e., total score on DAFS) was not associated to any of these biomarkers. Finally, Tolbert et al. (2019) investigated FDM performances (i.e., on the FCI-SF) in relation to cortical β -amyloid deposition. A higher cortical-to-cerebellum standardized uptake value ratio/SUVr indicates greater cortical β -amyloid deposition which is described as one of the pathological hallmarks of AD and has the utility of predicting cognitive decline in normal aging and MCI (Clark et al., 2011; Doraiswamy et al., 2014). In a pooled sample of people living with MCI and people living with AD, while controlling for age, education and sex, higher β -amyloid SUVr was significantly negatively correlated with FDM performances.

Frontotemporal Dementia (FTD)

Three studies, which included a total of 52 participants (weighted age = 67.3 years), investigated FDM in people living with FTD (Table 4.2c). All participants were diagnosed with the behavioral variant of FTD, although one study did not provide information about demographics and disease characteristics of participants (Giannouli et al., 2018). The included studies consistently found lower performances on tests of FDM compared to healthy controls (Giannouli et al., 2018; Gill et al., 2019; Lima-Silva et al., 2015). This is confirmed by the large pooled mean effect size found in the meta-analysis (i.e., $g = 2.56$ [1.73; 3.39], $SE = 0.42$, $p < .001$ based on three studies; Figure 4.2). Significant heterogeneity was found ($Q(2) = 7.4$, $p = .025$, $I^2 = 73.0\%$) and the funnel plot showed significant asymmetry ($p = .010$; Figure 4.3). However, only a small number of studies were included so these bias assessments should be interpreted with caution.

Gill et al. (2019) reported that people living with FTD showed an intact performance on ‘reading/writing’, ‘rational beliefs about money’ and ‘debt management’ of the FACT and FCAI compared to healthy controls. One study indicated that people living with FTD showed significantly lower FDM performances compared to people living with mild AD (i.e., deviation

of ≥ 2 SD between groups on the ‘total score’, ‘financial decision-making’ and ‘assets knowledge’ domains of the LCPLTAS; Giannouli et al., 2018). Similar performances were, however, observed in people living with FTD and people in the moderate to severe stages of AD and when people living with FTD were compared with people living with AD who were matched based on their dementia severity (Giannouli et al., 2018; Lima-Silva et al., 2015). Furthermore, group differences between people living with FTD and people living with AD observed on the FACT and FCAI (Gill et al., 2019) were no longer significant when controlling for age. The association between FDM, cognition, age, sex, education and symptoms of depression has not been evaluated in people living with FTD.

Parkinson’s Disease (PD)

Seven studies investigated FDM in people living with PD (Table 4.2d). Two studies (Pirogovsky et al., 2013, 2014) used the same sample which were, therefore, treated as one study. In total, 222 people living with PD participated in these studies and participants were on average between 66.7 and 75.6 years old (weighted age = 70.1 years). Participants were on their regular medication during assessment, however, three studies (Giannouli et al., 2018; Giannouli & Tsolaki, 2014, 2019) did not provide any information about disease characteristics and medication use of their sample.

All studies reported that people living with PD had significantly more difficulties with FDM than healthy controls (Giannouli et al., 2018; Giannouli & Tsolaki, 2014, 2019; Martin et al., 2013; Pirogovsky et al., 2012, 2013, 2014). This is in accordance with the large pooled mean effect size found in the meta-analysis (i.e., $g = 1.49$ [0.71; 2.27], $SE = 0.40$, $p < .001$, based on five studies; Figure 4.2). Also for the PD studies, significant heterogeneity was found ($Q(4) = 58.8$, $p < .001$, $I^2 = 93.2\%$). The funnel plot showed no significant asymmetry ($p = .333$; Figure 4.3).

The association between FDM and cognition in patients with PD. Most studies used total scores to evaluate FDM in people living with PD, however, whether specific domains of FDM are impaired seems to depend on the severity of cognitive impairments in people living with PD. When people living with PD are divided in groups with and without cognitive impairments, no differences are found between healthy controls and people living with PD without cognitive impairments regarding FDM (Pirogovsky et al., 2014). People living with PD meeting the criteria of MCI (PD-MCI) showed, however, significantly lower performances on tests of FDM than healthy controls (Martin et al., 2013; Pirogovsky et al., 2014), even though no differences were found between people living with PD-MCI and people living with PD without cognitive impairments (Pirogovsky et al., 2014). When exploring the performances of people living with PD in tests of FDM in more detail, it was found that people living with PD-MCI showed significantly lower performances on relatively basic aspects of FDM (i.e., ‘basic monetary skills’, ‘financial concepts’ and ‘investment decision-making’) compared to healthy controls. No group differences were found on other domains of the FCI between these groups (Martin et al., 2013). Problems with FDM were most consistently found in people living with PDD compared to healthy controls (Giannouli et al., 2018; Giannouli & Tsolaki, 2019; Martin et al., 2013). People living with PDD scored significantly lower than both healthy controls and

people living with PD-MCI on almost all domains of FDM as measured with the FCI (Martin et al., 2013), even though ‘financial judgment’ and ‘knowledge of assets/estate arrangement’ seem to remain relatively intact in people living with PDD (i.e., no group differences were observed). In one study (Pirogovsky et al., 2012), seven people living with PDD were included in the sample, but the differences between people living with PD and healthy controls on the measure of FDM remained significant when excluding these people living with PDD. The remaining PD sample (n = 26) was described as non-demented, but it is unclear whether they suffered (mild) cognitive impairment(s). The researchers did report a direct moderate correlation between FDM and global cognition in people living with PD (Giannouli & Tsolaki, 2019; Pirogovsky et al., 2012). Another study, however, was not able to find a significant correlation between global cognition and FDM in people living with PD without dementia (Pirogovsky et al., 2014).

Two studies investigated the association between FDM and specific cognitive functions in people living with PD. Prospective memory, both time and event based, seems to be positively related to FDM in people living with PD (Pirogovsky et al., 2012). However, this correlation was no longer significant when people living with PDD were excluded from the sample. In accordance, when investigating people living with PD without dementia, no significant correlations were found between measures of attention, memory, executive functions, language and visuospatial abilities and FDM (Pirogovsky et al., 2014, 2013; Table 4.3).

Influence of age, sex, education, symptoms of depression and disease characteristics in patients with PD. One study reported strong associations between age, sex and FDM in people living with PD (Pirogovsky et al., 2012). However, another study did not find any significant correlations between demographic characteristics and FDM in people living with PD (Pirogovsky et al., 2014). A more severe disease severity (i.e., higher Hoehn & Yahr scores) and a longer disease duration were weakly to moderately associated with lower scores on FDM in people living with PD (Pirogovsky et al., 2012). Another study could, however, not replicate these findings (Pirogovsky et al., 2013). One study found significantly lower FDM performances in people living with PDD with symptoms of depression compared to people living with PDD without symptoms of depression (Giannouli & Tsolaki, 2019). This corresponds with the weak to moderate associations found between symptoms of depression and lower scores on tests of FDM in people living with PD (Pirogovsky et al., 2012, 2013). People living with PD diagnosed with a major depressive disorder prior to the diagnosis of PD were, however, excluded in these studies.

Multiple Sclerosis (MS)

Only recently did researchers start examining FDM in people living with MS. Three studies were included in the review (Table 4.2e) as well as in the meta-analysis (Figure 4.2). In total, 86 people living with MS participated in these studies and the average age ranged between 44.3 and 49.4 years (weighted age = 47.3 years). Gerstenecker, Myers et al. (2017) included exclusively people living with MS with either a primary progressive or secondary progressive disease subtype, while the other two studies included a more mixed group with approximately

half of the sample diagnosed with relapsing remitting MS and the other half with either primary progressive, secondary progressive or progressive relapsing MS or with a disease subtype that was uncertain (see Table 4.2e for more details).

All three studies (Gerstenecker, Myers, et al., 2017; Goverover et al., 2016; Tracy et al., 2017) concluded that people living with MS have more difficulties with FDM compared to healthy controls, which corresponds with the results of the meta-analysis ($g = 0.71 [0.23; 1.16]$, $SE = 0.23$, $p < .001$). According to the meta-analysis, the effect size of one of the three studies was, however, not significant (Gerstenecker, Myers, et al., 2017; Figure 4.2). The heterogeneity test was not significant ($Q(2) = 3.9$, $p = .141$, $I^2 = 49.0\%$) and the funnel plot showed no significant asymmetry ($p = .290$; Figure 4.3). However, only a small number of studies were included so these bias assessments should be interpreted with caution.

Based on the AR test, which required skills such as planning and budgeting, people living with MS are more likely to make errors when using their credit card than healthy controls (Goverover et al., 2016). Furthermore, people living with MS also worked at a slower pace than healthy controls when performing this FDM test. However, people living with MS were equally able to ‘stay within the price range’, ‘respond to unexpected situations’ and ‘to make appropriate decisions and choose financially the best options’ (Goverover et al., 2016). Gerstenecker, Myers et al. (2017) used the FCI to evaluate FDM in people living with MS and found that the performance of people living with MS was significantly lower than healthy controls on the total score and on almost all domains of the FCI (i.e., ‘basic monetary skills’, ‘conceptual knowledge’, ‘cash transactions’, ‘checkbook management’, ‘bank statement management’ and ‘investment decision-making’). Group differences between people living with MS and healthy controls were not found for the domains ‘financial judgment’ and ‘bill payment’ of the FCI (Gerstenecker, Myers, et al., 2017).

The association between FDM and cognition in patients with MS. In the study of Tracy et al. (2017), patients with MS were divided in subgroups based on their cognitive abilities. Healthy controls and cognitively unimpaired patients with MS did not differ with regard to their performances on the FCI. Patients with MS with cognitive impairments (i.e., a performance of ≤ 1 SD on at least three neurocognitive tests), however, showed more difficulties with FDM than both cognitively unimpaired patients with MS and healthy controls. On FCI domain level, cognitively impaired patients with MS had more difficulties with ‘basic monetary skills’, ‘conceptual knowledge’, ‘checkbook management’, ‘bank statement management’, ‘bill payment’ and ‘investment decisions’, than the other groups. However, the ability to perform ‘cash transactions’ and ‘financial judgments’ remained relatively intact since no group differences were observed.

All three studies (Gerstenecker, Myers, et al., 2017; Goverover et al., 2016; Tracy et al., 2017) investigated the associations between performances on tests of FDM and specific aspects of cognition (Table 4.3). In patients with MS, weak to moderate correlations were found between FDM tests and measures of attention, processing speed, language, memory (i.e., verbal and visual memory), arithmetic and executive functioning including mental flexibility and working memory, verbal reasoning (Gerstenecker, Myers, et al., 2017; Goverover et al., 2016; Tracy et al., 2017). Verbal memory and arithmetic explained 51.0% of variance of the FCI total

score in patients with MS (Gerstenecker, Myers, et al., 2017). Goverover et al. (2016) calculated a total money management score based on their FDM performance-based test and a FDM self-report questionnaire and reported that processing speed was the only significant predictor of this total money management score, explaining 18.0% of variance.

Influence of age, sex, education, symptoms of depression and disease characteristics in patients with MS. No significant associations were found between FDM and age or education in people living with MS (Tracy et al., 2017). Also no significant associations were found between FDM and symptoms of depression (Gerstenecker, Myers, et al., 2017; Tracy et al., 2017) or anxiety (Goverover et al., 2016) in people living with MS. However, when the impact of motor disabilities on physical functioning in people living with MS increased, as measured with the Timed 25-Foot Walk, poorer performances on ‘basic monetary skills’ of the FCI were observed, although the association was weak (Tracy et al., 2017). Goverover et al. (2016), however, found no significant correlation between FDM and MS disease severity as measured with the Expanded Disability Status Score. Furthermore, group differences regarding FDM between people living with MS and healthy controls remained significant after controlling for upper extremity motor speed (Goverover et al., 2016). Sex in relation to FDM has not been studied in people living with MS.

Huntington’s Disease (HD)

Only one study (Sheppard et al., 2017; Table 4.2f) investigated FDM in people living with HD and included 20 people living with symptomatic HD with a mild to moderate disease severity (based on the Unified Huntington’s Disease Rating Scale; UHDRS) and compared them with 20 healthy controls. People living with HD had significantly more difficulties with FDM than healthy controls. Furthermore, a significant moderate positive correlation was observed between FDM and global cognition (Table 4.3). More specifically, the Mattis Dementia Rating Scale subtests initiation and perseveration, construction and memory were found to be significantly related to FDM in people living with HD. FDM was, however, not related to disease characteristics of HD (i.e., UHDRS total motor score) nor to symptoms of depression (i.e., Beck Depression Inventory-II and Geriatric Depression Scale short form). The associations between FDM and demographic variables, such as age, sex or education, were not evaluated in people living with HD.

Table 4.2a. Overview of studies measuring financial decision-making in people living with Alzheimer's disease ($k = 25$).

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Bassett (1999)	USA	CS	AD ($n=20$) / Stage: mild/moderate - age (y) 75.3±9.9 - education n.r. - 20.0% male HC ($n=20$) - age (y) 75.2±5.9 - education (y) 13.6±2.4 - 30.0% male	FCQ (total score)	- People living with mild/moderate AD showed a significantly lower FDM performance than HC on the FCQ total score. - 55% of people living with mild/moderate AD were classified as incompetent ($\leq 2SD$ below the mean of controls) based on the FCQ total score.	AD (mild/moderate) < HC
Clark <i>et al.</i> (2014) [†]	USA	LS	AD ($n=41$) / Stage: mild - age (y) 72.5±6.0 - education (y) 14.0±3.0 - 63.4% male HC ($n=44$) - age (y) 70.5±7.1 - education (y) 14.4±2.2 - 38.6% male	FCI (total score based on domains 1-7, 9)	- 46% (5/11) and 20% (1/5) of people living with mild AD showed significant decline (≥ 10 points difference) compared to baseline after 1 and 2 years, respectively. - In contrast, 15.8% (6/38) and 17.6% (6/34) of HC showed significant decline (≥ 10 points difference) compared to baseline after 1 and 2 years, respectively.	N/A
Eamst <i>et al.</i> (2001)	USA	CS	AD ($n=20$) / Stage: mild/moderate - age (y) 71.9±7.2 - education (y) 13.3±2.9 - % male n.r. HC ($n=23$) - age (y) 71.0±9.2 - education (y) 14.6±1.9 - % male n.r.	FCI (scores on domains 1-7, total score based on domains 1-7)	- People living with mild/moderate AD showed significantly lower FDM performances than HC on the FCI total score and on all domains separately.	AD (mild/moderate) < HC
Gerstenecker, Hoaghey <i>et al.</i> (2017) [†]	USA	CS	AD ($n=39$) / Stage: mild - age (y) 71.3±8.0 - education (y) 14.1±2.6* - 51.2% male ^a HC ($n=60$) - age (y) 70.6±7.0 - education (y) 16.0±2.3 - 72.1% male ^a	FCI (scores on domains 1-7, total score based on domains 1-7)	- People living with mild AD showed significantly lower FDM performances than HC on the FCI total score and on all domains separately.	AD (mild) < HC
Gerstenecker <i>et al.</i> (2018) [†]	USA	CS	AD ($n=112$) / Stage: mild - age (y) n.r. - education (y) n.r. - % male n.r. HC ($n=179$) - age (y) n.r. - education (y) n.r. - % male n.r.	FCI (scores on 4 domains extracted from factor analyses)	- People living with mild AD showed significantly lower FDM performances than HC on all domains.	AD (mild) < HC

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Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Gerstenecker <i>et al.</i> (2019) ^a	USA	CS	AD (n=59) / Stage: mild - age (y) 74.5±8.7 - education (y) 14.5±2.3 - 54.2% male HC (n=64) - age (y) 70.6±7.4 - education (y) 15.8±2.3 - 29.7% male	FDM test (scores on FCI (scores on domains 1-7, 9, total score based on domains 1-7, 9)) - MMSE 23.7±3.1 ^a - MMSE 28.7±3.9	- People living with mild AD showed significantly lower FDM performances than HC on the FCI total score and on all domains separately. - All patient groups showed significantly lower FDM performances than HC (i.e., <2.5SD below the mean of controls) on all domains of the FDM test. - People living with severe AD showed significantly lower FDM performances than people living with mild AD (i.e., <2.5SD below the mean of people living with mild AD) on three domains of the FDM test, i.e., 'basic monetary skills', 'decision making capacity and judgment for different dilemmas'. - People living with severe AD also showed significantly lower FDM performances than people living with moderate AD (i.e., <2.5SD below the mean of people living with moderate AD) on one domain of the FDM test, i.e., 'decision making capacity and judgment for different dilemmas'. - People living with moderate AD showed significantly lower FDM performances than people living with mild AD (i.e., <2.5SD below the mean of people living with mild AD) on one domain of the FDM test, i.e., 'decision making capacity and judgment for different dilemmas'.	AD (mild) < HC
Giannouli & Tsolaki (2014) ^a	Greece	CS	AD (n=10) / Stage: severe - age (y) 74.4±8.6 ³ - education (y) 5.65±2.6 ³ - % male n.r. AD (n=22) / Stage: moderate - age (y) 77.8±6.1 ³ - education (y) 7.4±4.0 ³ - % male n.r. AD (n=32) / Stage: mild - age (y) 76.7±7.4 ³ - education (y) 6.9±4.3 ³ - % male n.r. HC (n=83) - age (y) 73.6±9.8 - education (y) 8.1±4.6 - % male n.r.	FDM test ^b (scores on six domains) - MMSE 5.4±2.8 ³ - MMSE 15.2±2.4 ³ - MMSE 22.2±2.6 ³ - MMSE 29.5±1.2	- All patient groups showed significantly lower FDM performances than HC (i.e., <2.5SD below the mean of controls) on all domains of the FDM test. - People living with severe AD showed significantly lower FDM performances than people living with mild AD (i.e., <2.5SD below the mean of people living with mild AD) on three domains of the FDM test, i.e., 'basic monetary skills', 'decision making capacity and judgment for different dilemmas'. - People living with severe AD also showed significantly lower FDM performances than people living with moderate AD (i.e., <2.5SD below the mean of people living with moderate AD) on one domain of the FDM test, i.e., 'decision making capacity and judgment for different dilemmas'. - People living with moderate AD showed significantly lower FDM performances than people living with mild AD (i.e., <2.5SD below the mean of people living with mild AD) on one domain of the FDM test, i.e., 'decision making capacity and judgment for different dilemmas'.	AD (severe) < AD (moderate) < AD (mild) < HC
Giannouli <i>et al.</i> (2018) ^a	Greece	CS	AD (n=23) / Stage: severe - age (y) n.r. ^c - education (y) n.r. ^c - % male n.r. ^c AD (n=20) / Stage: moderate - age (y) n.r. ^c - education (y) n.r. ^c - % male n.r. ^c AD (n=21) / Stage: mild - age (y) n.r. ^c - education (y) n.r. ^c - % male n.r. ^c HC (n = 22) - age (y) n.r. ^c - education (y) n.r. ^c - % male n.r. ^c	LCPLTAS (scores on seven domains, total score based on all domains) - MMSE 5.6±3.2 ³ - MMSE 14.7±2.6 ³ - MMSE 21.8±2.1 ³ - MMSE 29.2±0.9	- All patient groups showed significantly lower FDM performance than HC on the LCPLTAS total score and on all domains separately. - People living with severe AD showed significantly lower FDM performances than people living with mild or moderate AD on the LCPLTAS total score and on all domains separately. - People living with moderate AD showed significantly lower FDM performances than people living with mild AD on the LCPLTAS total score and on all domains separately.	AD (severe) < AD (moderate) < AD (mild) < HC

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Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Gill <i>et al.</i> (2019) ⁺	Canada ⁺⁺	CS	AD (n=15) / Stage: n.r. - age (y) 77.3±6.4* - education (y) 14.2±4.4 - 66.7% male [?] HC (n=20) - age (y) 67.9±8.9 - education (y) 13.7±2.9 - 40.0% male	FACT (scores on eight domains and total score based on all domains) & FCAI (scores on six domains, total score based on all domains)	- People living with AD showed a significantly lower FDM performance than HC on the FACT domain 'memory'. No group differences were found for the total score and for all other domains. - People living with AD showed a significantly lower FDM performance than HC on the FCAI total score and on all domains separately, with the exception of 'debt management'.	AD ≤ HC
Griffith <i>et al.</i> (2003) ⁺	USA	CS	AD (n=22) / Stage: mild - age (y) 71.5±9.2 - education (y) 14.5±2.5 - 40.1% male HC (n=21) - age (y) 66.7±7.2 - education (y) 14.3±2.7 - 33.3% male	FCI (scores on domains 1-9, total score based on domains 1-7)	- People living with mild AD showed significantly lower FDM performances than HC on the FCI total score and on all domains separately, with the exception of 'assets and estate'.	AD (mild) ≤ HC
Griffith <i>et al.</i> (2007)	USA	CS	AD (n=14) / Stage: mild - age (y) 75.9±8.0 - education (y) 15.0±2.8 - 57.1% male HC (n=14) - age (y) 71.0±4.2 - education (y) 14.2±2.2 - 28.6% male	FCI (total score based on domains 2, 5-7)	- People living with mild AD showed a significantly lower FDM performance than HC on the FCI total score. - FDM (total score of the FCI) was mildly to moderately negatively correlated with neural tissue loss or damage (NAA/Cr ratio) and neural demyelination (Cho/Cr ratio).	AD (mild) ≤ HC
Kershaw & Webber (2008)	Australia	CS	AD (n=22) / Stage: n.r. - age (y) 83.0±5.3* - education (y) ≈ 9* - 13.6% male [?] HC (n=59) - age (y) 52.5±19.3 - education (y) ≈ 12 - 40.0% male	FCAI (scores on six domains, total score based on all domains)	- People living with AD showed significantly lower FDM performances than HC on the FCAI total score and on all domains separately, with the exception of 'support resources'. The degree of impairment of people living with AD was > 1.5SD below the mean of HC.	AD ≤ HC
Lima-Silva <i>et al.</i> (2015) ⁺	Brazil	CS	AD (n=30) / Stage: n.r. - age (y) 68.7±6.8 - education (y) 8.6±4.5 - 56.7% male HC (n=34) - age (y) 65.4±5.9 - education (y) 9.6±3.9 - 62.8% male	Subscale 'financial skills' of DAFS – Brazilian version (total score based on five domains)	- People living with AD showed a significantly lower FDM performance than HC on the 'financial skills' total score.	AD ≤ HC

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Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Loewenstein <i>et al.</i> (1989)	USA	CS	AD (n=12) / Stage: n.r. - age (y) 78.2±10.1 - education (y) n.r. - 58.3% male ² HC (n=18) - age (y) 75.4±5.7 - education (y) 13.8±2.7 - 27.8% male	Subscale 'financial skills' of DAFS (scores on four domains, total score based on all domains) - n.r. - MMSE 28.0±2.2	- People living with AD showed significantly lower FDM performances than HC on the total score of the 'financial skills' subscale and on all domains separately, with the exception of 'identifying change'. 	AD ≤ HC
Loewenstein <i>et al.</i> (1995)	USA	LS	AD (n=52) / Stage: n.r. - age (y) 76.6±7.2 - education (y) 12.4±3.8 - 38.5% male no HC group	Subscale 'financial skills' of DAFS (scores on four domains) - MMSE 19.0±4.7 ^d	- People living with AD showed a significant deterioration after 1 year on all FDM domains, with the exception of 'balancing a checkbook'. 	N/A
Lui <i>et al.</i> (2013) ⁺	China ⁺	CS	AD (n=90) / Stage: mild - age (y) 82.2±6.6 ^a - education (y) 1.7±3.3 ^a - 15.6% male ³ HC (n=93) - age (y) 74.2±6.5 - education (y) 4.3±3.7 - 10.8% male	'money management' version of ACED – Chinese version (scores on four domains, total score based on all four domains) - MMSE 19.7±2.5 ^a - MMSE 26.6±2.5	- People living with mild AD showed significantly lower FDM performances than HC on the 'money management' total score and on all domains separately. 	AD (mild) < HC
Mahurin <i>et al.</i> (1991)	USA	CS	AD (n=18) / Stage: n.r. - age (y) 66.9±5.4 - education (y) 14.1±2.5 - 50.0% male HC (n=18) - age (y) 66.6±6.4 - education (y) 14.0±2.6 - 50.0% male	Subscale 'money-related skills' of SAILS (total score) - MMSE 19.4±3.4 ^a - GDS 3.6 ^a - MMSE 29.0±0.9 - GDS 1.0	- People living with AD showed a significantly lower FDM performance than HC on the total score of the 'money-related skills' subscale. 	AD < HC
Marson <i>et al.</i> (2000)	USA	CS	AD (n=50) / Stage: mild (n=30) and moderate (n=20) - age (y) 75.2±5.9 - education (y) 12.8±3.3 ^a - 38.0% male HC (n=23) - age (y) 70.3±6.7 - education (y) 15.2±1.8 - 39.1% male	FCI (scores on domains 1-6) - MMSE 20.4±4.4 ^a - MMSE 29.2±0.9	- People living with mild AD showed significantly lower FDM performances than HC on all domains of the FCI, with the exception of 'basic monetary skills'. - People living with moderate AD showed significantly lower FDM performances than HC on all domains of the FCI. - People living with moderate AD showed significantly lower FDM performances than people living with mild AD on all domains of the FCI. 	AD (moderate) < AD (mild) ≤ HC

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Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Marson <i>et al.</i> (2009) ⁺	USA	CS	AD (n=31) / Stage: moderate - age (y) 75.3±8.4* - education (y) 11.1±3.7* - 32.3% male [§] AD (n=97) / Stage: mild - age (y) 72.4±8.4* - education (y) 13.4±2.1* - 53.6% male HC (n=75) - age (y) 66.1±7.7 - education (y) 14.3±1.6 - 32.0% male	SCIFC (scores on domains 1-8, total score based on domains 1-7) - MMSE 16.4±4.2* - DRS 90.7±19.6* - CDR 1.0 to 3.0 ⁷ - MMSE 24.0±3.1* - DRS 114.0±12.1* - CDR 0.5 to 1.0 ⁷	- People living with moderate AD were more often marginally capable or incapable regarding FDM than HC on the SCIFC total score and on all domains separately. - People living with mild AD were more often marginally capable or incapable regarding FDM than HC on the SCIFC total score and on all domains separately, with the exception of 'basic monetary skills'. - People living with moderate AD were more often marginally capable or incapable regarding FDM than people living with mild AD on the SCIFC total score and on all domains separately, with the exception of 'checkbook management' and 'bill payment'.	AD (moderate) ≤ AD (mild) ≤ HC
Martin, Griffith <i>et al.</i> (2008)	USA	LS	AD (n=55) / Stage: mild - age (y) 70.6±8.4* - education (y) 13.1±2.3* - 56.4% male [§] HC (n=63) - age (y) 66.3±7.6 - education (y) 14.4±1.7 - 31.7% male	FCI (scores on domains 1-9, total score based on domains 1-7, total score based on domains 1-8) - MMSE 24.5±3.1* - DRS 116.2±10.5* - CDR 0.5 or 1.0 ⁷ - MMSE 29.3±1.0 - DRS 136.7±4.8 - CDR 0 ⁸	- People living with mild AD showed a significant deterioration after 1 year on the FCI total scores and on all domains separately. No significant deterioration was observed in HC.	N/A
Martin <i>et al.</i> (2019) ⁺	USA	CS	AD (n=54) / Stage: mild - age (y) 73.3±8.2* - education (y) 13.7±3.2* - 53.7% male HC (n=82) - age (y) 66.3±8.5 - education (y) 15.2±2.5 - 36.6% male AD (n=26) / Stage: n.r. - age (y) 77.9±6.0* - education (y) 8.8±5.5* - 42.0% male [§] HC (n=32) - age (y) 71.6±5.6 - education (y) 13.3±6.0 - 25.0% male	FCI (scores on domains 1-9, total score based on domains 1-7, 9) - MMSE 24.5±3.2* - DRS 118.4±12.0* - CDR 0.5 to 1.0 - MMSE 29.5±0.9 - DRS 138.9±3.7 - CDR 0.0 or 0.5 Subscale 'financial skills' of DAFS – Brazilian version (total score) - MMSE 19.5±5.5* - MMSE 28.8±1.5	- People living with mild AD showed significantly lower FDM performances than HC on the FCI total scores and on all domains separately. - People living with AD showed a significantly lower FDM performance than HC on the total score of the 'financial skills' subscale.	AD (mild) < HC AD < HC
Pereira, Yassuda <i>et al.</i> (2010) ⁺	Brazil	CS	AD (n=43) / Stage: mild - age (y) 73.8±8.5* - education (y) 13.6±2.9* - 55.8% male HC (n=85) - age (y) 67.2±8.2 - education (y) 15.0±2.4 - 35.3% male	FCI (total score based on domains 1-7) - MMSE 24.6±2.9* - DRS 118.7±10.2* - CDR 0.5 to 2.0* - MMSE 29.4±0.9 - DRS 138.8±3.3 - CDR 0 or 0.5	- People living with mild AD showed a significantly lower FDM performance than HC on the FCI total score.	AD (mild) < HC

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Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Stoeckel <i>et al.</i> (2013)	USA	CS	AD (n=16) / Stage: mild	FCI (total score based on domains 2, 5-7)	<ul style="list-style-type: none"> - People living with mild AD showed a significantly lower FDM performance than HC on the FCI total score. - FDM was moderately positively correlated with grey matter volumes (MRI) of medial frontal cortex, dorsolateral frontal cortex, precuneus and the angular gyri in people living with mild AD. No significant correlation between grey matter volume (MRI) of hippocampi and FDM was found in people living with mild AD. 	AD (mild) < HC
			<ul style="list-style-type: none"> - age (y) 77.0±8.2 - education (y) 14.3±2.5 - 43.8% male 			
Tolbert <i>et al.</i> (2019) ^a	USA	CS	HC (n=16)	FCI – SF (score on 5 domains and total score based on all domains)	<ul style="list-style-type: none"> - People living with mild AD showed a significantly lower FDM performance than HC on the FCI – SF total score and on all domains separately. - FDM was mildly to moderately negatively correlated to β-amyloid SUVr in people living with mild AD. 	AD (mild) < HC
			<ul style="list-style-type: none"> - age (y) 75.0±4.4 - education (y) 14.3±2.8 - 31.3% male 			
			AD (n=20) / Stage: mild	<ul style="list-style-type: none"> - MMSE 24.3±3.6* - CDR 0.5 or 1.0^b 		
			<ul style="list-style-type: none"> - age (y) 74.8±6.5* - education (y) 15.5±2.7* - 55.0% male 			
			HC (n=144)			
			<ul style="list-style-type: none"> - age (y) 71.6±6.2 - education (y) 16.8±2.4 - 48.0% male 			

Table 4.2b. Overview of studies measuring financial decision-making in people living with mild cognitive impairment (k = 26).

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Arcara <i>et al.</i> (2019)	Italy	CS	MCI (n = 40) / Type: n.r.	NADL-F test (scores on seven domains)	<ul style="list-style-type: none"> - People living with MCI showed a significantly lower FDM performance than HC on all domains of the NADL-F test, with the exception of 'reading abilities', 'purchase' and 'financial judgments'. 	MCI < HC
			<ul style="list-style-type: none"> - age (y) n.r.^c - education (y) n.r.^c - 50.0% male 			
			HC (n = 40)			
			<ul style="list-style-type: none"> - age (y) n.r.^c - education (y) n.r.^c - 37.5% male 			
Bangen <i>et al.</i> (2010)	USA	CS	MCI (n=22) / Type: amnesic	Subscale 'managing money' of ILS (total score)	<ul style="list-style-type: none"> - People living with amnesic MCI showed significantly lower FDM performances than HC on total score of the 'managing money' subscale. - No differences were found between people living with non-amnesic MCI and HC. - No differences were found between people living with amnesic MCI and people living with non-amnesic MCI. 	MCI (amnesic) < HC MCI (non-amnesic) = HC
			<ul style="list-style-type: none"> - age (y) 74.9±7.1 - education (y) 16.5±2.13 - 36.4% male 			
			MCI (n=16) / Type: non-amnesic	<ul style="list-style-type: none"> - DRS 49.8±5.7* - DRS 51.3±5.4* 		
			<ul style="list-style-type: none"> - age (y) 77.1±8.5 - education (y) 15.2±3.2 - 62.5% male 			
			HC (n=82)			MCI (amnesic) < HC MCI (non-amnesic) = HC
			<ul style="list-style-type: none"> - age (y) 74.3±9.4 - education (y) 16.0±2.3 - 63.4% male 			

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Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Benavides-Varela <i>et al.</i> (2015)	Italy	CS	MCI (n=33) / Type: n.r. - age (y) 74.4±6.0* - education n.r. - 60.6% male HC (n=29) - age (y) 67.1±8.4 - education n.r. - 37.9% male	Subscale 'money usage' of NADL (total score) - MMSE 26.6±2.5*	- People living with MCI showed a significantly lower FDM performance than HC on the total score of the NADL 'money usage' subscale.	MCI < HC
Clark <i>et al.</i> (2014)*	USA	LS	MCI converters (n=44) / Type: n.r. - age (y) 72.8±6.3 - education (y) 14.6±3.2 - 45.5% male MCI non-converters (n=36) / Type: n.r. - age (y) 71.5±6.2 - education (y) 14.8±2.9 - 38.9% male HC (n=44) - age (y) 70.5±7.1 - education (y) 14.4±2.2 - 38.6% male	FCI (total score based on domains 1-7, 9) Type: n.r. - MMSE 27.2±1.9** - DRS 129.0±7.1** Type: n.r. - MMSE 28.4±1.7** - DRS 133.7±5.8** - MMSE 29.3±1.2 - DRS 138.9±3.9	- 35% (15/43) and 32% (11/34) of MCI converters showed significant decline (≥ 10 points difference) compared to baseline after 1 and 2 years, respectively. - 21% (7/34) and 21% (7/33) of MCI non-converter showed significant decline (≥ 10 points difference) compared to baseline after 1 and 2 years, respectively. - In contrast, 15.8% (6/38) and 17.6% (6/34) of HC showed significant decline (≥ 10 points difference) compared to baseline after 1 and 2 years, respectively.	N/A
Czajka <i>et al.</i> (2017)	USA	CS	MCI (n=62) / Type: amnesic - age (y) 75.9±7.7* - education 14.6±4.0 - 33.0% male HC (n=85) - age (y) 72.0±8.3 - education (y) 14.5±3.2 - 23.0% male	Subscale 'money management' of the UMCFAB (total number of correct answers, total number of errors, and efficiency score) - CDR 0.5 - CDR 0	- People living with MCI showed lower FDM performances than HC on all scores. - 40% and 34% of people living with amnesic MCI were classified as impaired (i.e., ≤ 2 SD below the mean of controls) based on the 'total number of correct answers' and 'total number of errors', respectively.	MCI (amnesic) < HC
Duke Han <i>et al.</i> (2015)	USA	CS	MCI (n=114) / Type: n.r. - age (y) 84.3±6.1* - education (y) 15.4±3.0 - 30.6% male* HC (n=586) - age (y) 81.1±7.8 - education (y) 15.2±3.1 - 22.7% male	Subscale FDM of DMCAAT (total score) - Global cognition z-score -0.3±1.4* - Global cognition z-score 0.4±0.4*	- People living with MCI showed significantly lower FDM performances than HC on the total score.	MCI < HC
Gerstenecker <i>et al.</i> (2016)	USA	LS	MCI (n=51) / Type: n.r. - age (y) 71.0±6.6 - education (y) 14.9±3.3 - 54.9% male no HC group	FCI (scores on domains 1-7, 9) Baseline: - MMSE 27.6±1.9 - DRS 130.9±7.3 Year 2: - MMSE 25.9±4.2 - DRS 124.8±14.6 - 9 participants converted to AD	- People living with MCI showed a significant deterioration regarding FDM in the domains 'checkbook management', 'bank statement management', 'bill payment' and 'investment decision-making'.	N/A

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Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Gerstenecker, Hoagey <i>et al.</i> (2017) [†]	USA	CS	MCI (n=31) / Type: amnesic - age (y) 71.9±7.1 - education (y) 15.2±2.5 - 69.7% male HC (n=60) - age (y) 70.6±7.0 - education (y) 16.0±2.3 - 72.1% male	FCI (scores on domains 1-7, total score based on domains 1-7)	- Patients with MCI showed significantly lower FDM performances than HC on the FCI total score and on all domains separately, with the exception of 'basic money skills' and 'identifying fraud/financial judgment'.	MCI (amnesic) ≤ HC
Gerstenecker <i>et al.</i> (2018) [†]	USA	CS	MCI (n=149) / Type: amnesic - age (y) n.r. - education (y) n.r. - % male n.r. HC (n=179) - age (y) n.r. - education (y) n.r. - % male n.r.	FCI (scores on 4 domains extracted from factor analyses)	- Patients with MCI showed significantly lower FDM performances than HC on all domains, with the exception of one which was described as 'financial conceptual knowledge'.	MCI (amnesic) ≤ HC
Gerstenecker <i>et al.</i> (2019) [†]	USA	CS	MCI (n=65) / Type: amnesic - age (y) 72.6±7.4 - education (y) 15.2±2.6 - 49.2% male HC (n=64) - age (y) 70.6±7.4 - education (y) 15.8±2.3 - 29.7% male	FCI (scores on domains 1-7, 9, total score based on domains 1-7, 9)	- Patients with MCI showed significantly lower FDM performances than HC on the FCI total score and on all domains separately, with the exception of 'basic money skills' and 'identifying fraud/financial judgment'.	MCI (amnesic) ≤ HC
Giannouli & Tsolaki (2014) [†]	Greece	CS	MCI (n=46) / Type: amnesic - age (y) 69.7±9.0 [†] - education (y) 9.4±4.3 [†] - % male n.r. HC (n=83) - age (y) 73.6±9.8 - education (y) 8.1±4.6 - % male n.r.	FDM test^b (scores on six domains)	- Patients with MCI showed significantly lower FDM performances than HC on all domains of the FDM test.	MCI (amnesic) < HC
Giannouli <i>et al.</i> (2018) [†]	Greece	CS	MCI (n = 20) / Type: amnesic - age (y) n.r. ^c - education (y) n.r. ^c - % male n.r. ^c HC (n = 22) - age (y) n.r. ^c - education (y) n.r. ^c - % male n.r. ^c	LCPLTAS (scores on seven domains, total score based on all domains)	- Patients with MCI showed a significantly lower FDM performance than HC on the LCPLTAS total score and on all domains separately.	MCI (amnesic) < HC

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Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Griffith <i>et al.</i> (2003) ⁺	USA	CS	<p>MCI (n=21) / Type: amnesic</p> <ul style="list-style-type: none"> - age (y) 68.1±8.8 - education (y) 14.3±2.2 - 47.6% male <p>HC (n=21)</p> <ul style="list-style-type: none"> - age (y) 66.7±7.2 - education (y) 14.3±2.7 - 33.3% male 	<p>FCI (scores on domains 1-9, total score based on domains 1-7)</p> <ul style="list-style-type: none"> - MMSE 28.4±1.2 - DRS 129.2±5.7* - CDR 0.0 or 0.5* 	<p>- People living with MCI showed significantly lower FDM performances than HC on the total score and on the domains 'financial concepts', 'bank statement management' and 'bill payment'. No differences were found with regard to the other domains.</p>	MCI (amnesic) ≤ HC
Griffith <i>et al.</i> (2010)	USA	CS	<p>MCI (n=38) / Type: amnesic</p> <ul style="list-style-type: none"> - age (y) 70.8±6.4 - education 14.2±2.6 - 34.2% male <p>HC (n=28)</p> <ul style="list-style-type: none"> - age (y) 71.6±5.4 - education 14.8±2.6 - 32.1% male 	<p>FCI (total score based on domain 2, 5-7)</p> <ul style="list-style-type: none"> - MMSE 28.2±1.4* 	<p>- People living with MCI showed a significantly lower FDM performance than HC on the FCI total score.</p>	MCI (amnesic) < HC
Kenney <i>et al.</i> (2019)	USA	CS	<p>MCI (n=160) / Type: n.r.</p> <ul style="list-style-type: none"> - age (y) n.r. - education n.r. - % male n.r. <p>HC (n=71)</p> <ul style="list-style-type: none"> - age (y) n.r. - education n.r. - % male n.r. 	<p>Subtest 'Bill Payment' of the NAB (total score)</p> <ul style="list-style-type: none"> - n.r. 	<p>- People living with MCI showed significantly lower FDM performances than HC on the NAB 'Bill Payment' total score.</p>	MCI < HC
Lassen-Greene <i>et al.</i> (2017)	USA	CS + LS	<p>MCI (n=80) / Type: n.r.</p> <ul style="list-style-type: none"> - age (y) 70.6±7.6 - education 15.2±3.0 - 53.8% male* <p>HC (n=80)</p> <ul style="list-style-type: none"> - age (y) 68.6±7.5 - education 15.2±2.5 - 36.3% male 	<p>FCI (total score based on domain 2, 3, 5, 7)</p> <ul style="list-style-type: none"> - DRS 132.3±6.9* - DRS 138.6±5.5 	<p>- At baseline, people living with MCI showed a significantly lower FDM performance than HC on the FCI total score.</p> <p>- People living with MCI showed significant deterioration over time (in total 5 visits over a three-year period). No significant deterioration was observed in HC.</p>	MCI < HC
Lui <i>et al.</i> (2013) ⁺	China ⁺⁺	CS	<p>MCI (n=92) / Type: amnesic</p> <ul style="list-style-type: none"> - age (y) 77.8±6.8* - education (y) 3.0±3.2* - 28.3% male* <p>HC (n=93)</p> <ul style="list-style-type: none"> - age (y) 74.2±6.5 - education (y) 4.3±3.7 - 10.8% male 	<p>'money management' version of ACED – Chinese version (scores on four domains, total score based on all four domains)</p> <ul style="list-style-type: none"> - MMSE 25.3±2.6* - MMSE 26.6±2.5 	<p>- People living with MCI showed significantly lower FDM performances than HC on the 'money management' total score and on all domains separately, with the exception of 'expressing a choice'.</p>	MCI (amnesic) ≤ HC

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Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Marson <i>et al.</i> (2009) [*]	USA	CS	MCI (n=58) /Type: amnesic - age (y) 68.0±8.3 [*] - education (y) 13.7±2.0 [*] - 31.0% male [*] HC (n=75) - age (y) 66.1±7.7 - education (y) 14.3±1.6 - 32.0% male	SCIFC (scores on domains 1-8, total score based on domains 1-7) - MMSE 28.2±1.9 - DRS 131.3±7.4 [*] - CDR 0.0 to 1.0	- People living with MCI showed significantly lower FDM performances than HC on the SCIFC total score and on 'bank statement management', but not on other domains.	MCI (amnesic) ≤ HC
Martin <i>et al.</i> (2019) [*]	USA	CS + LS	MCI (n=91) /Type: n.r. - age (y) 72.1±6.4 [*] - education (y) 14.7±3.1 - 54.9% male HC (n=82) - age (y) 66.3±8.5 - education (y) 15.2±2.5 - 36.6% male	FCI (scores on domains 1-9, total score based on domains 1-7, total score based on domains 1-7, 9) - MMSE 27.6±1.9 [*] - DRS 130.6±6.7 [*] - CDR 0.0 to 0.5 - MMSE 29.5±0.9 - DRS 138.9±3.7 - CDR 0.0 or 0.5	- People living with MCI showed significantly lower FDM performances than HC on the FCI total scores and on all domains separately, with the exception of 'knowledge of personal finances'. - After 6-years follow-up, people living with MCI showed a significant deterioration on the FCI total scores and on all domains separately. No significant deterioration was observed in HC.	MCI ≤ HC
Niccolai <i>et al.</i> (2017)	USA	LS	MCI (n=48) /Type: amnesic - age (y) 71.4±6.4 [*] - education 14.7±3.3 - 54.2% male HC (n=66) - age (y) 66.3±8.6 - education 15.1±2.4 - 36.4% male	FCI (total score based on domains 1-7) - MMSE 27.6±1.9 [*] - DRS 131.1±7.4 [*] - MMSE 29.6±0.8 - DRS 139.0±3.3	- After 2-year follow-up, people living with MCI showed a significant deterioration on the FCI total score compared to baseline. No significant deterioration was observed in HC. - The FCI total score at baseline was not significantly correlated with the change score of the FCI total score.	N/A
Okonkwo <i>et al.</i> (2006)	USA	CS	MCI (n=43) /Type: amnesic/non-amnesic - age (y) 69.5±8.2 - education 14.7±3.0 - 55.8% male HC (n=43) - age (y) 66.8±7.4 - education 15.1±2.5 - 37.2% male	FCI (scores on domains 2, 3, 5, 7) - MMSE 28.5±1.5 [*] - DRS 132.9±6.9 [*] - MMSE 29.4±0.9 - DRS 138.3±6.5	- People living with MCI showed significantly lower FDM performances than HC on all FCI domains, with the exception of 'cash transactions'.	MCI (amnesic/non-amnesic) ≤ HC
Okonkwo <i>et al.</i> (2009)	USA	CS	MCI (n=57) /Type: amnesic - age (y) 70.1±8.1 - education 15.4±3.0 - 52.6% male HC (n=68) - age (y) 67.9±7.4 - education 15.1±2.5 - 38.2% male	FCI (total score based on domain 2, 3, 5, 7) - DRS 133.0±7.9 [*] - GDS 4.5±4.4	- Significantly more people living with MCI (39.3%) showed some difficulty (≤ 1.5SD below the mean of controls) with FDM on the FCI total score than HC (6.2%).	MCI (amnesic) ≤ HC

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Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Pereira, Yassuda <i>et al.</i> (2010) ⁺	Brazil	CS+LS	MCI (n=31) / Type: amnesic / non-amnesic - age (y) 72.9±7.0 - education (y) 8.5±5.5* - 26.0% male HC (n=32) - age (y) 71.6±5.6 - education (y) 13.3±6.0 - 25.0% male	Subscale 'financial skills' of DAFS – Brazilian version (total score)	- People living with MCI showed a significantly lower FDM performance than HC on the total score of the 'financial skills' subscale. - No significant differences were found between MCI subtypes and between MCI converters (n=8, follow-up at 15.7±3.7 months) and non-converters (n=23, follow-up at 17.1±4.1 months). - FDM (total score of the 'financial skills' subscale) was moderately negatively correlated with total tau and phospho-Ttau ¹⁸¹ concentrations in cerebrospinal fluid in people living with MCI.	MCI (amnesic/non-amnesic) < HC MCI (amnesic) = MCI (non-amnesic) MCI (non-converters) = MCI (non-converters)
Sherod <i>et al.</i> (2009) ⁺	USA	CS	MCI (n=113) / Type: amnesic - age (y) 70.3±7.4* - education (y) 14.6±3.2 - 43.4% male HC (n=85) - age (y) 67.2±8.2 - education (y) 15.0±2.4 - 35.3% male	FCI (total score based on domains 1-7)	- People living with MCI showed a significantly lower FDM performance than HC on the FCI total score.	MCI (amnesic) < HC
Tolbert <i>et al.</i> (2019) ⁺	USA	CS	MCI (n=79) / Type: amnesic - age (y) 71.4±6.7 - education (y) 16.3±2.8 - 57.0% male HC (n=144) - age (y) 71.6±6.2 - education (y) 16.8±2.4 - 48.0% male	FCI – SF (score on 5 domains and total score based on all domains)	- People living with MCI showed a significantly lower FDM performance than HC on the FCI – SF total score and on all domains separately, with the exception of 'mental calculation'.	MCI (amnesic) ≤ HC
Triebel <i>et al.</i> (2009)	USA	LS	MCI converters (n=25) / Type: n.r. - age (y) 74.4±6.0 ⁸ - education (y) 14.4±3.3 - 44.0% male MCI non-converters (n=62) / Type: n.r. - age (y) 68.5±7.5 - education (y) 15.2±2.8 - 45.2% male HC (n=76) - age (y) 66.7±8.5 - education (y) 15.0±2.3 - 36.8% male	FCI (scores on domains 1-7, 9, total score based on domains 1-7, total score based on domains 1-7, 9)	- After 1-year follow-up, MCI converters showed significantly steeper deteriorations than HC and MCI non-converters on the FCI total scores and domain 'checkbook management'. No significant deterioration was observed in HC and MCI non-converters.	N/A

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Table 4.2c. Overview of studies measuring financial decision-making in people living with frontotemporal dementia (k = 3).

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Giannouli <i>et al.</i> (2018) ⁺	Italy	CS	FTD (n = 17) / Type: n.r. - age (y) n.r. ^e - education (y) n.r. ^e - % male n.r. ^e	LCPLTAS (scores on seven domains, total score based on all domains) - MMSE 16.8±6.0 ^f	- People living with FTD showed a significantly lower FDM performance than HC on the LCPLTAS total score and on all domains separately.	FTD < HC
			HC (n = 22) - age (y) n.r. ^e - education (y) n.r. ^e - % male n.r. ^e			
Gill <i>et al.</i> (2019) ⁺	Canada ⁺⁺	CS	FTD (n=15) / Type: behavioral variant - age (y) 67.5±8.7 - education (y) 13.9±2.7 - 46.7% male ^f	FACT (scores on eight domains and total score based on all domains) & FCAI (scores on six domains, total score based on all domains) - MoCa 19.1±4.7 ⁺ - MoCa 27.3±1.9	- People living with FTD showed a significantly lower FDM performance than HC on the FACT total score and on all domains separately, with the exception of 'reading/writing' and 'rational beliefs about money'. - People living with FTD showed a significantly lower FDM performance than HC on the FCAI total score and all domains separately, with the exception of 'debt management'.	FTD < HC
			HC (n=20) - age (y) 67.9±8.9 - education (y) 13.7±2.9 - 40.0% male			
Lima-Silva <i>et al.</i> (2015) ⁺	Brazil	CS	FTD (n=20) / Type: behavioral variant - age (y) 67.1±6.6 - education (y) 9.6±5.9 - 70.0% male	Subscale 'financial skills' of DAFS – Brazilian version (total score) - MMSE 23.5±4.3 - CDR 1.0	- People living with FTD showed a significantly lower FDM performance than HC on the 'financial skills' total score.	FTD < HC
			HC (n=34) - age (y) 65.4±5.9 - education (y) 9.6±3.9 - 62.8% male			

Table 4.2d. Overview of studies measuring financial decision-making in people living with Parkinson's disease (k = 6⁵).

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Giannouli & Tsolaki (2014) ⁺	Italy	CS	PD (n=10) - age (y) 75.6±10.0 ^f - education (y) 8.5±5.2 ^f - % male n.r.	FDM test^f (scores on six domains) - MMSE 24.3±4.8 ^f - UPDRS n.r. - H&Y n.r.	- People living with PD showed significantly lower FDM performances than HC on all domains of the FDM test.	PD < HC
			HC (n=83) - age (y) 73.6±9.8 - education (y) 8.1±4.6 - % male n.r.			
Giannouli <i>et al.</i> (2018) ⁺	Italy	CS	PD with dementia (n = 17) - age (y) n.r. ^e - education (y) n.r. ^e - % male n.r. ^e	LCPLTAS (scores on seven domains, total score based on all domains) - MMSE 21.6±4.5 ^f - UPDRS n.r. - H&Y n.r.	- People living with PDD showed a significantly lower FDM performance than HC on the LCPLTAS total score and on all domains separately.	PDD < HC
			HC (n = 22) - age (y) n.r. ^e - education (y) n.r. ^e - % male n.r. ^e			

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Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Giannouli & Tsolaki (2019)	Italy	CS	PD with dementia without depression (n = 16)	LCPLTAS (total score based seven domains)	<ul style="list-style-type: none"> - People living with PDD with and without depression showed a significantly lower FDM performance than HC with and without depression on the LCPLTAS total score. - People living with PDD with depression showed a significantly lower FDM performance than people living with PDD without depression on the LCPLTAS total score. 	PDD < HC
			- age (y) 77.2±7.4			
			- education (y) 8.1±93.6			
			- % male n.r. ^c			
			PD with dementia and depression (n = 14)			
Martin <i>et al.</i> (2013)	USA	CS	- age (y) 74.7±10.4	FCI (scores on domains 1-9, total score based on domains 1-7 and total score based on domains 1-7, 9)	<ul style="list-style-type: none"> - People living with PD-MCI showed significantly lower FDM performances than HC on the FCI total score and on the domains 'basic monetary skills', 'financial concepts' and 'investment decisions'. No significant differences were found between patients with PD-MCI and HC regarding all other domains. - Patients with PDD showed significantly lower FDM performances than HC and patients with PD-MCI on the FCI total score and on all domains separately, with the exception of 'financial judgment' and 'knowledge of assets/estate arrangement'. 	PDD ≤ PD-MCI ≤ HC
			- education (y) 9.2±4.9			
			- % male n.r. ^c			
			HC without depression (n = 16)			
			- age (y) 77.1±7.5			
			- education (y) 8.2±3.4			
			- % male n.r. ^c			
			HC with depression (n = 14)			
			- age (y) 74.8±10.1			
			- education (y) 8.9±4.3			
Pirgovsky <i>et al.</i> (2012)	USA	CS	- % male n.r. ^c	AFT (total score)	<ul style="list-style-type: none"> - Patients with PD showed significantly lower FDM performances than HC on the AFT total score. Group differences remained significant after exclusion of people living with PDD (n=7). 	PD < HC
			PD with dementia (n=17)			
			- age (y) 71.0±6.1			
			- education (y) 15.1±3.3			
			- 76.5% male			
			PD with MCI (n=18)			
			- age (y) 66.9±9.3			
			- education (y) 14.7±2.5			
			- 50.0% male			
			HC (n=20)			
Pirgovsky <i>et al.</i> (2012)	USA	CS	- age (y) 69.5±8.1	AFT (total score)	<ul style="list-style-type: none"> - Patients with PD showed significantly lower FDM performances than HC on the AFT total score. Group differences remained significant after exclusion of people living with PDD (n=7). 	PD < HC
			- education (y) 15.2±2.7			
			- 50.0% male			
			PD (n=33)			
			- age (y) 71.2±1.4			
			- education (y) 16.6±0.4			
			- 72.7% male			
			HC (n=26)			
			- age (y) 69.8±1.3			
			- education (y) 16.4±0.5			
			- 65.4% male			

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Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Pirgovsky <i>et al.</i> (2013, 2014) ^f	USA	CS	PD with MCI (n=41) - age (y) 69.2±7.1 - education (y) 15.8±2.8** - 73.2% male PD cognitively unaffected (n=56) - age (y) 66.7±7.5 - education (y) 17.1±2.4 - 58.9% male HC (n=47) - age (y) 67.1±8.7 - education (y) 16.4±2.5 - 46.8% male	Subscale 'finances' of the UCSD performance-based skills assessment (total score) - DRS 136.7±4.0** - UPDRS 23.1±12.3 - H&Y (median) 2 - DRS 140.1±2.9 - UPDRS 25.6±12.3 - H&Y (median) 2	- When combining both PD groups, people living with PD showed significantly lower FDM performances than HC on the total score of the 'finances' subscale. - People living with PD-MCI showed significantly lower FDM performances than HC on the total score of the 'finances' subscale. No differences in FDM were found between people living with PD-MCI and people living with PD who were cognitively unaffected and between people living with PD who were cognitively unaffected and HC.	PD < HC PD-MCI < HC PD cognitively unimpaired = PD-MCI and HC

Table 4.2e. Overview of studies measuring financial decision-making in people living with multiple sclerosis (k = 3).

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Gerstenecker, Myers <i>et al.</i> (2017)	USA	CS	MS (n=22) / Type: primary progressive and secondary progressive - age (y) 49.4±8.7 - education (y) 13.6±2.5 - 40.9% male HC (n=18) - age (y) 48.6±8.8 - education (y) 13.8±2.0 - 33.3% male	FCI (scores on domains 1-7, 9, total score based on domains 1-7, 9) - Global cognition n.r. - Onset MS (y) ≥ 5 - EDSS 5.9±1.0	- People living with MS showed a significantly lower FDM performance than HC on the FCI total score and on all domains separately, with the exception of 'financial judgment' and 'bill payment'. - In people living with MS, 36.4% were classified as severely impaired (degree of impairment ≤ 2.5*) and 13.6% were classified as mild/moderately impaired (degree of impairment ≤ 1.5 to > 2.5*) based on the FCI total score.	MS ≤ HC
Goverover <i>et al.</i> (2016)	USA	CS	MS (n=30) / Type: relapsing remitting, primary progressive and secondary progressive - age (y) 47.9±10.6 - education (y) 16.3±2.0 - 23.3% male HC (n=23) - age (y) 50.0±9.4 - education (y) 16.0±2.3 - 43.5% male	Money management skills assessed with a website-based AR test (score on five goal-directed actions, total score on five goal-directed actions) - MSFC (z) -1.3±2.0 - Global cognition n.r.	- People living with MS showed a significantly lower FDM performance than HC on the AR test total score. More specifically, people living with MS showed significantly more errors than HC with regard to 'credit card use' and 'performing at an efficient pace' on the AR test. No group differences between people living with MS and HC were found on the other goal-directed actions.	MS ≤ HC

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Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Tracy <i>et al.</i> (2017)	USA	CS	MS cognitively impaired (n=14) / Type: relapsing remitting and uncertain <ul style="list-style-type: none"> - age (y) 46.8±11.1 - education (y) 14.2±1.9 - 28.6% male MS cognitively unaffected (n=20) Type: relapsing remitting, secondary progressive, progressive relapsing and uncertain <ul style="list-style-type: none"> - age (y) 44.3±11.7 - education (y) 15.3±2.5 - 15.0% male HC (n=16) <ul style="list-style-type: none"> - age (y) 44.3±13.4 - education (y) 14.2±2.1 - 37.5% male 	FCI (scores on domains 1-7, 9, total score based on domains 1-7, 9)	<ul style="list-style-type: none"> - Cognitively impaired people living with MS showed significantly lower FDM performances than HC and cognitively unaffected people living with MS on the FCI total score and on all domains separately, with the exception of 'cash transactions' and 'financial judgment'. - No significant differences were found between cognitively unaffected people living with MS and HC regarding the performances on the FCI. 	MS cognitively impaired ≤ MS cognitively unaffected = HC

Table 4.2f. Overview of the study measuring financial decision-making in people living with Huntington's disease (k = 1).

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Sheppard <i>et al.</i> (2017)	USA	CS	HD (n=20) / Stage: symptomatic <ul style="list-style-type: none"> - age (y) 58.8±12.3 - education (y) 15.2±3.1 - 45.0% male HC (n=20) <ul style="list-style-type: none"> - age (y) 61.0±13.7 - education (y) 16.5±2.6 - 40.0% male 	AFT (total score) <ul style="list-style-type: none"> - MDRS 133.7±8.4 - Age of disease onset (y) 50.4±2.8 - UHDRS-TFCS 9.4±0.7 - CAG 42.0±0.6 	<ul style="list-style-type: none"> - People living with HD showed significantly lower FDM performances than HC on the AFT total score. 	HD < HC

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Note of Table 4.2. All results are considered significant when $p < .05$.

ACED = Assessment of Capacity for Everyday Decision-making; **AD** = Alzheimer's disease; **AFT** = Advanced Finances Test; **AR test** = Actual Reality test; **CAG** = number of C-A-G repeats; **CDR** = Clinical Dementia Rating; **Cho/Cr ratio** = Choline-containing compounds/Creatine ratio; **CS** = Cross-Sectional study; **DAFS** = Direct Assessment of Functional Status; **DMCAT** = Decision Making Competence Assessment Tool; **DRS** = Dementia Rating Scale; **EDSS** = Expanded Disability Status Score; **FACT** = Financial Assessment and Capacity Test; **FCAI** = Financial Competence Assessment Inventory; **FCI** = Financial Capacity Instrument; **FCI-SF** = Financial Capacity Instrument – Short Form; **FCQ** = Financial Competency Questions; **FDM** = Financial Decision-Making; **FTD** = frontotemporal dementia; **GDS** = Global Deterioration Scale; **HC** = Healthy controls; **HD** = Huntington's disease; **H&Y** = Hoehn and Yahr stage; **ILS** = Independent Living Scale; **LCPLTAS** = Legal Capacity for Property Law Transactions Assessment Scale; **LS** = Longitudinal study; **MCI** = Mild Cognitive Impairment; **MDRS** = Mattis Dementia Rating Scale; **MMSE** = Mini-Mental State Examination; **MoCA** = Montreal Cognitive Assessment; **MRI** = Magnetic Resonance Imaging; **n.r.** = not reported; **MS** = Multiple Sclerosis; **MSFC** = Multiple Sclerosis Functional Composite score; **N/A** = not applicable; **NAA/CR ratio** = N-Acetylaspartate/Creatine ratio; **NAB** = Neuropsychological Assessment Battery; **NADL** = Numerical Activities of Daily Living; **NADL-F** = Numerical Activities of Daily Living – Financial; **PD** = Parkinson's disease; **PDD** = Parkinson's disease dementia; **PD-MCI** = Parkinson's disease with mild cognitive impairment; **SAILS** = Structured Assessment of Independent Living Skills; **SCIFC** = Semi-Structured Clinical Interview for Financial Capacity; **SUVr** = Standardized Uptake Value ratio; **TTFW** = Timed 25-Foot Walk; **UCSD** = University of California, San Diego; **UHDRS-TFCS** = Unified Huntington's Disease Rating Scale - Total Functional Capacity Score; **UPDRS** = Unified Parkinson's Disease Rating Scale; **UMCFAB** = University of Miami Computer-Based Functional Assessment Battery.

^a Percentage male cited from original article, however, the sum of the number of males and females in article does not correspond with total number of participants.

^b No official name of test reported, test is likely a pilot version of the LCPLTAS.

^c Participants were matched based on age, sex and/or level of education.

^d Not described in original article whether global cognition score(s) reflect baseline or follow-up.

^e Global cognition = average z-score based on nineteen measures of cognition.

^f Two studies presumably used the same sample and are therefore considered and described as one study.

^g Degree of impairment = $(\text{mean_HC} - \text{score_person living with MS}) / \text{SD_HC}$.

⁺ Study included more than one NDD group.

⁺⁺ In collaboration with authors from other countries.

^{*} Significant difference between people living with an NDD and HC.

[§] Significant difference with other NDD group(s).

[?] Group differences not analyzed/reported.

< performances significantly worse on all FDM outcome measures;

≤ performances significantly worse on some FDM outcome measures, but not all.

= performances are equal on all FDM outcome measures.

Figure 4.2. Forrest plot of studies measuring financial decision-making in people living with Alzheimer’s disease (AD), mild cognitive impairment (MCI), frontotemporal dementia (FTD), Parkinson’s disease (PD) or multiple sclerosis (MS).

Figure 4.3. Funnel plots of studies measuring financial decision-making in people living with Alzheimer's disease (AD), mild cognitive impairment (MCI), frontotemporal dementia (FTD), Parkinson's disease (PD) or multiple sclerosis (MS) included in the meta-analysis. An asymmetric funnel plot indicates publication bias.

Table 4.3. Associations between FDM and cognition in people living with neurodegenerative diseases.

Study	Group	FDM task	Global cognition	Verbal memory	Episodic memory	Prospective memory	Visuospatial memory	Verbal fluency	Processing speed	Attention	Language	Executive functions	Working memory	Cognitive flexibility	Verbal reasoning	Abstract reasoning	Initiation and perseveration	Numeracy	Visuospatial abilities
Bassett 1999	AD	FCQ	n.s.	+					+				+					+	
Earnst et al. 2001	AD	FCI																	
Griffith et al. 2007	AD	FCI	+										+					+	
Kershaw & Webber 2008	AD	FCAI	+										+						
Martin, Griffith et al. 2008	AD	FCI	+																
Sherod et al. 2009*	AD	FCI	n.s.	+				n.s.	+	n.s.		n.s.						+	n.s.
Stoeckel et al. 2013	AD	FCI	+	n.s.						+		+							n.s.
Arcara et al. 2019	MCI ^f a	NADL-F	+	+				+					+						n.s.
Bangen et al. 2010	MCI ^f	ILS	+	n.s.								n.s.							
Benavides-Varela et al. 2015*	MCI	NADL		n.s.						n.s.	n.s.	n.s.				+			+
Czaja et al. 2017	MCI	UMCFAB		n.s.				n.s.	+					+	n.s.				n.s.
Duke Han et al. 2015*	MCI	DMCAT	+	+	n.s.				+				+						n.s.
Gerstenecker et al. 2016	MCI	FCI	+																
Griffith et al. 2010	MCI	FCI							+	+								+	
Niccolai et al. 2017	MCI	FCI		n.s.				+	+	n.s.	+	n.s.						+	
Niccolai et al. 2017*	MCI	FCI		n.s.			+	n.s.	+	n.s.	n.s.	n.s.						+	
Okonkwo et al. 2006*	MCI	FCI		n.s.						+	n.s.	+							n.s.
Sherod et al. 2009*	MCI	FCI	n.s.	n.s.				n.s.	n.s.	n.s.	+	+						+	n.s.
Clark et al. 2014	mixed ^b	FCI	+	+	n.s.					n.s.	+	n.s.	+				+		
Lui et al. 2013	mixed ^b	ACED	+	n.s.				+											
Giannouli & Tsolaki 2014*	mixed ^d	FDM test ^e	+																
Giannouli et al. 2018*	mixed ^e	LCPLTAS	+	n.s.			n.s.	n.s.		n.s.		+	+						
Giannouli & Tsolaki 2019	PD ^f	LCPLTAS	+																
Pirogovsky et al. 2012	PD	AFT	+			+													
Pirogovsky et al. 2013/2014 ^f	PD	UCSD-PBSA	n.s.	n.s.			n.s.			n.s.	n.s.	n.s.							n.s.
Gerstenecker, Myers et al. 2017	MS [†]	FCI	+	+			+		+	+	+	+	+					+	
Goreover et al. 2016	MS [†]	AR test		+		n.s.	+		+			+	+						
Tracy et al. 2017*	MS [†]	FCI		+									+	+					
Sheppard et al. 2017	HD	AFT	+																
SUMMARY (k significant / k number of studies)			15/19	7/18	0/2	1/2	4/6	3/8	10/11	4/12	3/7	6/13	8/8	2/2	1/1	2/3	1/1	8/8	1/8
SUMMARY (% significant)			78.9	38.9	0.0	50.0	66.7	37.5	90.9	33.3	42.9	46.2	100.0	100.0	100.0	66.7	100.0	100.0	12.5

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Note of Table 4.3. All correlations are in the expected direction (e.g., poorer performances on a test of cognition are associated with poorer performances on test of FDM). Empty gray cell means that cognitive domains were not evaluated. **AD** = Alzheimer's disease; **ACED** = Assessment of Capacity for Everyday Decision-making; **AFT** = Advanced Finances Test; **AR test** = Actual Reality test; **DMCAT** = Decision-Making Competence Assessment Tool; **FCAI** = Financial Competence Assessment Inventory; **FCI** = Financial Capacity Instrument; **FCQ** = Financial Competency Questions; **HD** = Huntington's disease; **ILS** = Independent Living Scale; **LCPLTAS** = Legal Capacity for Prospective and Retrospective Memory Questionnaire; **MCI** = mild cognitive impairment; **MS** = multiple sclerosis; **NADL** = Numerical Activities of Daily Living; **NADL-F** = Numerical Activities of Daily Living - Financial; **PD** = Parkinson's disease; **UCSD-PBSA** = University of California, San Diego - Performance-Based Skills Assessment; **UMCFAB** = University of Miami Computer-Based Functional Assessment Battery.

^a Includes also 5 people living with pathologies other than MCI.

^b Mixed group including people living with AD, people living with MCI and healthy controls.

^c No official name of test reported, test is likely a pilot version of the LCPLTAS.

^d Mixed group including people living with AD, people living with MCI, people living with PD and healthy controls.

^e Mixed group including people living with AD patients, people living with MCI, people living with PD, people living with FTD, people living with vascular dementia and healthy controls.

^f Studies presumably used the same sample and are therefore considered and described as one study.

[†] Included both people with an NDD and healthy controls in analyses.

* (multiple) regression analyses used instead of correlation analyses.

+ Means significant correlation/predictor.

n.s. Means not significant correlation/predictor.

Discussion

The aim of the present study was to provide a comprehensive overview and meta-analysis of studies evaluating FDM in people living with an NDD. For this, the reliability of performance-based tests to consistently identify FDM difficulties in people living with an NDD compared to healthy controls was evaluated. Furthermore, if studies allowed, the performances on tests of FDM between groups with different NDDs was compared. Finally, the influence of disease severity and disease progression on FDM was explored, as well as the associations between FDM and performances on standard measures of cognition and demographic variables (i.e., age, sex and education). In the current review, FDM is used as a hypernym for every day knowledge, performances, skills and actions related to the use of money. Gambling or risk-taking were not taken into account. According to the conceptual model of financial capability (Appelbaum et al., 2016), gambling or risk-taking are contextual factors that may be of influence on financial competence and can result in a decreased financial performance in everyday life. Since the present review focuses specifically on the competence or capacity to make financial decisions, contextual factors such as gambling or risk-taking were, therefore, considered to be beyond the scope of this review. With the inclusion of 47 studies, the performances of people living with AD, MCI, FTD, PD, MS or HD could be compared to the performances of healthy controls. Meta-analyses were conducted within each group if more than one study could be included. The majority of studies included people living with AD and/or MCI (i.e., 38 studies in total).

FDM in patients with NDDs

All included studies consistently reported more problems with FDM, based on performance-based tests, in people living with different NDDs compared to healthy controls. This is confirmed by the medium to large pooled mean effect sizes found for each group in the meta-analyses (no meta-analysis has been performed for people living with HD). The severity of cognitive decline in people living with an NDD seems to be related to the degree of problems with FDM. People living with AD, characterized by problems in multiple domains of cognition resulting in problems in daily life (American Psychiatric Association, 2013), have, for example, significantly more problems with FDM than people living with MCI (Gerstenecker et al., 2018, 2019; Gerstenecker, Hoagey, et al., 2017; Giannouli et al., 2018; Giannouli & Tsolaki, 2014; Griffith et al., 2003; Lui et al., 2013; Marson et al., 2009; Martin et al., 2019; Tolbert et al., 2019). This corresponds with the significantly larger pooled mean effect size found for people living with AD compared to people living with MCI. Also, over time, a significant deterioration of FDM performances is found in people living with MCI and people living with AD in longitudinal studies. Within this context, some domains of FDM seem to be less vulnerable to cognitive decline than others. In people living with MCI, the domains ‘basic monetary skills’ and ‘financial judgment’ of the FCI appear relatively intact since no differences were found compared to healthy controls (Gerstenecker et al., 2016, 2019; Gerstenecker, Hoagey, et al., 2017; Griffith et al., 2003). Both domains are described as relatively simple tasks of FDM (Griffith et al., 2003). Similar results are found for people living with mild AD (Gerstenecker, Hoagey, et al., 2017; Giannouli et al., 2018; Griffith et al., 2003; Loewenstein et al., 1989; Marson et al., 2000, 2009; Martin et al., 2019). However, when AD progresses to more advanced stages, significantly poorer performances are found on all assessed domains of FDM in people living with AD compared to people living with MCI and healthy controls. Also, when matched for their dementia severity (Lima-Silva et al., 2015) or when compared to people living with moderate to severe AD (Giannouli et al., 2018), people living with FTD and people living with AD show comparable performances on performance-based tests of FDM. Finally, also people living with PDD show more problems with FDM than people living with PD-MCI (Martin et al., 2013) and, interestingly, similar performances on FDM were found between healthy controls and people living with PD who were cognitively unaffected and people living with MS who were cognitively unaffected (Pirogovsky et al., 2014; Tracy et al., 2017).

The impact of cognition on FDM is further supported by the significant relations found between measures of global cognition and performances on tests of FDM in different NDD groups. The strength of these associations, however, differs between groups and seems to depend on the tests used for the assessment of FDM and global cognition. With regard to specific cognitive functions, especially working memory appears to be relevant for adequate performance on tests of FDM (e.g., Czaja et al., 2017; Earnst et al., 2001; Tracy et al., 2017; Table 4.3). Also processing speed and numeracy are consistently found to be related to FDM (e.g., Gerstenecker, Myers et al., 2017; Griffith et al., 2010; Sherod et al., 2009; Table 4.3). According to the scientific literature and diagnostic guidelines (American Psychiatric Association, 2013), impairments in (verbal) memory and executive functions are predominantly present in typically amnesic syndromes (e.g., MCI and AD) and dysexecutive syndromes (e.g.,

FTD or PDD), respectively. These cognitive problems, however, seem to insufficiently explain the diminished performances on FDM in these groups since results with regard to the relation between both domains of cognition and FDM are inconsistent. This might explain why no profound differences appear to be present between the NDDs with regard to FDM.

Besides the relation between specific cognitive functions and FDM, also the associations between other potential determinants and FDM were evaluated in some studies. In people living with MCI, being younger and more years of education were found to be related to fewer difficulties with FDM (Duke Han et al., 2015; Lassen-Greene et al., 2017; Lui et al., 2013; Niccolai et al., 2017; Tolbert et al., 2019). An association between age and FDM was not found in people living with AD (Bassett, 1999; Mahurin et al., 1991; Martin, Griffith, et al., 2008). Significant group differences on measures of FDM between people living with AD and people living with FTD were, however, no longer significant when controlled for age (Gill et al., 2019), assuming some influence of age. The results with regard to the relation between sex, years of education and performances on measures of FDM in people living with AD are mixed (Bassett, 1999; Giannouli et al., 2018; Mahurin et al., 1991; Martin, Griffith, et al., 2008) and in the other NDDs these variables are insufficiently examined to draw conclusions. In people living with MS and people living with PD, studies found evidence that FDM is related to disease severity and motor disabilities (Pirogovsky et al., 2012; Tracy et al., 2017), but again results are mixed. Furthermore, some studies found a negative influence of symptoms of depression on FDM outcomes in people living with MCI and people living with PD (Niccolai et al., 2017; Pirogovsky et al., 2012, 2013). Within the context of other NDDs, this relation was absent or not studied. In most studies, however, clinically depressed people were excluded from the sample which makes the evaluation of the impact of this variable difficult.

In summary, even though there are some indications that FDM is associated with demographic variables and disease characteristics, overall, these associations are not evaluated systematically in the included studies. However, their potential influence on measures of FDM cannot be ruled out, especially since it is known that these variables have an influence on cognitive functioning (e.g., Murman, 2015; Van Der Elst et al., 2006b, 2006c, 2006a; Van Hooren et al., 2007). Therefore, future studies should control for group differences in these variables. Also, the impact of symptoms of depression on FDM is not well studied even though this variable might have a potential negative influence on performances on FDM. It is important to study this association in more detail since symptoms of depression are frequently present in people living with an NDD (Baquero & Martín, 2015). Furthermore, the influence of motor disabilities and disease severity in NDDs such as PD and MS should further be evaluated, especially when using performance-based tests that potentially require motor actions. Additional factors are also found to be of influence on someone's ability to make financial decisions, such as financial experience (Eberhardt et al., 2019; Marson et al., 2000) and income level (Bangma et al., 2017). Only a few of the included studies controlled for financial experience (Bassett, 1999; Griffith et al., 2003; Marson et al., 2000, 2009; Martin, Griffith, et al., 2008; Sherod et al., 2009; Stoeckel et al., 2013; Triebel et al., 2009) and none of the studies examined other potential influential variables such as income level.

Evaluation of FDM tests

In total, nineteen different measures of FDM were used in the included studies. One of the most frequently used tests is the FCI (i.e., in 22 of 47 studies; Marson et al., 2000). Furthermore, the conceptual model of Appelbaum & Grisso (1988) is frequently used as a basis of FDM tests, e.g., for the FACT (Black et al., 2007) and ACED (Lai et al., 2008; Lai & Karlawish, 2007). Most tests simulate everyday FDM abilities, such as counting coins or paying bills. Some studies, however, used experimental tests or new scales to assess FDM. Consequently, psychometric properties of these tests are currently unknown. For some tests (i.e., FCI and DAFS) marked differences were observed between studies that used these tests, as different domains were included and total scores were calculated in different ways. With regard to the FCI, various versions have been developed over time, since new domains are introduced and different minimum and maximum scores are calculated for the same FCI domains (e.g., Earnst et al., 2001; Marson et al., 2000; Martin et al., 2019; Martin, Griffith, et al., 2008). This makes a direct comparison between studies that applied the FCI difficult.

A major problem that has been identified within the context of assessment of FDM is the lack of accessibility to tests measuring FDM which contributes to the development of new FDM tests (Engel et al., 2016). Even though differences in financial systems and procedures between countries sometimes require the development or adjustment of tests, more openness, collaboration and sharing test material is recommended to improve current and future tests focusing on FDM. Furthermore, the ecological validity of FDM tests remains unclear and it can, therefore, not be determined how performances on these tests can be translated to strengths and weaknesses within the context of money management in everyday life. For example, intact performance of people living with relatively mild cognitive disturbances, such as people living with MCI and mild AD, on specific domains of FDM tests suggest the preservation of some FDM skills. Possibly these people can function relatively well in everyday life when performing more basic FDM related actions, such as grocery shopping or paying bills, but need assistance with more complex tasks, such as buying property or taking out (health) insurance(s). Currently it is, however, not possible to formulate clear advice for people living with NDDs and their relatives based on FDM test performances. It also remains unclear whether a deterioration or decline in FDM, as observed in longitudinal studies, results in more everyday life problems. Ceiling effects are frequently found in healthy controls and the actual differences between groups are often very small in terms of scores or points on a test. Therefore, an important focus for further research is the ecological validity of FDM tests. The lack of normative data also complicates the use of performance-based FDM tests in clinical practice.

There are also other reasons why the formulation of (legal) decisions about someone's capacity to manage his or her finances is not possible solely based on performance-based FDM tests. First, it is unclear whether current FDM tests investigate all domains of financial competence. Recently, Engel et al. (2016) described nine domains of financial skills (e.g., basic monetary skills, paying bills, budgeting) and concluded that none of the currently available FDM tests examine all nine domains. Different theoretical models are used and there is major variability in content, type of tasks and administration between tests. More theoretical consensus and the development of more multidimensional FDM instruments, including both

simple and complex financial skills, is therefore recommended. Furthermore, most FDM tests focus on either practical financial skills, financial knowledge or the ability to judge and make decisions, which are also described as someone's financial competence (Appelbaum et al., 2016). Financial competence or FDM, however, also relies on contextual factors and financial performances (i.e., the abilities and opportunities to implement financial decisions in everyday life; ABA/APA, 2008; Appelbaum et al., 2016), which are both insufficiently assessed in current research. Finally, it is of utmost importance that decisions about a person's financial competence should be taken carefully to minimize the risk of, e.g., financial abuse. According to Engel et al. (2016), the currently available most useful tests for the evaluation of a person's financial competence are the FCI and SCIFC. Also, the LCPLTAS, which is based on the FCI, and the FCAI might be useful in this context. However, according to our knowledge, these tests have, so far, only been used in research and are not available for use in clinical practice. In order to make these tests suitable for clinical practice, more information about the clinimetrics of these tests is needed. Furthermore, as already mentioned, normative data is largely lacking. Only with this type of data, the performance on a financial competence test of an individual living with an NDD can be interpreted.

Limitations

Some limitations may be of influence on the conclusions drawn in the present study and need to be taken into account. First, there might be different interpretations of what is considered a performance-based test and what is considered a self and proxy report. According to the best of our knowledge, we included only performance-based tests of FDM and excluded all studies using self-report or proxy report assessments of FDM. However, only half of the tests included in this review were also identified as tests of FDM in a recent review identifying instruments to quantify financial management skills (Engel et al., 2016). One test included in this review (i.e., the ACED) was even described as a 'combined self-report and proxy report' measure of FDM. The ACED indeed partly contains a proxy evaluation of FDM. However, in the current review the other part of this test was considered as performance-based because of the way the test is administered and scored. Finally, some other tests (e.g., NADL-F or LCPLTAS) were published after the review of Engel et al. was conducted. Second, studies included in this review and meta-analyses vary in study design. For example, they vary in sample characteristics or FDM tests used. Furthermore, the diagnostic criteria for the different NDDs and the accuracy of diagnosis evolved over time. For example, the diagnostic criteria for dementia as described in the diagnostic and statistical manual of mental disorders (DSM) IV-TR changed to include minor and major neurocognitive disorders in the DSM-5 in 2013. Since the publication dates of the studies that were included in the present systematic review and meta-analysis ranges from 1989 to 2019, adaptations to diagnostic criteria and improvements in accuracy of diagnosis of NDDs most likely were of influence on the results found in the different studies. Consequently, the heterogeneity between studies is relatively high (I^2 ranged between 48.9% to 93.5%; Higgins et al., 2003). Random-effects methods instead of fixed-effects methods are used in the meta-analyses. Nevertheless, this unavoidable bias in clinical research might have been of influence on the results, so that the meta-analytic pooled mean effect sizes need to be

interpreted with caution. Furthermore, the funnel plots (Fig. 3) cannot sufficiently confirm or exclude the possibility of publication bias because of the relatively small number of studies for each NDD group. Observed asymmetry might also be the result of heterogeneity between studies and the random-effects method used (Deeks et al., 2019). Third, the present study was not preregistered. For reasons of transparency, reproducibility and rigor this should have been done. Finally, no evaluation of the risk of bias has been executed. According to our knowledge, there is no valid and reliable tool available for the evaluation of the risk of bias for cross-sectional studies as included in the current review. The inability to appropriately evaluate the risk of bias and publication bias of the included studies, together with the moderate to high heterogeneity between studies, therefore need to be considered when interpreting the results.

Conclusion

Taking these limitations into account, there is ample evidence that people living with an NDD are vulnerable for impairments in their capacity to make financial decisions. FDM performance in people living with an NDD appears to be related to cognitive decline, specifically in working memory, processing speed and numeracy. However, the number of studies focusing on FDM in people living with an NDD other than AD or MCI are limited or have not been performed to date. Further research is thus necessary to further elaborate this topic. Furthermore, the associations between the observed problems with FDM and difficulties in everyday life remain unclear. It is conceivable that problems with FDM can lead to major negative consequences in the everyday lives of people with living with an NDD and their relatives and can result in debts or poverty. A focus on more multidimensional research on FDM and an emphasis on the ecological validity of current and new FDM tests is therefore recommended.

Appendices

Appendix 4-1. Overview of primary and secondary keywords used for search.

Primary search terms	Primary keywords
neurodegenerative *	neurodegenerative neurodegenerative disease(s)/disorder(s)
parkinson *	parkinson parkinson disease/disorder parkinson's disease/disorder
alzheimer *	alzheimer alzheimer disease/disorder alzheimer's disease/disorder
huntington *	huntington huntington disease/disorder huntington's disease/disorder
multiple sclerosis	multiple sclerosis
progressive supranuclear palsy	progressive supranuclear palsy
amyotrophic lateral sclerosis	amyotrophic lateral sclerosis
* dementia	dementia frontotemporal dementia vascular dementia lewy bodies dementia
* cognitive impairment	cognitive impairment(s) mild cognitive impairment(s) vascular cognitive impairment(s)
Secondary search terms	Secondary keywords
finance	finance finances
financial *	financial financial ability/abilities financial capability financial capacity financial competence financial decision(s) financial decision(-)making financial literacy financial management financial planning
money *	money money management

Appendix 4-2. References of the included articles.

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* Articles with asterisk were also included in meta-analysis.

CHAPTER

5

FINANCIAL DECISION-MAKING CAPABILITY OF PATIENTS WITH MILD COGNITIVE IMPAIRMENTS, ALZHEIMER'S DISEASE AND PARKINSON'S DISEASE:

A case control approach.

Based on:

*“Een nieuwe testbatterij gericht op financiële
competentie en financiële prestaties: Hoe
presteren patiënten met neurodegeneratieve
aandoeningen hierop?”*

J. Koerts, D.F. Bangma, J. Jansen,
P.P. De Deyn & O. Tucha

Neuropraxis (2020)

Abstract

Making adequate financial decisions is very important to our autonomy. Loss of or reduction in the capability to make those decisions often has major consequences, such as financial shortfalls or financial abuse. An important question is how to assess that capability in a person. Capability to make financial decisions is a wide-ranging concept, and it can therefore be difficult to assess all the aspects and concepts that fall under this heading correctly and systematically. This article presents a battery of seven tests of financial competence, financial performance and related contextual factors – concepts that in Appelbaum et al.'s framework underlies the capability to make financial decisions. In order to assess the extent to which and the way in which neurodegenerative disorders affect that capability, the performance scores of nine patients (i.e., three with Alzheimer's disease, three with mild cognitive impairment and three with Parkinson's disease) on the test battery were presented and discussed.

Introduction and Methods

We make many financial decisions in our everyday life, ranging from relatively simple decisions, such as buying products at the supermarket, to relatively complex ones, such as taking out a mortgage or insurances. By making financial decisions we can meet our own (and if necessary other people’s) basic needs, e.g., buying food and providing a roof over our head. Adequate capability to make financial decisions is also necessary to our independence or autonomy (i.e., our self-reliance and ability to decide for ourselves what needs to happen). It comes as no surprise, then, that loss of or reduction in that capability often has major consequences for both the person concerned and those around them, and can result in serious financial problems.

The capability to make financial decisions is defined as successfully managing (or guiding the management of) a person’s own financial resources in line with their needs and goals (Appelbaum et al., 2016). As shown schematically in Figure 5.1, ‘financial competence’ and ‘financial performance’ underlie the capability to make financial decisions. Financial competence refers to financial skills, which we can measure in a controlled setting and

Figure 5.1. Conceptual model of financial capability (based on figure S-1 in Appelbaum, et al., 2016).

comprises two aspects: (1) financial knowledge (e.g., knowledge of financial terms and concepts and knowledge of one's own finances; also procedural knowledge of how to pay a bill or how to take out an insurance), and (2) financial judgment (i.e., ability to make financial decisions or choices based on one's best interests). Financial performance is defined as the success in dealing with financial tasks in everyday life. It is highly influenced by the context in which those financial tasks are performed, with the result that financial competence does not always match financial performance in everyday life: the subject may be sufficiently financially competent but display reduced financial performance due to depression, for example. Or the subject may have reduced financial competence but nevertheless appear to be financially capable as a result of social support and assistance. Contextual factors thus play a major role, having an influence on both financial competence and financial performance in everyday life.

An important – but difficult – question is how best to assess the capability to make financial decisions. This is a question that needs careful answering, as an incorrect assessment of a person's capability can result in loss of autonomy, financial shortfalls or even financial abuse. There are, however, no tests or questionnaires to measure a person's capability to make financial decisions directly. There are several performance tests and questionnaires that focus on financial competence and financial performance, but to date they have only been usable in a research setting. Appelbaum et al. (2016), Ghesquiere et al. (2019) and Bangma, Tucha, Tucha et al. (2020) all provide an overview of the tools available, and some of those articles describe the pros and cons of those tests and questionnaires. Most of the tools available focus on measuring financial competence and claim to measure financial knowledge and/or financial judgment. Financial knowledge is examined, e.g., by assessing whether the subject is able to explain what a mortgage is or to show how to pay a bill. As regards financial judgment, case studies of a hypothetical financial problem are presented and five different skills are assessed (Appelbaum et al., 2016; Bangma, Tucha, Tucha, et al., 2020; Ghesquiere et al., 2019; Marson, 2016):

1. Identification: competence to identify the financial problem.
2. Understanding: competence to understand information relevant to a financial situation or transaction and related situations or transactions.
3. Appreciation: competence to relate information on a financial situation or transaction and related situations or transactions to one's own personal situation.
4. Reasoning: competence to reason and think logically about the various choices involved in a financial situation or transaction.
5. Communication: competence to make a choice within the context of a financial situation or transaction and articulate it clearly.

There are a few tools that claim to assess financial performance in everyday life. That aspiration is not an easy one to meet in view of privacy considerations, as the patient needs to be willing to provide at least some insight into their personal finances. Tools that focus on financial performance in everyday life mainly assess whether the patient is able to meet their basic needs while they may still be able to do so (especially if they have sufficient funds) while their capability to make financial decisions is reduced. A converse scenario is also possible,

i.e., the subject is not able to meet their basic needs, despite the fact that they have adequate capability to make financial decisions.

Unfortunately, to date (as far as we know) none of the published performance tests or questionnaires that focus on measuring financial competence and/or performance is available in Dutch. Also, as the foregoing makes clear, it is not possible to make a good estimate of a person's ability to make financial decisions by merely looking at their financial competence (i.e., financial knowledge or financial judgment) or financial performance. Lastly, it is noteworthy that none of the published tools measures contextual factors that have an influence on financial performance and competence, or that are inherent in financial behaviour in everyday life, such as income, impulse buying behaviour or different coping and personality styles that influence financial decisions. It would seem, then, that a broad-based, detailed approach is needed to gain a good understanding of a person's capability to make financial decisions. It was therefore decided to compile and develop a comprehensive Financial Decision-Making (FDM) test battery, one that covers not only financial competence and financial performance but also contextual factors that could have an influence on financial competence and performance. The battery (or parts of it) has/have been used on various groups of participants (Bangma et al., 2017, 2019; Bangma, Tucha, Fuermaier, et al., 2020) with the aim of gathering information on it and developing it so that it can eventually be used in clinical practice.

This article focuses specifically on describing the test battery and the initial results of a study that used it on patients with neurodegenerative disorders, namely Alzheimer's disease (AD), mild cognitive impairment (MCI) or Parkinson's disease (PD). The aim of the study is to assess to what extent and in what way those neurodegenerative diseases affect the capability to make financial decisions.

The Financial Decision-Making (FDM) test battery

The test battery compiled and developed to assess the capability to make financial decisions comprises seven different tests (Bangma et al., 2017).

1. The aim of the Dutch version of the Financial Competence Assessment Inventory (FCAI) is to measure the subject's strengths and weaknesses regarding financial judgment and financial knowledge. It comprises six different subscales: 'everyday financial abilities (e.g., ability to understand information on an invoice); 'financial judgment' (e.g., identifying and understanding information on a bank statement); 'financial management' (e.g., understanding banking protocols); 'financial cognitive functioning' (e.g., making a funds transfer); 'debt management' (e.g. having an overview of one's personal debts); and 'financial support resources' (e.g., knowing who or what can provide support with financial problems).
2. The Financial Decision-Making Interview (FDMI) is a semi-structured interview that focuses on financial judgment. Two case studies are presented at the interview, each setting out a hypothetical financial problem. The questions evaluate the five financial judgment skills: 'identification', 'understanding', 'appreciation', 'reasoning' and 'communication'.

3. The Financial Decision Style (FDS) questionnaire is a tool for assessing what style(s) play(s) a major role in making financial decisions, namely (1) rational, (2) intuitive, (3) dependent, (4) avoidant and (5) spontaneous.
4. The Competence in Decision Rules (CDR) test focuses on the ability to make financial decisions based on specific rules and criteria, such as choosing a product that meets specific requirements. It comprises ten scenarios of increasing difficulty. In each scenario, five television sets are presented and the participant is asked to say which is the best choice, taking specific requirements and criteria into consideration.
5. The Temporal Discounting Task (TDT) comprises eighteen different scenarios and focuses on making decisions that have implications for the future, such as spending or saving money. An important feature of decisions of this kind is that the subjective value of money decreases over time. For example, receiving 100 euros today has a higher subjective value than receiving the same amount of money in a year's time. This phenomenon is known as 'temporal discounting'. In each TDT scenario, the participant is asked what amount they would accept today or after a short time instead of a larger amount after a longer time (e.g., 'what amount would you accept today instead of 100 euros in a year's time'). Six different intervals are used in the TDT ('today versus one week', 'today versus one month', 'today versus one year', 'one week versus one month', 'one week versus one year', and 'one month versus one year') combined with three different amounts (100, 500 and 1,000 euros).
6. The Impulsive Buying Questionnaire (IBQ) assesses the extent to which the subject is inclined to make impulse purchases. It comprises three different components. The affective component focuses on emotions and feelings relating to impulse buying behaviour; the cognitive component refers to ideas about the tendency to make impulse buys; the situational component focuses on the availability of time and money required to make an impulse buy.
7. The Iowa Gambling Task (IGT) is used to measure affective decision-making (Bechara et al., 1994). It involves the participants selecting cards from four different decks. Each deck is associated with a particular amount of profit and loss. Two decks produce high profits but also high losses, whereas the other two decks produce a relatively small amount of profit but also a relatively small amount of loss. The participants are not told about the amount of profit or loss associated with each deck, so they have to learn which decks are best to choose based on trial and error.

So far the test battery has been used on healthy adults and it appears to be sensitive to the effects of normal ageing (Bangma et al., 2017). It has also been used on adults with ADHD who displayed reduced financial competence and had more difficulty with financial decisions that had implications for the future (i.e., with temporal discounting), compared with adults without ADHD. Adults with ADHD also reported more impulse buying behaviour and tended more to adopt an avoidant or spontaneous style when making financial decisions than adults without ADHD (Bangma et al., 2019). The next step in this line of research is to use the FDM test battery on patients with neurodegenerative disorders.

Financial decisions and neurodegenerative disorders: what do we know at present?

A recent systematic review and meta-analysis (Bangma, Tucha, Tucha, et al., 2020) shows that to date 47 studies have been published that focused on financial decision-making by patients with neurodegenerative disorders using objective performance tests. All those studies used tests that claimed to measure financial knowledge, financial judgment and/or financial performance. The vast majority of the 47 studies focused on AD ($k = 25$) and MCI ($k = 26$). They all consistently showed that patients with AD scored lower on tests of financial knowledge, financial judgment and/or financial performance than healthy controls. The studies that focused on MCI too showed that these patients scored significantly lower on the financial tests than healthy controls. Patients with MCI displayed intact performance, however, on a few financial tests, compared with healthy controls, but the tests on which they did so varied widely between the studies. When patients with AD and MCI were compared directly with one another ($k = 13$), it was found that patients in both the mild and moderate-to-severe stages of AD scored lower on tests of financial knowledge, financial judgment and/or financial performance than patients with MCI. Seven studies focusing on financial decision-making by patients with PD have been published to date (Bangma, Tucha, Tucha, et al., 2020). These showed that patients with PD too scored lower on financial tests than healthy controls. The degree of impaired financial decision-making by patients with PD would seem to depend on the severity of cognitive dysfunctions. When patients with PD are divided into groups with and without cognitive dysfunctions, the performance of those with no cognitive dysfunctions was similar to that of healthy controls. Patients with PD and MCI did display reduced performance on financial tests, compared with healthy controls and patients with PD with no cognitive impairments (Giannouli et al., 2018; Martin et al., 2013; Pirogovsky et al., 2014).

Although the studies that have been conducted so far are transparent and have been provided a good deal of relevant information, they did have some shortcomings. First, they focused mainly on financial competence (i.e., financial knowledge and financial judgment); there has been far less research into financial performance, and not a single study has focused on both financial competence and financial performance. There has also been hardly any research into the contextual factors inherent in financial competence, financial performance in everyday life or associated with it. Lastly, all the studies conducted to date have focused on groups of patients, assessing whether one group performed better than the other group. The question, of course, is what a study of this kind can say about individual patients. Therefore, in current study, we describe the *individual* performance scores of nine patients on the FDM test battery, which focuses not only on financial knowledge, financial judgment and financial performance but also on various contextual factors.

Results and Discussion

Performance scores of patients with neurodegenerative disorders on the FDM test battery

The nine patients described here all took part in ‘Financial decision-making in patients with neurodegenerative disorders – a pilot study’, which was approved by the medical ethics

committees of the University Medical Center Groningen and the Antwerp Hospital Network. Three of the patients were diagnosed by an independent physician with AD, three with MCI and three with PD in line with diagnostic criteria laid down for this purpose (Albert et al., 2011; Hughes et al., 1992; McKhann et al., 2011). Table 5.1 gives an overview of the demographic and clinical characteristics of the patients. Eight of the nine patients were pensioners, did voluntary work or were unemployed at the time of the study, and one patient with PD worked part-time. Their gross annual incomes ranged from 15,000-25,000 euros to 45,000-55,000 euros. Although the three patients with AD did not score consistently lower on the Mini Mental State Examination than the three with MCI, the three with AD did report more problems with instrumental activities of daily living than the three with MCI, which is in line with the diagnostic criteria for these disorders (Albert et al., 2011; McKhann et al., 2011). The severity of the motor symptoms of the three patients with PD ranged from mild (i.e., unilateral) to moderate (i.e., bilateral with loss of balance). All the patients were asked about their experience of and degree of independence in financial decision-making in everyday situations (e.g., keeping financial records, doing the shopping, making large purchases, saving, taking out insurance, managing pension and dealing with debts or payment arrears), both now and in the past. When the score for now was deducted from the score for the past, we found that eight of the nine patients reported no deterioration or only mild deterioration. One of the patients with AD, however, reported a relatively severe deterioration in their experience of and/or independence in financial decision-making in everyday life.

Table 5.2 and Figures 5.2, 5.3 and 5.4 show the scores of all nine patients on the tests and questionnaires in the FDM test battery. The performance scores of the individual patients on the various tests were converted into z-scores by comparing them with a norm group created especially for each individual patient. The norm groups (group size range: 12-338) consisted of participants with no psychiatric or neurological disorders who were similar to the individual patients in terms of age (± 10 years), education (± 1 level on the Verhage scale) and sex. The z-scores were then classified as ‘average to very high’ (< 0.7 standard deviation (SD) below the average), ‘low to low-average’ ($0.7-2$ SD below the average) or ‘very low’ (> 2 SD below the average), based on the transformation table of Bouma et al. (2012).

The results (Table 5.2 and Figures 5.2, 5.3 and 5.4) show that the nine patients appeared to perform worse than the norm groups particularly on the FCAI and FDMI, compared with the other financial tests and questionnaires. The FCAI and FDMI are both tests that focus on financial knowledge and financial judgment (i.e., financial competence). Some patients also displayed very low to low-average performance on the other tests (i.e., the CDR, IGT, FDS, IBQ and TDT), which rely mainly on financial performance and the contextual factors inherent in or associated with it. These results, however, seemed to be less pronounced than the very low to low-average performance on the tests that measured financial competence.

The striking thing is that the performance scores of the individual patients with various neurodegenerative disorders differed widely: the three patients with PD generally seemed to do better than those with AD or MCI. Another interesting point is that two of the three patients with MCI seemed to do relatively poorly. Although it is difficult to determine, based on this data, whether they did worse generally than patients with AD, the very low performance of

these two patients with MCI seemed to be more pronounced, particularly on the FCAI and FDMI, compared with the patients with AD. While it is certainly possible that this observation is a chance finding that cannot be generalized to MCI across the board, it is striking, as a diagnosis of MCI by definition includes independent social functioning and intact everyday functioning (apart from complex tasks), including everyday financial functioning. Several very low scores on the FCAI and FDMI, however, raise the question of how these patients with MCI are able to function adequately in everyday life when it comes to their financial decision-making. The scores on the Lawton-Brody questionnaire (for instrumental activities of daily living) and the semi-structured interview on experiences of financial decisions now and in the past (Table 5.1) indicate that the three patients with MCI functioned relatively well in everyday life, or at least did not report any deterioration. There is a second striking observation in this context, namely that AD patient 2 reported a relatively sharp deterioration when it came to making financial decisions in everyday life independently (score -15; Table 5.1), whereas that patient performed better on financial tests than MCI patients 2 and 3. This discrepancy between test performance and degree of deterioration in financial functioning in everyday life may be an indication of insufficient ecological validity of the financial tests used. The difference in outcomes could also be indicative of a difference between performance on objective performance tests such as the FCAI and FDMI and reporting on subjective measures such as the Lawton-Brody questionnaire and the semi-structured interview used. While performance tests often call for the subject's best performance and are accompanied by clear instructions on how to tackle them, subjective measures often focus on general, self-reported, average performance (Fuermaier et al., 2015; Koerts et al., 2012). These different ways of measuring are thus likely to produce different outcomes. It could also be the case that AD patient 2 subjectively experienced a high degree of deterioration, whereas he did not perform differently on tests, compared with people of approximately the same age and the same level of education and sex. Lastly, it may be that AD patient 2 had a reduced disease insight, or conversely a strong disease awareness, which could be associated with incorrect or distorted self-reporting of symptoms.

The question remains to what extent conclusions on an individual's capability to make financial decisions can be drawn from performance on the FDM test battery. It was already clear from the foregoing that it is not possible to measure the capability to make financial decisions directly. What is possible is to assess the constructs underlying the capability to make financial decisions, i.e., financial competence and financial performance and the related contextual factors. The FDM test battery seems to achieve this latter aim. Performance on all the various tests and questionnaires provides a good overview of the subject's strengths and weaknesses in terms of financial knowledge, financial judgment and financial performance, which could provide a basis for targeted individual support. It goes without saying that there are some limitations of the FDM test battery. First, the contextual factors that influence the interaction between financial competence and financial performance differ from one person to another. In that respect, the FDM test battery only focuses on a limited number of contextual factors. It should therefore never be used in isolation but always supplemented with various (neuro)psychological tests and questionnaires. It should also be noted that financial

performance in everyday life can only be assessed to a limited extent using the FDM test battery. As already pointed out, this is no easy task – or even an impossible one – in view of privacy considerations, as the patient needs to be willing to provide some insight into their personal finances. Lastly, the ecological validity of the tests and questionnaires used has not been sufficiently investigated yet, and more research and further development of the FDM test battery is required. An option that could be considered in this context is to add a semi-structured interview to it, focusing on both simple and complex everyday financial decisions and performance, which could be taken by the patients and/or someone who has a good knowledge of their everyday functioning. A qualitative addition of this kind to the quantitative FDM test battery could be used to investigate the ecological validity of the various FDM tests and questionnaires, and could yield an even better idea of individual ability to make financial decisions.

Conclusion

Assessing an individual patient's ability to make financial decisions is a difficult task. First, it is not possible to measure the capability to make financial decisions directly. Furthermore, the capability to make financial decisions is a wide-ranging concept, which can make it difficult to assess all the aspects and concepts that fall under this heading correctly and systematically. The FDM test battery presented here, on the other hand, appears to be able to assess the strengths and weaknesses of patients with various neurodegenerative disorders in terms of financial knowledge, financial judgment, financial performance and the related contextual factors. For the time being, however, caution is called for as regards applying it to individual patients and drawing conclusions about their capability to make financial decisions. In order to be able to say more about this, it would seem that more detailed research into ecological validity and a more detailed assessment of financial performance in everyday life are required.

Table 5.1. Overview of demographic and clinical characteristics of nine patients enrolled in the study on financial decision-making by patients with neurodegenerative diseases.

	Patient AD 1	Patient AD 2	Patient AD 3	Patient MCI 1	Patient MCI 2	Patient MCI 3	Patient PD 1	Patient PD 2	Patient PD 3
Age (in years)	62	55	69	66	76	82	62	52	61
Sex	female	male	male	female	female	male	female	male	female
Level of education[^]	5	7	6	5	3	6	7	6	6
Sector (former) profession	health care	ict	finances	finances	facility	*	policy officer	security	education
Work status	retired	volunteer	retired	retired	retired	retired	part-time work	incapacitated	retired
Civil status	married	married	married	married	widowed	divorced	in relation	married	married
Estimated gross annual income (in euros)	25.000 to 35.000	35.000 to 45.000	15.000 to 25.000	25.000 to 35.000	*	15.000 to 25.000	45.000 to 55.000	45.000 to 55.000	*
Experience with making financial decisions[#]	0	-15	-4	-1	1	-4	0	0	-1
IADL	3	3	4	0	1	2	1	0	0
MMSE	26	23	27	25	22	22	30	30	26
Hoehn and Yahr score[‡]	-	-	-	-	-	-	3	1	2

Note. AD = Alzheimer's disease; IADL = Instrumental activities of daily living; MCI = mild cognitive impairment; MMSE = Mini Mental State Examination; PD = Parkinson's disease.

* No answer.

[^] According to Verhage's coding system (Verhage, 1964) which ranges from 1 (primary school not finished) to 7 (university degree).

[#] Assessed with a semi-structured interview that focuses on the experience and the degree of independence with making financial decisions in specific everyday situations (e.g., saving money, pension or taking out health insurance) both in present and in the past. The total score is determined by subtracting the score representing the present situation from the score representing the situation in the past (range scores -32 – 32). A negative score indicates a decline in experience and/or degree of independence.

[†] Assessed with Lawton Brody's questionnaire about instrumental activities of daily living (Lawton & Brody, 1969).

[‡] Only for patients with Parkinson's disease. The Hoehn and Yahr score reflects the severity of motor symptoms in patients with Parkinson's disease. The scale ranges from 1 (unilateral presentation) to 5 (severely disabled condition).

Table 5.2. Performance of three patients with Alzheimer's disease, three patients with mild cognitive impairment and three patients with Parkinson's disease on the test battery focused on the ability to make financial decisions.

	Patient AD 1	Patient AD 2	Patient AD 3	Patient MCI 1	Patient MCI 2	Patient MCI 3	Patient PD 1	Patient PD 2	Patient PD 3
FCAI Total	-0,68	-0,91	-1,16	-0,55	-3,79	-3,87	0,26	-1,06	-0,61
Financial abilities	-1,75	-0,15	-2,60	0,32	-3,16	-2,34	0,36	-0,56	-0,90
Financial judgment	0,02	-1,58	-0,94	-0,59	-1,86	-2,81	-0,75	-2,71	-0,43
Financial management	0,44	2,26	-1,14	0,44	-2,33	-3,51	1,46	1,95	0,08
Financial cognitive functioning	0,66	-2,33	-1,21	-2,38	-3,08	-4,28	-0,77	0,00	-1,85
Debt management	0,36	-1,81	0,49	0,37	0,00	0,00	-1,43	-1,72	0,40
Support resources	-0,79	-0,79	0,21	-1,05	-1,30	-1,96	0,75	-0,56	0,57
FDMI Total	-2,49	0,04	-3,87	-0,37	-3,37	-0,77	-1,51	-1,46	-0,96
Identification	-1,47	0,67	-0,52	0,77	-3,13	-0,57	-0,38	0,76	0,71
Understanding	-2,07	0,75	-3,34	-2,06	-3,24	-1,28	-2,10	-0,71	-2,28
Reasoning	-2,98	0,45	-1,09	0,54	0,51	0,47	-1,21	-4,59	-1,24
Appreciating	-0,31	-1,43	-1,35	0,86	-1,18	0,82	-0,35	-0,37	0,83
Communication	0,21	0,15	-5,60	-2,43	-2,57	-2,80	0,16	0,19	-3,35
CDR Total	-0,73	-2,78	-1,49	*	*	-1,03	1,63	-0,49	-1,50
IGT Total	*	-0,41	-1,45	0,96	*	*	-0,21	0,69	0,12
TDT Total	-0,65	*	-0,50	*	-1,00	*	-1,55	0,10	-0,55
IBQ Total	0,08	-0,68	-0,70	1,14	0,85	0,46	-0,27	-1,59	0,05
Cognitive component	0,05	-0,32	-0,77	0,96	0,64	-0,46	0,22	-1,76	1,41
Affective component	0,09	-0,94	-0,52	1,11	0,90	1,26	-0,71	-1,07	-1,36
Situational component	-0,16	0,60	0,14	-0,81	-0,82	-0,45	-0,21	-0,95	-0,89

Table continues on the next page

	Patient AD 1	Patient AD 2	Patient AD 3	Patient MCI 1	Patient MCI 2	Patient MCI 3	Patient PD 1	Patient PD 2	Patient PD 3
FDS rational	0,39	2,21	-0,14		0,83	-0,21	-0,22	0,20	-1,01
FDS intuitive	0,21	2,56	0,26	0,04	2,83	-1,23	1,73	1,53	-0,82
FDS dependent	-1,11	0,80	-1,05	0,29	-1,29	-2,54	-0,20	0,27	0,60
FDS avoidant	-0,03	-0,75	0,14	-2,13	0,90	-1,85	0,27	0,27	0,32
FDS spontaneous	1,24	1,83	-0,21	1,77	1,14	0,30	0,28	-0,09	-0,70

Note. All numbers represent z-scores determined by comparing the performance of individual patients with the performance of a norm group consisting of participants without neurological and psychiatric disorders with approximately the same age, level of education and sex as the individual patient (range n: 12 – 338). Dark grey colored cells with bold italic numbers represent scores > 2 standard deviations below the mean ($z = 0.00$) of the control group. These scores are classified as very low (Bouma et al., 2012). Light grey colored cells with italic numbers represent scores that are 0.7 to 2 standard deviations below the mean ($z = 0.00$) of the control group. These scores are classified as low to low average (Bouma et al., 2012). White cells represent scores that are < 0.7 standard deviations below the mean ($z = 0.00$) of the control group. These scores are classified as average to very high (Bouma et al., 2012). **AD** = Alzheimer’s disease; **CDR** = Competence in Decision Rules; **FCAI** = Financial Competence Assessment Inventory; **FDMI** = Financial Decision-Making Interview; **FDS** = Financial Decision Style questionnaire; **IBQ** = Impulsive Buying Questionnaire; **IGT** = Iowa Gambling Task; **MCI** = mild cognitive impairment; **PD** = Parkinson’s disease; **TDT** = Temporal Discounting Task.

* Test could not be administered or the administration was not reliable.

Figure 5.3. Performance of three patients with mild cognitive impairment on the test battery focused on the ability to make financial decisions. **CDR** = Competence in Decision Rules; **FCAI** = Financial Competence Assessment Inventory; **FDMI** = Financial Decision-Making Interview; **FDS** = Financial Decision Style questionnaire; **IBQ** = Impulsive Buying Questionnaire; **IGT** = Iowa Gambling Task; **MCI** = mild cognitive impairment; **TDT** = Temporal Discounting Task.

Figure 5.4. Performance of three patients with Parkinson's disease on the test battery focused on the ability to make financial decisions. **CDR** = Competence in Decision Rules; **FCAI** = Financial Competence Assessment Inventory; **FDMI** = Financial Decision-Making Interview; **FDS** = Financial Decision Style questionnaire; **IBQ** = Impulsive Buying Questionnaire; **IGT** = Iowa Gambling Task; **PD** = Parkinson's disease; **TDT** = Temporal Discounting Task.

PART

III

FINANCIAL DECISION-MAKING
CAPABILITY IN ADULTS WITH
ADHD

CHAPTER

6

DECISION-MAKING IN ADULTS WITH ADHD:

A systematic review.

Based on:

*“Het nemen van beslissingen door volwassenen
met ADHD: Een systematisch
literatuuronderzoek.”*

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Neuropraxis (2020)

Abstract

Objectives: Individuals with attention-deficit/hyperactivity disorder (ADHD) are more likely to make poor (life) decisions and to engage in risky activities than individuals without ADHD. This appears to be related to problems in the decision-making process. Whilst deficits in decision making have been well-established in children and adolescents with ADHD, relatively little is known about decision making in the adult population. The aim of this review is therefore to determine the nature and extent of potential deficits in the decision making of adults with ADHD.

Methods: The existing literature, comparing the performance of adults with ADHD on decision-making tasks with the performance of a healthy control group, was systematically searched, using the databases PsycINFO, MEDLINE and PubMed. In total, 31 studies were included in the review.

Results & conclusion: In the majority of the studies (i.e., 55%), the performance of adults with ADHD deviated from the performance of the control group(s) in one or more of the decision-making tasks at hand. This review therefore cautiously provides evidence of differences in the decision making between healthy individuals and adults with ADHD. The substantial inconsistency in the findings is suggested to partly be explained by the variety of decision-making domains that were examined, the comorbid disorders of the participants, and the use of medication in the ADHD groups. The review concludes with a discussion of the implications that the present findings have for theories about the underlying mechanisms of ADHD.

Introduction

In society we face a multitude of decisions on a daily basis. These decisions range from simple to more complex, where the complexity of a decision depends mainly on the number of response options to consider, and the immediate and future consequences of the decision made (Damasio, 1994). A simple decision could, e.g., be the choice between white or whole-wheat bread for lunch, while buying a house or taking out insurance are more complex decision-making situations. During the process of decision making, we try to make the best choice to prevent experiencing regret (Schepman et al., 2012). The decision-making process involves both deliberative and intuitive thought processes (e.g., Kahneman, 2003; Kahneman & Frederick, 2005) and is of great importance for independent functioning. Difficulties in decisions making can have a strong impact on everyday life and can, e.g., lead to unnecessary risk-taking (e.g., Balogh et al., 2013).

Attention-deficit/hyperactivity disorder (ADHD) is a disorder characterized by attentional problems, hyperactivity and impulsivity (American Psychiatric Association, 2013) that affects about 5.3% and 4.4% of the child- and adult population, respectively (Polanczyk et al., 2007; Polanczyk & Rohde, 2007). The characteristics of ADHD seem to be related to problems in the decision-making process. Research shows that individuals with ADHD (i.e., children, adolescents and adults) are more likely to make poor (life) decisions (Toplak et al., 2005) and to engage in risky activities (Barkley, 1997a, 1998) than individuals without ADHD. This puts individuals with ADHD at an increased risk of substance abuse (Charach et al., 2011), engagement in criminal behavior (Fletcher & Wolfe, 2009), unprotected sex (Sarver et al., 2014), and dangerous driving (Fuermaier et al., 2017).

The problems in decision making experienced by individuals with ADHD may be explained by the dual-pathway model of ADHD (Sonuga-Barke, 2003, 2005) and the dual-process models of judgment and decision making (e.g., Kahneman, 2003; Kahneman & Frederick, 2005). The dual-pathway model of ADHD describes ADHD symptomatology to originate from: (1) a dysregulation of the motivational-emotional pathway in the brain, which has been related to an impairment of the reward system (Luman et al., 2005; Sonuga-Barke, 2003, 2005), and (2) a dysregulation of the cognitive pathways, which has been related in particular to deficits in the executive functions, including response inhibition and working memory (Barkley, 1997b; Sonuga-Barke, 2003, 2005). The dual-process models of judgment and decision making distinguish in turn intuitive and affective decision-making processes from analytic and deliberative decision-making processes (e.g., Kahneman, 2003; Kahneman & Frederick, 2005). Within the context of these two models, it is hypothesized that ADHD-related impairments in the motivational-emotional pathway reflect problems in making emotional or intuitive evaluations, and that impairments in the cognitive pathways reflect problems in deliberative decision making (Mäntylä et al., 2012).

Research into ADHD and decision making has so far focused mainly on children and adolescents with ADHD. These studies have persistently shown that children and adolescents with ADHD encounter difficulties with various aspects of decision making. Specifically, in comparison to children and adolescents without ADHD, children and adolescents with ADHD

tend to make decisions in a more impulsive manner, often sacrificing choice accuracy for speed (Patros et al., 2016). This impulsiveness has furthermore been associated with deficits in delay gratification and delay discounting. This means that children and adolescents with ADHD are more likely to prefer choice options linked to small, immediate rewards over those linked to larger, delayed rewards than children and adolescents without ADHD (Mies et al., 2019; Patros et al., 2016; Sonuga-Barke et al., 1992). Moreover, the ability to learn from past decisions, which would enhance successful decision making, seems to be impaired in children with ADHD (Humphreys et al., 2018). Research shows that such problems in learning from experience may arise from an aberrant sensitivity to feedback in the form of punishment and reward (Luman et al., 2005; Masunami et al., 2009).

Whereas the symptoms of adults with ADHD may resemble those starting in (early) childhood, the disorder does not necessarily manifest identically in children and adults. For example, the intensity of the expression of ADHD symptomatology, especially hyperactivity, changes in adulthood (Gentile et al., 2006). Although little research has been done into the development of cognitive functioning in individuals with ADHD in the period from childhood to adulthood, there are also indications that neuropsychological functioning improves with age, as has been demonstrated for measurements of response inhibition and selective attention (Bramham et al., 2012). However, adults with ADHD also more frequently present with psychiatric comorbidities than children and adolescents with ADHD (Gentile et al., 2006). This comorbid symptomatology may negatively affect the subjective symptom severity in adults with ADHD (Bramham et al., 2012). Because of the disparities between adult- and childhood ADHD, the understanding of decision making in adults with ADHD cannot mainly rely on research conducted in the childhood population. Since adults often have to make more fundamental and complex decisions than children and adolescents, it is however likely that the negative consequences of potential deficits in decision making will increase in adulthood.

The aim of the current review was therefore to determine the nature and extent of potential deficits in the decision making of adults with ADHD. To this end, the existing literature has been systematically searched for studies comparing the performance of adults with ADHD on decision-making tasks with the performance of a healthy control group.

Methods

A systematic literature search of all available literature addressing decision making and ADHD was carried out according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Moher et al., 2009). Relevant literature was searched by consulting the databases PsycINFO, MEDLINE and PubMed. The primary keywords for the literature search were *ADHD*, *Attention Deficit Hyperactivity Disorder* or *Attention-Deficit-Hyperactivity-Disorder* and the secondary keywords were *decision making*, *decision-making*, *decision*, *judgment* or *judging*. A combination of primary and secondary keywords (e.g., ADHD [AND] decision-making) had to appear in the abstract and/or title of the articles. Next, the search results were refined to include English-language, peer-reviewed articles only. Selection

criteria of the review were as follows: all studies included should make use of: (1) a sample of adults with ADHD that was compared to a healthy control group, and (2) one or more performance-based tasks that clearly assessed a particular domain of decision making (e.g., risky-, social-, or reward-related decision making). Decision making was defined in this study as ‘any process leading to the selection of one of several alternatives’ (after Mowinckel et al., 2015). Each performance-based task in which the participant had to make such a selection was taken into account as a decision-making task. The systematic literature search was completed on the 17th of March 2020 and resulted in a literature list of 489 articles. The literature retrieved was supplemented with relevant literature cited in the articles found (manual search; Figure 6.1). In total, 31 studies could be included in the literature review (Appendix 6-1). The content of all of these studies has been systematically analyzed.

Results

All 31 included studies made use of one or more performance-based tasks to assess the following domains of decision making: risky decision-making, deliberative decision-making, delay/temporal discounting or delay aversion, reward-related decision-making, social decision-making, decision making in relation to driving and financial decision-making. A description of the adopted decision-making tasks is shown in Table 6.1. Table 6.2 provides a comprehensive overview of the included studies and the most important study results. Seventeen studies reported that adults with ADHD showed an aberrant performance as compared to a healthy control group on one or more of the tasks used (17/31 = 55%). In 14 studies, no (significant) group differences in task performance were found (14/31 = 45%).

Table 6.1. Overview and description of the identified decision-making tasks.

Name of test	Test description	Possible outcome measures	Construct of measurement
Iowa Gambling Task (IGT; Bechara <i>et al.</i> , 1994)	Goal: maximize gain. <ul style="list-style-type: none"> ▪ The participant chooses one card from four decks of cards 100 times. ▪ For each card drawn, (hypothetical) money is gained/lost. ▪ 2 out of 4 decks are considered advantageous/safe (i.e., consistent selection from these decks leads to a net gain). ▪ 2 out of 4 decks are considered disadvantageous/risky (i.e., consistent selection from these decks leads to a net loss). 	Scores are usually calculated for five blocks of 20 trials each. <ul style="list-style-type: none"> ▪ Number of choices from each deck. ▪ Number of safe choices. ▪ Number of risky choices. ▪ Financial gain and loss. ▪ Net score (i.e., number of safe minus risky choices). ▪ Total financial outcome. 	Risky decision-making
Forgone Payoff Gambling Task (FPGT; Agay <i>et al.</i> , 2010)	Variant version of the IGT. <ul style="list-style-type: none"> ▪ Differences FPGT compared to IGT: <ol style="list-style-type: none"> 1. Different payoff distribution. 2. A feedback method called ‘<i>foregone payoffs</i>’ is used: following each choice, the participant not only gets to see the card chosen (as with the IGT), but the three cards from the remaining decks are also shown. 	See outcome measures IGT.	Risky decision-making
Game of Dice Task (GDT; Brand <i>et al.</i> , 2005)	Goal: maximize starting capital. <ul style="list-style-type: none"> ▪ The participant makes guesses about the number of dots on a die (or several dice). ▪ Money is gained/lost if the guess corresponds/does not correspond with the dots on the die/dice, respectively. ▪ Choices are related to stable and inversely proportional gains/losses and winning probabilities. ▪ Choices related to small gains/losses and a winning probability of > 50% are considered safe. ▪ Choices related to large gains/losses and a winning probability of < 50% are considered risky. 	<ul style="list-style-type: none"> ▪ Number of safe choices. ▪ Number of risky choices. ▪ Financial end capital ▪ Net score (i.e., number of safe minus risky choices). ▪ Use of positive feedback (i.e., frequency of staying with a safe choice after winning). ▪ Use of negative feedback (i.e., frequency of switching from a risky to a safe choice after loss). 	Risky decision-making

Table continues on the next page

Name of test	Test description	Possible outcome measures	Construct of measurement
Cambridge Gambling Test (CGT; Rogers <i>et al.</i> , 1999)	<p>Goal: maximize total number of points.</p> <ul style="list-style-type: none"> ▪ A yellow token has been hidden inside one box out of a row of 10 boxes (some boxes are colored red, others blue). ▪ The participants must indicate whether they think the token is in a red or a blue box, and are offered a series of betting options, to place bets on their choice being correct. ▪ The chosen bet is added/subtracted from the total number of points depending on the choice being correct/incorrect, respectively. ▪ The task is usually performed in two conditions (both containing 4 blocks of 9 trials each): <ol style="list-style-type: none"> 1. Ascending condition: series of offered bets starts low and increases. 2. Descending condition: series of offered bets starts high and decreases. 	<ul style="list-style-type: none"> ▪ Deliberation time (i.e., speed of decision-making). ▪ Quality of decision making (i.e., percentage of trials in which the participant chooses the more likely outcome). ▪ Percentage of bets made (i.e., percentage of the total points placed on a choice, when that choice was the more likely outcome). ▪ Sum of bets (i.e., average bet across box ratios) ▪ Risk adjustment 	Risky decision-making
Card Playing Task (CPT; Newman <i>et al.</i> , 1987, 1992)	<p>Goal: maximize gain.</p> <ul style="list-style-type: none"> ▪ In a deck of cards, red and black cards represent gain and losses of €50, respectively. ▪ The first 2 out of 8 blocks are associated with gaining money, from the third block onward there is a gradual shift towards loss. ▪ After completing each block, the participant is asked to decide whether to continue or to quit playing. 	<ul style="list-style-type: none"> ▪ Total gain (i.e., total amount of money gained at the end of the task). 	Risky decision-making
Rapid Decision Making Under Risk task (RDMUR; Fernandez-Duque & Wifall, 2007; Slovic, 1966)	<p>Goal: maximize gain.</p> <ul style="list-style-type: none"> ▪ A deck of 10 cards contains nine “good cards” and one “bad card” (i.e., the joker; unbeknownst to the participant, the joker is always the ninth card of the deck). ▪ The participant wins one dollar when a good card is turned. ▪ When the joker is turned, the participant loses all the money and the game ends. ▪ The participant is not informed about the location of the joker. ▪ Rational/safe decision makers stop after turning the fifth card (highest expected value). 	<ul style="list-style-type: none"> ▪ Total score. ▪ (Total) reaction time. 	Risky decision-making
Rapid Decision Gambling Task (RDGT; Gehring & Willoughby, 2002)	<p>Goal: maximize gain.</p> <ul style="list-style-type: none"> ▪ The participant has to select one out of two squares: one square contains the number “5”, the other square contains the number “25”. ▪ After the choice has been made, each square turns red or green. If the chosen square turns green, the amount on the square is added to the total score, if the square turns red, the amount on the square is subtracted from the total score. ▪ Participants are informed about how much they gained or lost, but also about what they could have gained or lost. 	<ul style="list-style-type: none"> ▪ Positive and negative feedback is used to obtain Event-Related Potential (ERP) waveforms. 	Risky decision-making

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Name of test	Test description	Possible outcome measures	Construct of measurement
Probabilistic Gambling Task (PGT; based on Gneezy & Potters, 1997)	<p>Goal: maximize gain.</p> <ul style="list-style-type: none"> During each trial, the participant must choose a number of points to gamble with. The participant can either win four times the number of points (1/3 winning probability) or lose the entire amount (2/3 losing probability). The task has two conditions: <ol style="list-style-type: none"> High frequency feedback condition: after each trial the participant is informed about the amount of money won/lost. Low frequency feedback condition: after each trial the participant is only informed that the outcome of the gambling was determined. 	<ul style="list-style-type: none"> Total gains (i.e., total amount of money at the end of the task). Total gains earned during low frequency feedback trials. Total gains earned during high frequency feedback trials. Risk Index^a. Response times. 	Risky decision-making
Balloon Analogue Risk Task (BART; Lejuez <i>et al.</i> , 2002)	<p>Goal: maximize gain.</p> <ul style="list-style-type: none"> In a computer task, the participant must inflate balloons. For each pump of air, the participant can earn money. When the balloons pops, the participant loses all the money earned during a trial. 	<ul style="list-style-type: none"> Performance (i.e., average number of pumps based on the trials where the balloon did not pop). 	Risky decision-making
Adult Decision-Making Competence battery (A-DMC; Bruine de Bruin <i>et al.</i> , 2007; Parker & Fischhoff, 2005)	<p>The test battery consists of seven subtests, two of which are included in the current literature review:</p> <ol style="list-style-type: none"> Applying Decision Rules Task: For 10 decision-making problems, participants have to select the best option(s) according to different decision rules. Under/Overconfidence Task: Participants must answer 34 factual questions (true/false). Afterwards, they must indicate how certain they are of their answer on a scale from 50% (just guessing) to 100% (absolutely sure). 	<p>Applying Decision Rules Task:</p> <ul style="list-style-type: none"> Total score (i.e., total number of correct choices according to the decision rule applied). <p>Under/Overconfidence Task:</p> <ul style="list-style-type: none"> Absolute discrepancy between the mean level of certainty and the percentage of correct answers (0 = absolute discrepancy, 1 = perfect calibration). 	Deliberative decision-making
Delay Discounting Task (DDT) / Temporal Discounting Task (TDT) / Inter-temporal Choice Task	<p>Goal: choose from two or more reward options.</p> <ul style="list-style-type: none"> During each trial, participants must choose between two (monetary) reward options that differ in amount and time of pay-out. Choices are between receiving (1) a relatively small reward immediately or after a fairly short delay, or (2) a larger reward after a long(er) delay. 	<ul style="list-style-type: none"> Discounting rate (i.e., measure indicating how much an individual/group prefers the immediate rewards over the future, larger reward). Total score (i.e., percentage of the amount of money chosen in relation to the maximum reward that can be obtained). Decision time (averaged for all choices) Preferences for immediate rewards. Preferences for delayed rewards. 	Delay discounting

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Name of test	Test description	Possible outcome measures	Construct of measurement
Delay Aversion Task (Müller <i>et al.</i> , 2006)	<p>Goal: to earn as much money as desired.</p> <ul style="list-style-type: none"> ▪ In 22 consecutive trials, the participant gets to see an image of a donkey spitting money in a basket. ▪ During a trial, the amount of money the donkey is spitting decreases. After 60 seconds, the money flow stops. ▪ The trial continues until the participant presses a button to go to the next donkey/trial. ▪ After each trial, the participant receives feedback on how many trials still follow. 	<ul style="list-style-type: none"> ▪ (total) Mean trial duration. 	Delay aversion
Effort Expenditure for Rewards Task (EEfRT; Treadway <i>et al.</i> , 2009)	<p>Goal: maximize gain.</p> <ul style="list-style-type: none"> ▪ During each trial, the participant chooses between two options: <ol style="list-style-type: none"> 1. <i>Low effort</i>: the participant has to press a button 30 times within seven seconds, using the index finger of their dominant hand. The participant can earn \$1 per trial that has been completed in time. 2. <i>High effort</i>: the participant has to press a button 100 times within 21 seconds with the little finger of their non-dominant hand. The participant can earn \$1.24-\$4.30 (reward magnitude) per trial that has been completed in time. ▪ Before the trial, the reward magnitude and reward probability (i.e., 12, 50 or 88 percent) of the following trial are presented, after which the participant has five second to opt for a high or low effort trial (no choice leads to random allocation to either a low or high effort trial). ▪ Feedback comprises whether the trial goal has been completed and whether money was earned. 	<ul style="list-style-type: none"> ▪ Percentage of high effort selections <i>multiplied by</i> reward probability and magnitude. ▪ Total number of (timely) completed trials. ▪ Ratio of number of completed high-effort trials <i>divided by</i> number of selected high-effort trials. 	Reward-related decision-making
Reinforcement Learning Task + Novelty Manipulation (Wittmann <i>et al.</i> , 2008)	<p>Goal: maximize the total reward.</p> <ul style="list-style-type: none"> ▪ Pre-familiarization phase: The participant is familiarized with 32 pictures by looking at them passively and later actively. ▪ Three-armed-bandit-task: The participant chooses between three images in each trial. Each trial is linked to a fixed probability (1/3) of winning \$1. ▪ In 25% of the trials, one picture is randomly replaced by an unfamiliar picture (<i>novelty manipulation</i>). 	<ul style="list-style-type: none"> ▪ Total gain. ▪ Reward learning rate. ▪ Novelty bonus (i.e., number of new options selected minus number of familiar options selected). • Number of times novel options are chosen at first presentation. 	Reward-related decision-making
Reward-based Decision-Making Task (Basten <i>et al.</i> , 2010)	<p>Goal: maximize gain.</p> <ul style="list-style-type: none"> ▪ First phase: the participant learns to associate six positive and six negative monetary value ranges with different stimuli through trial and error. ▪ Second phase: a composite figure is shown to the participant, consisting of stimuli associated with either the positive or the negative monetary value ranges. ▪ Participants are asked to accept the stimuli with positive values and reject the negative stimuli. 	<ul style="list-style-type: none"> ▪ Task accuracy. ▪ Number of errors. ▪ Response time. ▪ Response time variability. 	Reward-related decision-making

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Name of test	Test description	Possible outcome measures	Construct of measurement
Social Justice Game (Schäfer & Kraneburg, 2015)	<p>Goal: to make decisions about the allocation of lottery tickets.</p> <ul style="list-style-type: none"> ▪ The participant plays against three (fictitious) players: two ‘strong players’ and one ‘weak player’. During the game, the weak player is treated unfairly by the two strong players. ▪ The participant plays four different positions (i.e., the decision making, the allocator, the referee and the helpless). During each trial (except when playing the position of the helpless), the participant has to make a particular decision: <ul style="list-style-type: none"> - Trial 1 (the decision maker/profiteer): In this trial, a strong player allocates 100 tickets unfairly (i.e., 60 to himself, 40 to the participant and 0 to the weak player). The participant has to decide whether to permit or prevent this unfair allocation. - Trial 2 (the allocator/perpetrator): In this trial, the participant divides 100 tickets between himself and the two strong players. - Trial 3 (the referee/observer): In this trial, a strong player allocates 100 tickets (i.e., 50 to himself, 45 to the other strong player and 5 to the weak player). In this trial, the participant can allow the allocation or intervene. When the participant chooses to intervene, there is a chance that the participant will lose part of his/her earned tickets. - Trial 4 (the helpless): In this trial, no decisions are made by the participant. 	<ul style="list-style-type: none"> ▪ Profiteer sensitivity (round 1). ▪ Perpetrator sensitivity (round 2). ▪ Observer sensitivity (round 3). 	Social decision-making
Driver Performance Analysis System (DPAS; Weaver, 1990)	<p>Goal: maximize total number of correct answers.</p> <ul style="list-style-type: none"> ▪ For one hour, recordings of 192 driving scenarios are shown from the driver’s point of view. ▪ After a scenario is shown, the participant must answer a multiple-choice question within 10 seconds. ▪ Test parts: ‘Driver and Traffic Knowledge’, ‘Traffic Perceptual Skills’, ‘Recognizing and Controlling Traffic Risk, and ‘Driver and Traffic Procedures’. 	<ul style="list-style-type: none"> ▪ Percentage correct answers (on each of the test parts). <p>Note: Only the part ‘Recognizing and Controlling Traffic Risk’ focuses on decision making.</p>	Decision making in relation to driving
Financial Competence Assessment Inventory (FCAI; Kershaw & Webber, 2008)	<p>Goal: maximize task performance.</p> <ul style="list-style-type: none"> ▪ The FCAI consists of 38 theoretical questions, practical assignments and questions about the financial situation of the participant. ▪ The FCAI measures financial competence and consist of six domains: <ol style="list-style-type: none"> 1. Financial abilities 2. Financial judgment 3. Financial cognitive functioning 4. Financial management 5. Debt management 6. Financial support resources 	<ul style="list-style-type: none"> ▪ Performance on subscales (i.e., total score on each of the six subscales). ▪ Total score (sum of the six subscales). 	Financial decision-making

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Name of test	Test description	Possible outcome measures	Construct of measurement
Financial Decision-Making Interview (FDMI; Bangma <i>et al.</i> , 2017)	Goal: maximize task performance. <ul style="list-style-type: none"> ▪ The participant gets to read and listen to two complex hypothetical financial problems. ▪ By means of a semi-structured interview, questions are asked about these problems. ▪ The FDMI measures financial judgment (or financial decision-making capacity) and consists of five domains: <ol style="list-style-type: none"> 1. Identification (of the problem) 2. Understanding (of risks and benefits) 3. Reasoning (evaluating choice options and making a decision) 4. Appreciating (evaluating the consequences of the decision) 5. Communication (articulation of the choice) 	<ul style="list-style-type: none"> ▪ Performance on the five domains (i.e., total score on each of the five domains). ▪ Total score (sum of the five domains). 	Financial decision-making

Note. ^aRisk index is calculated as $(HR - LR)/(HR + LR)$, with LR equals the number of trials a participant gambled with a low number of points (i.e., 0, 4 or 8 points; low risk index) and HR equals the number of trials a participant gambled with a high number of points (i.e., 12, 16 or 20 points; high risk index).

Risky decision-making

The majority of the studies looked into risky decision-making by means of various gambling tasks ($20/31 = 65\%$; see Table 6.1 and 6.2). Six of these 20 studies ($6/20 = 30\%$) showed that adults with ADHD performed in a more risky fashion than the control groups (Duarte *et al.*, 2012; Malloy-Diniz *et al.*, 2007, 2008; Miller *et al.*, 2013; Tamm *et al.*, 2013; Yang *et al.*, 2019). All six studies made use of the Iowa Gambling Task (IGT) to assess risky decision-making. Four studies provided inconsistent evidence of differences in risky decision-making between adults with ADHD and healthy adults (Agay *et al.*, 2010, 2014; Mäntylä *et al.*, 2012; Matthies *et al.*, 2012). For example, Agay *et al.* (2010) found that the task performance for the Forgone Payoff Gambling Task (FPGT) was aberrant for adults with ADHD, while in the same study no significant differences were found between adults with ADHD and the control groups for the IGT. Another study, by the same authors, found that task performance differed between groups for the IGT, but not for the FPGT (Agay *et al.*, 2014). Matthies *et al.* (2012) conducted a two-part study and concluded on the basis of the first part of the study that adults with ADHD clearly made riskier choices than the control group in the Game of Dice Task (GDT). However, in the second part of the study, these group differences disappeared after boredom was induced before administering the GDT. According to Matthies *et al.* (2012), the difference in findings between the first and second part of their study could be explained by an increase in risky behavior in the control group after the boredom induction. Finally, Mäntylä *et al.* (2012) initially found group differences for the IGT between the control group and adults with ADHD, but these findings were found to be mediated by the level of education of the participants, which meant that after correction for the level of education, the results were no longer significant. In the remaining ten studies that assessed risky decision-making, no (significant) group differences were observed ($10/20 = 50\%$; Abouzari *et al.*, 2015; Bangma *et al.*, 2019; Dai *et al.*,

2016; Ernst et al., 2003; Gonzalez-Gadea et al., 2013; Ibanez et al., 2012; McLean et al., 2004; Mesrobian et al., 2018; Pollak et al., 2018; Wilbertz et al., 2012).

Three studies (Matthies et al., 2012; Mesrobian et al., 2018; Wilbertz et al., 2012) also looked into the utilization of feedback during the gambling tasks. One of the three studies ($1/3 = 33\%$) found that, compared to the control group, there was an impaired feedback utilization in adults with ADHD (Matthies et al., 2012). However, this effect disappeared after the boredom induction in the second part of this study (Matthies et al., 2012). No significant group differences were observed in the other two studies with regard to the use of feedback (Mesrobian et al., 2018; Wilbertz et al., 2012).

Deliberative decision-making

Two studies focused on deliberative decision making in adults with ADHD (Bangma et al., 2019; Mäntylä et al., 2012). Mäntylä et al. (2012) found significant group differences for the Applying Decision Rules Task of the Adult Decision-Making Competence battery (A-DMC). The ADHD group performed significantly less well in this task than the control group. However, no significant group differences were found in this study for the Under/Overconfidence Task of the A-DMC battery. According to Mäntylä et al. (2012), this difference between the task findings could be due to the Applying Decision Rules Task requiring more of the cognitive and analytical skills of the participants than the Under/Overconfidence Task. Bangma et al. (2019), unlike Mäntylä et al. (2012), found no significant differences in task performance between adults with ADHD and the control group for the Applying Decision Rules Task of the A-DMC battery (Bangma et al., 2019).

Delay discounting

Of the nine studies that looked at delay/temporal discounting or delay aversion, four studies ($4/9 = 44\%$) showed that adults with ADHD had a significantly greater preference for immediate small rewards than for larger delayed rewards as compared to the healthy controls (Bangma et al., 2019; Dai et al., 2016; Hurst et al., 2011; Onnink et al., 2015). Dai et al. (2016), in this respect, differentiated between delay discounting (DD) and probability discounting (PD), where PD represented a measure of sensitivity to risk. They concluded that adults with ADHD showed a higher DD rate and a lower PD rate than the controls (Table 6.2), indicating a higher level of impulsivity in decision making in the ADHD group. Although Marx et al. (2013) initially also found significant group differences between the ADHD and control groups for the Delay Aversion Task, this task was found to have a ceiling effect. The ADHD groups, like the control groups, scored in the optimal range (Marx et al., 2013). The other four studies that made use of a delay/temporal discounting task did not find (significant) group differences in the degree of delay discounting ($4/9 = 44\%$; Ortiz et al., 2015; Plichta et al., 2009; Todokoro et al., 2018; Wilbertz et al., 2012).

Reward-related decision-making

Of the three studies that examined reward-related decision-making, two studies ($2/3 = 67\%$) found an aberrant performance in the ADHD group as compared to the healthy control group

(Table 6.2). Specifically, Sethi et al. (2018) found that the ADHD group presented with an impaired performance on a reward-related learning task compared to healthy adults, which was associated with a lower learning rate and heightened novelty-seeking. Mowinckel et al. (2017) found that adults with ADHD showed a significantly lower accuracy on a reward-related decision-making task than the control group. Addicott et al. (2019), on the other hand, found that adults with ADHD were as willing as the healthy controls to make an effort to receive a reward during the Effort Expenditure for Rewards Task (EEfRT).

Social decision-making

The only study that examined decision making in relation to social justice showed that adults with ADHD seem to have a more pronounced justice sensitivity than adults without ADHD (Schäfer & Kraneburg, 2015).

Decision making in relation to driving

In their study on the driving ability and driving behavior of adults with ADHD, Barkley et al. (2002) describe significantly reduced performances in the ADHD group on one part of the Driver Performance Analysis System (DPAS; i.e., Driver and Traffic Knowledge) compared to the control group. However, for the part of the DPAS that focuses on decision making during driving (i.e., Recognizing and Controlling Traffic Risk), the performance of the ADHD group did not differ significantly from the control group. No significant group differences were observed with regard to the performances in a simple driving simulator (Barkley et al., 2002).

Financial decision-making

In their study, Bangma et al. (2019) focused on financial decision-making in adults with ADHD. For this purpose, they included two tests for financial (decision-making) competence (Table 6.2). On the Financial Competence Assessment Inventory, adults with ADHD showed a significantly lower overall score than the control group. The ADHD group scored significantly lower than the control group on four of the six sub-scales of this test (i.e., financial abilities, financial judgment, financial management and financial support resources). The overall score for the Financial Decision-Making Interview was also significantly lower in the ADHD group than in the control group. The ADHD group showed significantly reduced performances on two of the five sub-scales of the Financial Decision-Making Interview (i.e., identification and understanding).

Medication effects

Five studies investigated the acute effects of stimulants (e.g. methylphenidate) on decision-making task performance (Addicott et al., 2019; Agay et al., 2010, 2014; Mowinckel et al., 2017; Sethi et al., 2018). Three of these five studies ($3/5 = 60\%$) concluded that the task performance of adults with ADHD improved under medication conditions compared to the placebo conditions (Addicott et al., 2019; Mowinckel et al., 2017; Sethi et al., 2018). Two studies of Agay et al. (2010, 2014) found no acute effects of methylphenidate on the decision-making task performances of adults with ADHD.

Table 6.2. Overview of studies on decision making in adults with ADHD ($k = 31$).

Study ^a	Sample characteristics ^b	Comorbidities ^c	Medication ^d	DM task(s)	Main results
Abouzari <i>et al.</i> (2015)	ADHD unmedicated/nongamblers: n (mf) = 5 (2/3) Age $M(SD)$ = 24.8y (3.6)	Unknown	See sample characteristics.	IGT (simplified)	<ul style="list-style-type: none"> IGT total net score: CG = ADHD medicated/nongamblers. IGT total net score: CG and ADHD nongamblers (unmedicated and medicated) > pathological gamblers (no ADHD) > ADHD unmedicated/pathological gamblers. CG and ADHD medicated/non-gambling showed a significant increase in the proportion of safe choices during the task. CG and ADHD nongamblers (unmedicated and medicated) tended to tolerate losses after good bets (i.e., advantageous choices), while ADHD unmedicated/pathological gamblers tolerated losses after bad bets (i.e., disadvantageous choices).
	ADHD medicated/nongambler: n (mf) = 23 (13/10) Age $M(SD)$ = 22.1y (3.8)				
	ADHD unmedicated/pathological gamblers: n (mf) = 4 (2/2) Age $M(SD)$ = 23.5y (2.4)				
	Pathological gamblers (no ADHD): n (mf) = 15 (9/6) Age $M(SD)$ = 23.1y (2.7)				
	CG: n (mf) = 16 (7/9) Age $M(SD)$ = 22.7y (3.2)				
	ADHD: n (mf) = 23 (12/11) Age $M(SD)$ = 32.9y (8.4)				
	CG: n (mf) = 23 (11/12) Age $M(SD)$ = 27.8y (6.5)				
	All participants were tested twice: once in a placebo and once in an MFD condition.				
	ADHD + MFD: n (mf) = 13 (5/8) Age $M(SD)$ = 31.7y (7.9)				
	ADHD + Placebo: n (mf) = 13 (6/7) Age $M(SD)$ = 33.2y (8.6)				
Agay <i>et al.</i> (2010) ^e	CG + MFD: n (mf) = 16 (8/8) Age $M(SD)$ = 32.9y (6.9)	<ul style="list-style-type: none"> All comorbid psychiatric disorders were part of the exclusion criteria, with the exception of ADHD comorbid depressive and/or anxiety symptoms ≥ 1 comorbid disorder(s) (present): none ≥ 1 comorbid disorder(s) (remitted): $n = 4$ Psychiatric diagnosis CG: none 	<ul style="list-style-type: none"> Participants were excluded if they had used ADHD medication daily within the past six months. Treated with MFD in adulthood: ADHD + Placebo: $n = 5$ ADHD + MFD: $n = 6$ All participants were off-medication on the morning of testing. 	<ul style="list-style-type: none"> IGT FPGT 	<ul style="list-style-type: none"> EEIRT total number of completed trials: ADHD = CG Ratio of number of completed high-effort trials / number of selected high-effort trials: ADHD = CG. Increase in average number of high-effort selections due to MFD: ADHD > CG Sensitivity to changes in high-effort reward probability: ADHD > CG IGT number of risky choices: ADHD = CG FPGT number of risky choices: ADHD > CG No performance effects of MPH.
	CG + Placebo: n (mf) = 16 (10/6) Age $M(SD)$ = 32.4y (7.7)				
	ADHD: $n = 20$				
	CG: $n = 19$				
	Groups matched for sex.				
	Age range both groups: 20–40y				
	All participants were tested twice: once in a placebo and once in an MFD condition.				
	Treated with MFD: Present: $n = 7$ Past: $n = 5$				
	Occasional MFD use CG (without prescription): $n = 2$				
	All participants were off-medication on the morning of testing.				
Agay <i>et al.</i> (2014) ^e		Comorbid psychiatric disorders that could have an effect on study parameters were part of the exclusion criteria.	<ul style="list-style-type: none"> Treated with MFD: Present: $n = 7$ Past: $n = 5$ Occasional MFD use CG (without prescription): $n = 2$ All participants were off-medication on the morning of testing. 	<ul style="list-style-type: none"> IGT FPGT 	<ul style="list-style-type: none"> IGT number of risky choices: ADHD > CG FPGT number of risky choices: ADHD = CG No performance effects of MPH.

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Study ^a	Sample characteristics ^b	Comorbidities ^c	Medication ^d	DM task(s)	Main results
Bangma <i>et al.</i> (2019)	ADHD: <i>n</i> (m/f) = 45 (26/19) Age <i>M(SD)</i> = 36.6y (10.2) CG: <i>n</i> (m/f) = 51 (26/25) Age <i>M(SD)</i> = 38.9y (13.2)	≥ 1 comorbid disorder(s) (present): <i>n</i> = 21 Psychiatric diagnosis CG: none	All participants were off-medication 48 hours before testing.	FDM tests: ▪ Applying decision rules task (DMCI) ^f ▪ TDT ▪ IGT ▪ FCAI ▪ FDMI	▪ DMCI ^g total score: ADHD = CG ▪ TDT total score: ADHD < CG ▪ IGT total net score: ADHD = CG ▪ FCAI total score: ADHD < CG ▪ FCAI performance on subscales 'financial abilities', 'financial judgment', 'financial management' and 'financial support resources': ADHD < CG ▪ FCAI performance on subscales 'financial cognitive functioning' and 'debt management': ADHD = CG ▪ FDMI total score: ADHD < CG ▪ FDMI performance on subscales 'identification' and 'understanding': ADHD < CG ▪ FDMI performance on subscales 'reasoning', 'appreciation' and 'communication': ADHD = CG ▪ Financial situation (debts, saving money): ADHD < CG ▪ DPAS percentage correct answers 'Driver and Traffic Knowledge': ADHD < CG ▪ DPAS percentage correct answers other subtests: ADHD = CG ▪ Performance in simple driving simulator: ADHD = CG
Barkley <i>et al.</i> (2002)	ADHD: <i>n</i> (m/f) = 105 (79/26) Age <i>M(SD)</i> = 21.1y (2.7) Age-range: 17-28y CG: <i>n</i> (m/f) = 64 (44/20) Age <i>M(SD)</i> = 21.2y (2.4)	ODD: 21.9% (CG: 0%) CD: 4.8% (CG: 0%) Depression and anxiety: ADHD > CG Alcohol and drug use: ADHD > CG	Stimulants: <i>n</i> = 17 Anti-depressants: <i>n</i> = 4 All participants were off-medication 24 hours before testing. Anti-depressants users were off-medication for 2 weeks before testing.	▪ DPAS	▪ DPAS percentage correct answers 'Driver and Traffic Knowledge': ADHD < CG ▪ DPAS percentage correct answers other subtests: ADHD = CG ▪ Performance in simple driving simulator: ADHD = CG
Dai <i>et al.</i> (2016)	ADHD: <i>n</i> (m/f) = 31 (14/17) Age <i>M(SD)</i> = 35.3 (13.36) Age-range: 17-64y CG: <i>n</i> (m/f) = 29 (15/14) Age <i>M(SD)</i> = 31.0y (12.35)	Mood disorder (present): ADHD: <i>n</i> = 9 CG: <i>n</i> = 0 Anxiety disorder or phobia (present): ADHD: <i>n</i> = 14 CG: <i>n</i> = 4 Alcohol abuse (present): ADHD: <i>n</i> = 4 CG: <i>n</i> = 1	MFD: <i>n</i> = 7 All participants were off-medication 24 hours before testing. Anti-depressants during testing: ADHD: <i>n</i> = 13 / CG: <i>n</i> = 1	▪ CPT ▪ DDT + PDT	▪ DDT discounting rate: ADHD > CG ▪ PDT discounting rate: ADHD < CG ▪ Level of impulsivity (delay discounting-probability discounting): ADHD > CG ▪ CPT total gain: ADHD = CG
Duarte <i>et al.</i> (2012)	ADHD MFM-dependent: <i>n</i> (m/f) = 23 (21/2) Age <i>M(SD)</i> = 40.0y (5.9) CG MFM-dependent: <i>n</i> (m/f) = 25 (24/1) Age <i>M(SD)</i> = 40.2y (6.2) CG: <i>n</i> (m/f) = 22 (20/2) Age <i>M(SD)</i> = 43.0y (14.3)	Mood disorder (present): ADHD+MFM: <i>n</i> = 4 CG+MFM: <i>n</i> = 5 CG: <i>n</i> = 1 ASPD: CG+MFM: <i>n</i> = 3 ADHD+MFM: <i>n</i> = 10 CG: <i>n</i> = 0	None of the participants in the ADHD group used stimulants.	▪ IGT	▪ IGT total net score: ADHD MFM-dependent < CG ▪ IGT total net score: ADHD-MFM dependent with working memory problems < all other participants. ▪ Working memory deficits may moderate the expression of risky decision-making in ADHD participants with MFM dependence.
Ernst <i>et al.</i> (2003)	ADHD: <i>n</i> (m/f) = 10 (5/5) Age <i>M(SD)</i> = 29.9y (7.3) CG: <i>n</i> (m/f) = 12 (6/6) Age <i>M(SD)</i> = 28.8y (6.6)	Comorbid psychiatric disorders (both present/remitted) were part of the exclusion criteria.	Stimulants: <i>n</i> = 2 All participants were off-medication 48 hours before testing.	▪ IGT	▪ IGT net scores: ADHD = CG

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Study ^a	Sample characteristics ^b	Comorbidities ^c	Medication ^d	DM task(s)	Main results
Gonzalez-Gadea <i>et al.</i> (2013)	ADHD: <i>n</i> (mf) = 22 (14/8) Age <i>M</i> (<i>SD</i>) = 35.3y (12.7) AS: <i>n</i> (mf) = 23 (15/8) Age <i>M</i> (<i>SD</i>) = 33.0y (9.8) CG: <i>n</i> (mf) = 21 (11/10) Age <i>M</i> (<i>SD</i>) = 38.3y (14.4)	Comorbid psychiatric disorders were part of the exclusion criteria.	MFD = 54.5% Atomoxetine = 9.1% Benzodiazepines = 18.8% >50% of the ADHD participants were on medication during testing.	■ IGT	■ IGT total net score: ADHD = AS = CG ■ IGT net score block 2: AS > ADHD
Hurst <i>et al.</i> (2011)	Sample of university students: ADHD <i>n</i> (mf) = 21 (5/16) CG: <i>n</i> (mf) = 218 (70/148) Age both groups ≥ 18y	Unknown	Unknown	■ DDT	■ DDT impulsiveness: ADHD > CG ■ DDT discounting rate: ADHD > CG ■ Earnings 1-, 3-, and 10-year delay conditions: ADHD < CG ■ DDT showed a moderate discriminant validity for detecting self-reported ADHD.
Ibanez <i>et al.</i> (2012)	ADHD: <i>n</i> (mf) = 12 (11/1) Age <i>M</i> (<i>SD</i>) = 31.4y (11.0) CG: <i>n</i> (mf) = 25 (16/9) Age <i>M</i> (<i>SD</i>) = 35.1y (11.2)	Comorbid psychiatric disorders were part of the exclusion criteria, except generalized anxiety disorders.	MFD: <i>n</i> = 12 All participants were off-medication on the day of testing.	■ IGT ■ RDMUR ■ RDGT	■ IGT total net score: ADHD = CG ■ RDMUR total score: ADHD = CG ■ RDMUR total reaction time: ADHD = CG ■ RDGT (ERP): Compared to CG, the ADHD group showed a neural pattern that appeared indicative of impaired learning by feedback and an insensitivity to reward magnitude.
Malloy-Diniz <i>et al.</i> (2007)	ADHD: <i>n</i> (mf) = 50 (28/22) Age <i>M</i> (<i>SD</i>) = 33.7y (11.7) CG: <i>n</i> (mf) = 51 (31/20) Age <i>M</i> (<i>SD</i>) = 32.2y (12.9)	≥ 1 comorbid disorder(s) (present): <i>n</i> = 14 Psychiatric diagnoses CG: <i>none</i>	None of the participants were long-term MFD users. All participants were off-medication on the day of testing.	■ IGT	■ IGT total net score: ADHD < CG ■ IGT net score block 1 and 2: ADHD = CG ■ IGT net score block 3, 4 and 5: ADHD < CG
Malloy-Diniz <i>et al.</i> (2008)	ADHD: <i>n</i> (mf) = 25 (15/10) Age <i>M</i> (<i>SD</i>) = 31.8 y (9.1) CG English: <i>n</i> (mf) = 25 (8/17) Age <i>M</i> (<i>SD</i>) = 28.5y (6.5) CG Portuguese: <i>n</i> (mf) = 25 (10/15) Age <i>M</i> (<i>SD</i>) = 32.1y (8.5)	Unknown Psychiatric diagnoses CG: <i>none</i>	None of the participants were long-term MFD users. All participants were off-medication on the day of testing.	■ IGT (English and Portuguese version)	■ IGT total net score: ADHD < CG ■ IGT net score block 1 and 2: ADHD = CG ■ IGT net score block 3, 4 and 5: ADHD < CG ■ IGT net scores: CG English = CG Portuguese
Mäntylä <i>et al.</i> (2012)	ADHD: <i>n</i> (mf) = 31 (17/14) Age <i>M</i> (<i>SD</i>) = 30.8y (12.58) CG: <i>n</i> (mf) = 32 (17/15) Age <i>M</i> (<i>SD</i>) = 29.84y (10.81)	Level of depression (BDI): ADHD > CG	MFD: <i>n</i> = 22 Other medication use: <i>n</i> = 1	■ Applying decision rules task (DMC1) ■ Under/overconfidence task (DMC2) ■ IGT ■ BART	■ DMC1 performance: ADHD < CG ■ DMC2 performance: ADHD = CG ■ IGT performance: ADHD < CG Note: group effects mediated by level of education. ■ BART performance: ADHD = CG

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Study ^a	Sample characteristics ^b	Comorbidities ^c	Medication ^d	DM task(s)	Main results
Marx <i>et al.</i> (2013)	ADHD + financial reward: <i>n</i> (mf) = 20 (11/9) Age <i>M</i> (<i>SD</i>) = 29.31y (6.58) ADHD + no reward: <i>n</i> (mf) = 18 (11/7) Age <i>M</i> (<i>SD</i>) = 27.72y (6.21) CG + financial reward: <i>n</i> (mf) = 20 (10/10) Age <i>M</i> (<i>SD</i>) = 25.13y (5.43) CG + no reward: <i>n</i> (mf) = 20 (9/11) Age <i>M</i> (<i>SD</i>) = 24.75y (3.63)	≥ 1 comorbid disorder(s); <i>n</i> = 14 Psychiatric diagnoses CG: <i>none</i>	Drug naïve; <i>n</i> = 18 All participants were off-medication 72 hours before testing.	<ul style="list-style-type: none"> Delay Aversion Task (adapted version) 	This study focused on the effect of reward on task performance (i.e., participants in the reward groups could earn money based on the quality of their performance). <ul style="list-style-type: none"> Mean trial duration: Financial reward > no reward Mean trial duration: ADHD < CG Note: Both CG and ADHD participants showed an optimal performance (ceiling effect). <ul style="list-style-type: none"> Task performance: ADHD + financial reward = CG + no reward.
Matthies <i>et al.</i> (2012) Study 1	ADHD: <i>n</i> (mf) = 15 (8/7) Age <i>M</i> (<i>SD</i>) = 38.1y (10.96) CG: <i>n</i> (mf) = 16 (8/8) Age <i>M</i> (<i>SD</i>) = 32.4y (14.37)	≥ 1 comorbid disorder(s); <i>n</i> = 13 Psychiatric diagnosis CG: <i>n</i> = 6	All participants were off-medication 48 hours before testing.	<ul style="list-style-type: none"> GDT 	<ul style="list-style-type: none"> GDT net score: ADHD < CG GDT financial end capital: ADHD < CG Frequency of staying with a safe choice after positive feedback (winning): ADHD < CG Continuation of risky choices after negative feedback (losing): ADHD > CG
Matthies <i>et al.</i> (2012) Study 2	ADHD: <i>n</i> (mf) = 14 (8/6) Age <i>M</i> (<i>SD</i>) = 32.8y (10.28) CG: <i>n</i> (mf) = 13 (6/7) Age <i>M</i> (<i>SD</i>) = 38.0y (11.95)	≥ 1 comorbid disorder(s); <i>n</i> = 12 Psychiatric diagnosis CG: <i>n</i> = 7	All participants were off-medication 48 hours before testing.	<ul style="list-style-type: none"> GDT + boredom induction 	After boredom induction: <ul style="list-style-type: none"> GDT net score: ADHD = CG GDT financial end capital: ADHD = CG Use of feedback: ADHD = CG Risky decision making: CG Study 2 > CG Study 1
McLean <i>et al.</i> (2004)	ADHD: <i>n</i> (mf) = 19 (15/4) Age <i>M</i> (<i>SD</i>) = 27.7y (1.6) CG: <i>n</i> (mf) = 19 (15/4) Age <i>M</i> (<i>SD</i>) = 29.5y (1.6)	Sample with multiple comorbid disorders (<i>n</i> = unknown). Psychiatric diagnosis CG: <i>none</i>	MFD: <i>n</i> = 13 All participants were off-medication 24 hours before testing.	<ul style="list-style-type: none"> CGT 	<ul style="list-style-type: none"> CGT percentage bets made: ADHD = CG CGT quality of decision making (number of optimal choices): ADHD = CG Deliberation time: ADHD = CG
Mesrobian <i>et al.</i> (2018)	ADHD: <i>n</i> (mf) = 18 (11/7) Age <i>M</i> (<i>SD</i>) = 22.3y (0.7) CG: <i>n</i> (mf) = 18 (10/8) Age <i>M</i> (<i>SD</i>) = 22.0y (0.8)	Comorbid psychiatric disorders were part of the exclusion criteria.	All participants were off-medication 24 hours before testing.	<ul style="list-style-type: none"> PGT 	<ul style="list-style-type: none"> PGT total gain: ADHD = CG PGT risk index: ADHD = CG - Participants of both groups kept the same risk-taking attitude in both feedback conditions (i.e., high-frequency and low-frequency). Response times: ADHD > CG
Miller <i>et al.</i> (2013)	ADHD: <i>n</i> = 114 CG: <i>n</i> = 77 Only female participants included in both groups. Age range both groups = 17-25y	Unknown	All participants were off-medication 24 hours before testing.	<ul style="list-style-type: none"> IGT 	<ul style="list-style-type: none"> IGT number of risky choices: ADHD > CG NOTE: marginally significant. <ul style="list-style-type: none"> Increase of preference for safe decks across blocks: ADHD < CG

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Study ^a	Sample characteristics ^b	Comorbidities ^c	Medication ^d	DM task(s)	Main results
Mowinckel <i>et al.</i> (2017) ^e	ADHD: <i>n</i> (mf) = 20 (7/13) Age <i>M</i> (<i>SD</i>) = 29.9y (1.4) ADHD participants were tested twice: once in a placebo and once in an MFD condition. CG: <i>n</i> (mf) = 27 (8/19) Age <i>M</i> (<i>SD</i>) = 27.4y (1.2)	Unknown	Use of medication for psychiatric disorders other than ADHD were part of the exclusion criteria.	DM task(s) ■ Reward-Based ■ Decision-Making Task	Main results ■ Task accuracy: ADHD+placebo < CG ■ Number of errors: ADHD+placebo > ADHD+MFD ■ Response time: ADHD > CG (no influence of MFD) ■ Response time variability: ADHD = CG (no influence of MFD)
Onnink <i>et al.</i> (2015)	ADHD: <i>n</i> (mf) = 107 (41/66) Age <i>M</i> (<i>SD</i>) = 35.0y (10.3) CG: <i>n</i> (mf) = 109 (47/62) Age <i>M</i> (<i>SD</i>) = 36.1y (11.0)	≥ 1 depressive episode (remitted): <i>n</i> = 52 (CG: <i>n</i> = 12) Anxiety disorder (remitted): <i>n</i> = 22 (CG: <i>n</i> = 6) Substance use (remitted): <i>n</i> = 21 (CG: <i>n</i> = 6) Borderline personality disorder: <i>n</i> = 10 (CG: <i>n</i> = 0)	Stimulants (present): <i>n</i> = 64 Stimulants (past): <i>n</i> = 14 Non-stimulants: <i>n</i> = 9 Drug naive: <i>n</i> = 20	DDT	■ DDT discounting rate: ADHD > CG
Ortiz <i>et al.</i> (2015)	ADHD: <i>n</i> (mf) = 10 (7/3) Age <i>M</i> (<i>SD</i>) = 28.4y (8.9) CG: <i>n</i> (mf) = 11 (unknown) Age <i>M</i> (<i>SD</i>) = 25.4y (5.8)	Sample with multiple comorbid disorders (<i>n</i> = unknown). Psychiatric diagnosis CG: none	Stimulants: <i>n</i> = 4 Non-stimulants: <i>n</i> = 1 Anti-depressants: <i>n</i> = 1 All participants were off-medication 48 hours before testing.	DDT	■ DDT discounting rate: ADHD = CG
Pielhita <i>et al.</i> (2009)	ADHD: <i>n</i> = 14 Age <i>M</i> (<i>SD</i>) = 23.3y (5.2) CG: <i>n</i> = 14 Age <i>M</i> (<i>SD</i>) = 23.6y (1.9) Only male participants included in both groups.	Comorbid psychiatric disorders were part of the exclusion criteria.	MFD: <i>n</i> = 7 All participants were off-medication 4 days before testing.	Intertemporal Choice Task	■ Preferences for immediate rewards: ADHD = CG ■ Decision time (averaged for all choices): ADHD = CG ■ Decision time ADHD: delayed rewards > immediate rewards.
Pollak <i>et al.</i> (2018)	Sample of university students: ADHD: <i>n</i> (mf) = 31 (13/18) Age <i>M</i> (<i>SD</i>) = 24.8y (2.81) CG: <i>n</i> (mf) = 31 (14/17) Age <i>M</i> (<i>SD</i>) = 24.8y (3.01)	≥ 1 comorbid disorder(s) (present): <i>n</i> = 4 ≥ 1 comorbid disorder(s) (remitted): <i>n</i> = 18 Psychiatric diagnosis CG (present): <i>n</i> = 0 Psychiatric diagnosis CG (remitted): <i>n</i> = 5	Medication use: Daily: <i>n</i> = 9 Occasionally: <i>n</i> = 10 All participants were off-medication 24 hours before testing.	CGT (modified version)	■ CGT sum of bets: ADHD = CG ■ CGT risk adjustment: ADHD = CG ■ Deliberation time: ADHD = CG ■ Risk-taking pattern: ADHD = CG ■ Substance use: ADHD > CG

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Study ^a	Sample characteristics ^b	Comorbidities ^c	Medication ^d	DM task(s)	Main results
Schäfer <i>et al.</i> (2015)	ADHD inattentive: <i>n</i> (mf) = 11 (3/8) Age <i>M</i> (<i>SD</i>) = 33.9y (9.6)	Unknown	Unknown	Social Justice Game	<ul style="list-style-type: none"> Task performance: ADHD inattentive presentation = ADHD hyperactive/impulsive or combined presentation Proffiler sensitivity: ADHD-groups > CG Perpetrator sensitivity: ADHD-groups = CG Observer sensitivity: ADHD-groups > CG
	ADHD hyperactive/impulsive or combined: <i>n</i> (mf) = 18 (8/10) Age <i>M</i> (<i>SD</i>) = 35.6y (10.5)				
	CG: <i>n</i> (mf) = 14 (4/10) Age <i>M</i> (<i>SD</i>) = 31.2y (4.9)				
	ADHD: <i>n</i> (mf) = 30 (19/11) Age <i>M</i> (<i>SD</i>) = 33.7y (9.51) CG: <i>n</i> (mf) = 30 (19/11) Age <i>M</i> (<i>SD</i>) = 32.6y (9.54) All participants were tested twice: once in a placebo and once in a medicated condition.				
Sethi <i>et al.</i> (2018) ^e		Comorbid psychiatric disorders were part of the exclusion criteria, except anxiety and/or unipolar depressive disorder in remission.	All patients were on a stable medication regimen (i.e., MFD/dexamphetamine) ≥ 2 months prior to participation. All participants were off-medication 48 hours before testing.	<ul style="list-style-type: none"> Reinforcement Learning Task + Novelty Manipulation 	<ul style="list-style-type: none"> Total gain: ADHD + placebo < CG Reward-related learning rate: ADHD + placebo < CG + placebo Novelty bonus: ADHD + placebo = CG <p>Note: although not statistically significant, the novelty bonus was more than twice as large in the ADHD + placebo group compared to the CG.</p> <ul style="list-style-type: none"> Selection of novel options at first presentation: ADHD + placebo > CG-groups MFD improved performances on all measures in ADHD, but not in CG (dissociable effects of MFD).
Tamm <i>et al.</i> (2013)	ADHD cannabis-users: <i>n</i> (mf) = 42 (39/3) Age <i>M</i> (<i>SD</i>) = 24.4y (1.3) ADHD non-users (no cannabis): <i>n</i> (mf) = 45 (33/12) Age <i>M</i> (<i>SD</i>) = 24.6y (1.4) CG cannabis-users: <i>n</i> (mf) = 20 (17/3) Age <i>M</i> (<i>SD</i>) = 23.7y (1.4) CG non-users (no cannabis): <i>n</i> (mf) = 21 (14/7) Age <i>M</i> (<i>SD</i>) = 23.4y (1.5)	Unknown	ADHD cannabis users: Stimulants (daily): <i>n</i> = 3 Stimulants (occasionally): <i>n</i> = 1 ADHD non-users: Stimulants (daily): <i>n</i> = 2 Stimulant (occasionally): <i>none</i> All participants were off-medication during testing.	<ul style="list-style-type: none"> IGT 	<ul style="list-style-type: none"> IGT total net score: ADHD-groups < CG IGT total net score: cannabis-users < non-users
Todokoro <i>et al.</i> (2018)	ADHD: <i>n</i> (mf) = 14 (5/9) Age <i>M</i> (<i>SD</i>) = 31.2y (6.7) CG: <i>n</i> (mf) = 16 (6/10) Age <i>M</i> (<i>SD</i>) = 32.2y (4.8)	≥ 1 comorbid disorder(s): <i>n</i> = 6 Psychiatric diagnosis CG: <i>none</i>	All participants were off-medication.	<ul style="list-style-type: none"> Intertemporal Choice Task 	<ul style="list-style-type: none"> Time discounting rate: ADHD = CG Behavioral choices dependent on waiting time: ADHD = CG ADHD-group showed no tendency to choose immediate rewards over delayed rewards. Total gain (total score): ADHD > CG
Wilbertz <i>et al.</i> (2012)	ADHD: <i>n</i> (mf) = 28 (15/13) Age <i>M</i> (<i>SD</i>) = 37.11y (9.13) CG: <i>n</i> (mf) = 28 (14/14) Age <i>M</i> (<i>SD</i>) = 36.71y (9.31)	≥ 1 comorbid disorder(s) (present): <i>n</i> = 7 ≥ 1 comorbid disorder(s) (remitted): <i>n</i> = 9 Psychiatric diagnosis CG: <i>none</i>	Stimulants (past): <i>n</i> = 4 Drug naive: <i>n</i> = 20 All participants were off-medication ≥ 2 months before testing.	<ul style="list-style-type: none"> DDT GDT 	<ul style="list-style-type: none"> DDT discounting rate: ADHD = CG GDT number of risky choices: ADHD = CG GDT use of negative feedback: ADHD = CG

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Study ^a	Sample characteristics ^b	Comorbidities ^c	Medication ^d	DM task(s)	Main results
Yang <i>et al.</i> (2019)	ADHD: n (m/f) = 20 (11/9) Age $M(SD)$ = 26.9y (4) CG: n (m/f) = 20 (8/12) Age $M(SD)$ = 27.7y (5.9)	Comorbid psychiatric disorders were part of the exclusion criteria.	MFD (present): n = 1 MFD (past): n = 1 Drug naive: n = 18	IGT	<ul style="list-style-type: none"> IGT total netscore: ADHD < CG IGT number of safe choices: ADHD = CG IGT number of risky choices: ADHD = CG IGT financial end capital: ADHD = CG

Note. **ADHD** = attention-deficit/hyperactivity disorder; **AS** = Asperger Syndrome; **ASPD** = Anti-Social Personality Disorder; **BART** = Balloon Analogue Risk Task; **BDI** = Beck Depression Inventory; **CD** = Conduct Disorder; **CG** = Control Group; **CGT** = Cambridge Gambling Test; **CPT** = Card Playing Task; **DDT**: Delay Discounting Task; **DM** = Decision Making; **DPAS** = Driver Performance Analysis System; **EEFT** = Effort Expenditure for Rewards Task; **ERP** = Event-Related Potential; **FCAI** = Financial Competence Assessment Inventory; **FDM** = Financial Decision Making; **FDMI** = Financial Decision-Making Interview; **FPGT** = Foregone Payoff Gambling Task; **GDT** = Game of Dice Task; **IGT** = Iowa Gambling Task; **MFD** = Methylphenidate; **MFM** = Methamphetamine; **ODD** = Oppositional Defiant Disorder; **PD** = Probability Discounting; **PDT** = Probability Discounting Task; **PCT** = Probabilistic Gambling Task; **RDMUR** = Rapid-Decision Gambling Task; **RDGT** = Rapid-Decision Making Under Risk task; **TDT** = Temporal Discounting Task.

^a First author (year)

^b n (m/f) = sample size (number of males in sample / number of females in sample). $M(SD)$ = Average age (standard deviation) in years.

^c Comorbidities refer to psychiatric diagnoses comorbid to ADHD that (if not otherwise specified in the table) may include: major depression, dysthymia, (generalized) anxiety disorder, social phobia, specific phobias, obsessive-compulsive disorder, bulimia, substance dependency/substance use disorder and personality disorders such as borderline personality disorder.

^d Medication refers to (stimulant) medication use in the ADHD-group (unless otherwise specified in the table).

^e Double blind placebo-controlled medication study.

^f In the article of Bangma *et al.* (2019) the DMCI is called the Competence in Decision Rules (CDR) test.

Discussion

The aim of this systematic review was to determine the nature and extent of potential deficits in the decision making of adults with ADHD. Given that ADHD and the associated impairments have only been studied extensively in adults from the 1990s and onwards (Lange et al., 2010), only a limited number of studies were found within the search parameters. In total, 31 studies that examined the performances of adults with ADHD in different types of decision-making tasks were included. Of these studies, 55% reported that adults with ADHD displayed aberrant behavior on one or more of the decision-making tasks at hand, as was indicated by significant group differences between the ADHD and control groups. This review therefore cautiously provides evidence of differences in the decision making of healthy individuals and adults with ADHD. However, the findings are highly inconsistent. Various factors that could influence the outcome of decision-making tasks, including the variety of decision-making domains that have been examined, the high level of comorbidity, and the use of medication in the ADHD groups, may explain this inconsistency.

Domains of decision making. A prominent finding of this review is that measures of risky decision-making (i.e., gambling tasks) appear to be largely overrepresented in the current evidence base as compared to other decision-making domains (Table 6.2). This may be due to the large availability of performance-based tasks that measure risky decision making as compared to the availability of other types of decision-making tasks (Table 6.1). Another explanation may be the appeal of risky decision-making in adults with ADHD as a topic for research. Risky decision-making has both been well established in children and adolescents with ADHD, and is clearly documented in real-life scenarios (e.g., Groen et al., 2013; Pollak et al., 2016). The consequences of increased risk-taking in adults with ADHD have been frequently described in terms of a higher risk of substance abuse (Charach et al., 2011), criminal behavior (Fletcher & Wolfe, 2009), unsafe sex (Sarver et al., 2014) and dangerous driving (Fuernberger et al., 2017) in this population. Contrary to what has been established in children with ADHD, and in the daily life of adults with ADHD, only a minority of studies (i.e., 45%) found that adults with ADHD performed in a more risky fashion than the control groups on the adopted tasks. With the previous results of Groen et al. (2013) in mind, this finding is not surprising (see also Mowinckel et al., 2015). Groen et al. (2013) argue that the developmental trajectory of ADHD, which is characterized by a reduction in ADHD symptoms from childhood to adulthood, could make risky decision-making less prominent in adults with ADHD than in children. Moreover, the experimental gambling tasks that have been used in the included studies, may not form a truly valid model for risk-taking behavior in daily life. According to Pollak et al. (2018), this lack of ecological validity may explain the gap between real-life risk-taking and experimental behavior (see also ‘limitations and future directions for research’).

Given the prominent role of delay discounting in theories about the underlying mechanisms of ADHD (e.g., Sonuga-Barke, 2003, 2005) and the clear deficits found in children and adolescents with ADHD regarding this decision-making domain (Mies et al., 2019; Patros et al., 2016; Sonuga-Barke et al., 1992), the inconsistency in the results of studies that looked at delay discounting in adults with ADHD is more surprising. Mowinckel et al. (2015)

concluded, following their meta-analysis, that too few studies may have been carried out so far to reliably estimate the level of delay discounting in adults with ADHD. Another explanation might be that adults, compared to children, have better learned to cope with their propensity to discount future rewards. According to Mowinckel et al. (2015) the latter explanation seems, however, unlikely as adults with ADHD are believed to experience problems in reward-related learning (Mowinckel et al., 2017; Sethi et al., 2018), which seems to be in line with the findings of the present review. Based on the currently available literature, no clear conclusions can be drawn on the level of delay discounting in adults with ADHD.

With regard to deliberative decision-making, reward-related decision-making, social decision-making, decision making in relation to driving, and financial decision-making in adults with ADHD, no clear conclusions can be drawn either on the basis of this review. These domains of decision making are largely underrepresented in the current evidence base. As the included studies do seem to indicate the existence of deficits in these domains of decision making, additional research into these domains is strongly recommended. The tasks used to assess these domains of decision making possibly provide a more valid model for daily life decision making in adults with ADHD.

Comorbidities. There are major differences between the studies concerning the inclusion and exclusion of participants with comorbid disorders (Table 6.2). These differences may partly explain the inconsistency in the current evidence base regarding decision making in adults with ADHD. Adults with ADHD, more often than children and adolescents, present with psychiatric comorbidities, including anxiety-, mood-, substance use-, and personality disorders (Gentile et al., 2006; Katzman et al., 2017). It is therefore not surprising that the majority of studies included in this review show a high level of (psychiatric) comorbidity in the ADHD group. A downside to the inclusion of participants with diagnoses comorbid to ADHD is that this limits the extent of which to speak of pure ADHD-effects in relation to decision-making task performance. Diagnoses comorbid to ADHD, including (current) depressive disorders (e.g., Matthies et al., 2012), can have an (additive) negative impact on the outcome measures of the decision-making tasks (Jensen et al., 1997). Excluding participants with comorbid disorders, which was done in nine studies (Table 6.2), can, however, limit the generalizability and ecological validity of the study results (Abramovitch et al., 2015; Jensen et al., 1997). Seven studies did not report on the presence of comorbidities in the ADHD groups (Abouzari et al., 2015; Hurst et al., 2011; Malloy-Diniz et al., 2008; Miller et al., 2013; Mowinckel et al., 2017; Schäfer & Kraneburg, 2015; Tamm et al., 2013).

Medication. Another explanatory factor for the inconsistency in the evidence base is the treatment of ADHD symptoms through stimulant medication. Although stimulants, including methylphenidate and amphetamines, are often prescribed for the treatment of ADHD (Safer, 2016), only five studies examined the acute effects of stimulants on task performance. Three studies found that the use of stimulants had a positive effect on decision-making task performance in the ADHD group. The other two studies found no effect of methylphenidate on task performance. As Groen et al. (2013) also concluded in their study on risky decision making in individuals with ADHD, no conclusions can be drawn on the effectiveness of stimulants in

reducing deficits in the decision-making process based on the findings of this small number of studies.

With regard to controlling for the (long-term) effects of stimulant medication upon performance, the included studies were also shown to differ in their approach. Although the participants in most studies were asked to discontinue medication treatment during testing, the moment of discontinuation varied greatly, from several hours to four days prior to the assessment. It should furthermore be noted that a discontinuation of medication treatment prior to assessment is not necessarily sufficient to control for the long-term effects of ADHD medication. A history of medication use can also have a (positive) effect on the participants' ability to make decisions, as the medication may have contributed at the time the decision-making abilities were learned/acquired. In four studies, the ADHD participants continued their pharmacological treatment during testing (Gonzalez-Gadea et al., 2013; Mäntylä et al., 2012; Onnink et al., 2015; Yang et al., 2019). This may have led to a reduction in ADHD symptoms in the participant sample (DeVito et al., 2008; Spencer et al., 1995) and consequently to an underestimation of the ADHD related impairments in the decision-making process (e.g., Mäntylä et al., 2012). Of these four studies, only one study controlled for the medication use of the participants (Onnink et al., 2015). Two studies did not specify to what extent the participants were using medication at the time of the assessment (Hurst et al., 2011; Schäfer & Kraneburg, 2015).

Underlying mechanisms. According to the dual-pathway model of ADHD, deficits in decision making in individuals with ADHD can be associated with dysregulations of the motivational-emotional and the cognitive pathways in the brain (Sonuga-Barke, 2003, 2005). Motivational-emotional deficits could subsequently lead to problems with intuitive decision-making and cognitive deficits to problems with deliberative decision-making (Mäntylä et al., 2012). Capabilities that are important for deliberative decision-making include knowledge and understanding of probabilities, the ability to update this knowledge in working memory and store it in long-term memory, and the ability to inhibit responses to occasional feedback (Van Duijvenvoorde et al., 2012). Capabilities that are important for intuitive decision-making are the processing of reward and punishment, and the visceral responses to these feedback cues (Dunn et al., 2006; Séguin et al., 2007). Most decision-making tasks included in this review can be seen as a measurement of both intuitive- and deliberative decision-making. However, some decision-making tasks are more specific: some of the included gambling tasks and the sub-tests of the A-DMC battery, e.g., mainly call for deliberative decision making; delay discounting tasks and reward-related tasks, in particular, call for intuitive decision making. In general, it can be concluded that the overall pattern of the findings of the present review (i.e., significant between-group differences in 55% of the studies) is consistent with dual-pathway model of ADHD. In the included studies, adults with ADHD show aberrant performances in both intuitive and deliberative decision-making tasks (Table 6.2). This review therefore provides no evidence that the decision-making deficits found can be explained by purely motivational-emotional or cognitive models. It should however be noted that the suitability of the dual-pathway model of ADHD as an explanatory model for the deficits in the decision making of

individuals with ADHD is questioned by the finding that 45% of the studies reported no significant group differences.

Limitations and future directions for research. The results of this literature search must be interpreted with care, and several limitations need to be acknowledged. Firstly, the diagnostic status of the participants with ADHD has not been verified in all of the included studies. Although most studies made use of a DSM interview to confirm diagnostic status prior to assessment, some studies adopted a different approach. For example, some studies made use of a (childhood) follow-up sample, leaving it unclear whether participants still met the diagnostic criteria for ADHD at the time of testing (Miller et al., 2013; Tamm et al., 2013). In a number of other studies, participants were asked whether they had received an ADHD diagnosis in the past. Such self-report methods can be seen as less reliable methods for group assignment (e.g., Hurst et al., 2011; Schäfer & Kraneburg, 2015). These differences in diagnosis verification may limit the extent of which to speak of (pure) ADHD effects, and can therefore be seen as a limitation of this review.

A second limitation concerns the ecological validity of the present findings. While this review indicates the existence of an association between ADHD in adulthood and the performance on decision-making tasks, little can be said about the relationship between task performance and decision making in everyday life. The dynamic factors that contribute to daily-life decision-making, including social context, emotional arousal and the extent of gains and losses of a particular decision, do not easily compare to the artificial context of experimental performance-based tasks (Pollak et al., 2018). More research is therefore needed to firmly establish the relationship between decision-making task performance and decision making in everyday life (Groen et al., 2013). Moreover, future research should aim to improve the ecological validity of decision-making tasks. This can be achieved, e.g., by introducing social and emotional aspects to the task environment (Pollak et al., 2018), and by attaching long-term consequences to the task decisions made. Further, future research could focus on the use of tasks that focus on more specific domains of decision making, such as financial decision making or decision making in relation to driving, which may better reflect everyday decision-making situations.

A third limitation, which manifests at the review level, is that despite the growth in the evidence base on adults with ADHD (see Lange et al., 2010), only a relatively small number of studies could be included in the present systematic review ($k = 31$). Thus far, the findings of these studies are rather inconsistent. More research is therefore needed into decision making in adults with ADHD (for a recent meta-analysis, see Mowinckel et al., 2015). As discussed, this recommendation especially applies to the domains of decision making that are currently not sufficiently studied (e.g., reward-related decision-making, social decision-making, etc.). Future research can in this way fill the gaps in the current evidence base, and substantiate the conclusions offered by the present review.

A final limitation of this review is that no risk of bias evaluation has been carried out. To the best of the authors knowledge, there is no valid and reliable measuring instrument available to date that can be used for cross-sectional studies, as have been included in this systematic review. This limitation should be taken into account when interpreting the results.

Conclusion

This systematic literature review on decision making in adults with ADHD cautiously provides evidence of differences between decision making in healthy individuals and adults with ADHD. Specifically, the majority of the included studies (i.e., 55%) reported that adults with ADHD showed aberrant performances on one or more of the decision-making tasks at hand as compared to the control group(s). However, the current findings are rather inconsistent, which has been further explained by the variety of decision-making domains that have been examined, the comorbid disorders, and the medication use in the ADHD groups. The overall pattern of the findings of this literature review appears to be consistent with the dual-pathway model of ADHD, as adults with ADHD show aberrant performances in both intuitive as well as deliberative decision-making tasks. The decision-making deficits of adults with ADHD may therefore originate from a dysregulation of the motivational-emotional pathway in the brain as well as from a dysregulation of the cognitive routes. The suitability of the dual-pathway model of ADHD as an explanatory model for the deficits in the decision making of individuals with ADHD is, however, questioned by the finding that 45% of the included studies reported no significant between-group differences.

Future research must aim to further expand the evidence base on decision making in adults with ADHD. Special attention is recommended to be given to the ecological validity of the adopted task paradigms in order to ensure generalizability of the findings to everyday decision-making. The information yielded by such research, can add to the help that is offered to reduce risky behavior and decision-making difficulties in the daily life of adults with ADHD.

Appendices

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CHAPTER

7

FINANCIAL DECISION-MAKING IN ADULTS WITH ADHD.

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Neuropsychology (2019)

Abstract

Objectives: Attention-deficit/hyperactivity disorder (ADHD) in adulthood is associated with problems in multiple domains of everyday life, including financial decision-making (FDM). Research on FDM in adults with ADHD is, however, limited and FDM has never been examined in an objective standardized manner in these patients. The aim of the present study is to explore FDM abilities of adults with ADHD, using both subjective and standardized objective measures.

Methods: Adults with ADHD ($n = 45$) and healthy controls ($n = 51$) completed a comprehensive test battery, including an evaluation of their personal financial situation, a neuropsychological assessment and standardized tests and questionnaires measuring various aspects of FDM.

Results: Adults with ADHD reported to have a significantly poorer financial situation than healthy controls, including having less income, more often debts and less often a savings account. Furthermore, adults with ADHD showed significantly lower scores than healthy controls in standardized tests measuring financial competence and capacity (i.e., understanding bank statements/protocols and evaluating financial problems) as well as in a test measuring decision making with implications for the future. Furthermore, compared to healthy controls, adults with ADHD reported more often to buy on impulse and to use an avoidant or spontaneous decision-making style. A mediating effect of numeracy was found for two measures of FDM (i.e., financial competence and capacity), however, group differences on these measures remained statistically significant.

Conclusion: Adults with ADHD have difficulties with several aspects of FDM. These difficulties may at least partly explain the poorer financial situation of adults with ADHD.

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a developmental disorder that is characterized by symptoms of inattention, hyperactivity and impulsivity (American Psychiatric Association, 2013). The symptoms of ADHD persist into adulthood in about 50% of children with ADHD (range 32.8 – 84.1%; Lara et al., 2009), resulting in a prevalence of adult ADHD of approximately 3.4% (range 1.2 – 7.3%; Fayyad et al., 2007). ADHD is a condition which has a negative impact on several aspects of everyday functioning, including educational and occupational performances (Barkley et al., 2008; Daley & Birchwood, 2010), social functioning (Michielsen et al., 2015; Nijmeijer et al., 2008) and driving (Barkley et al., 2002; Fuermaier et al., 2017). Financial decision-making (FDM) is also a domain of everyday functioning that is of utmost importance for independent living, in particular for adults who have to make numerous financial decisions with often far-reaching consequences (e.g., concerning insurances, mortgages or pension schemes). FDM describes various aspects of functioning related to decision-making in a financial context, such as dealing with money, paying bills or making financial decisions for the future. Poor FDM can have serious negative consequences, such as debts, poverty or financial dependency. So far, very few studies focused on FDM in patients with ADHD and the studies that have been performed only applied self-report measures and interviews. These studies reported that symptoms of ADHD (both hyperactivity-impulsivity and inattention) were found to be associated with financial problems (Altszuler et al., 2016; Barkley & Fischer, 2010; Das et al., 2012). Adults with ADHD specifically reported less often to have a credit card or a savings account and also to be more often financially dependent on their parents or welfare systems than healthy individual (Altszuler et al., 2016). Some studies found that adults with ADHD and healthy individuals do not differ with regard to income level and the amount of debts (Altszuler et al., 2016; Barkley et al., 2006). The participants in these studies were, however, relatively young (age at assessment was between 19 and 25) and predominantly male. In a follow-up of the Milwaukee study (Barkley et al., 2008), participants with ADHD aged 27 reported significantly more often problems with money management than age-matched controls, including difficulties with managing money, problems with buying on impulse, exceeding credit card limits, a lower monthly income, a lower saving-income ratio and problems with saving money. Similar money management problems were found in the UMASS study of Barkley et al. (2008) in adults with ADHD with an average age of 32.4 years. However, in the latter study the healthy comparison group was with an average age of 36.4 years significantly older than the adults with ADHD, which needs to be taken into account. Biederman and Faraone (2006) included adults with ADHD up to 64 years old and also found significantly lower income levels in their ADHD group compared to a healthy control group. In summary, the limited research available clearly indicates that adults with ADHD are more vulnerable to money management problems than healthy controls; problems that may become more evident when becoming older.

Indications that adults with ADHD may experience difficulties with FDM also come from the field of general decision-making. Within this field standardized tests are used that do not focus on FDM, but are context independent instead. Two systems of information processing

are suggested to be involved in general decision-making: an affective/experiential processing of information relying on affect or intuition and deliberative/analytic processing of information relying on cognitive control (see Evans (2008) for review). It is suggested that decision-making requires the input and integration of both systems (Kahneman, 2003; Peters et al., 2007). Poor decision-making of adults with ADHD appears to be particularly evident in situations requiring a high cognitive control and it has been suggested that poor decision-making is mediated by impairments of working memory or response inhibition (Mäntylä et al., 2012). This is consistent with the impairments in executive functioning that are often found in adults with ADHD (Boonstra et al., 2005, 2010; Fuermaier et al., 2015; Hervey et al., 2004; Matt Alderson et al., 2013) and corresponds with the view that ADHD can be described as a disorder of cognitive dysregulation (Sonuga-Barke, 2003). However, following the argumentation of the dual-pathway model of ADHD, ADHD can also be described as a disorder of motivational-affective dysregulation (Shaw et al., 2014; Sonuga-Barke, 2003). In the context of general decision-making, ADHD has been linked to problems with reward processing and delay aversion which might result in impulsivity and risk taking (Groen et al., 2013; Luman et al., 2005; Scheres et al., 2013; Sonuga-Barke, 2003). However, these problems appear to be less evident in adults with ADHD (Groen et al., 2013; Mowinckel et al., 2015).

In conclusion, adults with ADHD seem to be vulnerable to problems with FDM. Research on FDM in adults with ADHD is, however, very limited and most studies applied self-report measures and interviews and included relatively young and predominately male participants (Altszuler et al., 2016; Barkley et al., 2006; Barkley & Fischer, 2010; Das et al., 2012). Moreover, studies that focused on general decision-making in patients with ADHD used standardized but context independent tests and, therefore, do not allow conclusions about FDM. The present study is the first study that explores FDM abilities of adults with ADHD compared to healthy controls by including participants with a broad age range and by using subjective as well as objective measures of FDM. For this purpose, a recently developed comprehensive objective and standardized test battery will be used assessing multiple aspects of FDM (i.e., financial competence, financial decision-making capacity, financial decision styles, ability to apply rules, decisions with implications for the future, impulsive buying tendency and emotional decision-making; Bangma et al., 2017). Furthermore, cognitive functioning of adults with ADHD and healthy controls and the associations between cognition and the ability to make financial decisions will be evaluated. Due to the scarcity of research on FDM in adults with ADHD, it is difficult to formulate well-founded hypotheses. Nevertheless, based on the few studies reporting poorer money management of young adults with ADHD, it is expected that adults with ADHD have a less optimal financial situation (e.g., have more often debts or save less often money for the future) than healthy controls which may be due to adults with ADHD also having more difficulties with FDM than healthy controls.

Materials and Methods

Participants

In total, 138 adults (i.e., 50 adults with ADHD and 88 healthy controls) who were between 19 and 64 years old participated in this study. All patients with ADHD were diagnosed and currently treated at the Department of Psychiatry and Psychotherapy, University of Duisburg-Essen, Germany and were invited to participate in the current study by their clinician. All adults with ADHD were diagnosed by trained psychologists or psychiatrists prior to and independent of the study. The diagnosis of ADHD was established based on the criteria for ADHD as outlined in the Diagnostic and Statistical Manual of Mental Disorders 5th edition (DSM-5; American Psychiatric Association, 2013). The assessment procedure used for diagnosing ADHD included semi-structured interviews which are used to evaluate ADHD psychopathology (i.e., the Wender-Reimherr-Interview; Retz-Junginger et al., 2017) and the Essen-Interview-for-school-days-related-biography (Grabemann et al., 2017). Additionally, self-report questionnaires were used for both the retrospective assessment of childhood symptoms as well as current symptoms (Rösler et al., 2008). The diagnostic evaluation also included objective measures such as evidence derived from school reports and reports of failure in academic and/or occupational achievement, and comprised multiple informants for all patients (e.g., employer evaluation, partner- or parent-reports). Adults with ADHD were free of ADHD medication (i.e., stimulants) for 48-hours prior to the assessment of the present study, except one participant who was therefore excluded from the sample. Healthy controls were recruited via the contacts of the researchers and invited using e-mail, social media or word-of-mouth.

Table 7.1. Demographics and clinical characteristics of adults with ADHD (n = 45) and healthy controls (n = 51).

Demographics and Clinical Characteristics	ADHD	Healthy controls	<i>p-value</i>
Age range in years	19 - 61	20 - 64	
Age <i>M (SD)</i> in years	36.6 (10.2)	38.9 (13.2)	.332 ^a
Gender male:female	26:19	26:25	.505 ^b
Education <i>M (SD)</i> in years	16.6 (3.3)	16.9 (3.8)	.668 ^a
Work status %			.839 ^b
Full-time	51.1	58.8	
Part-time	24.4	17.6	
Unemployed	13.3	11.8	
Other	11.1	11.8	
WURS-K <i>M (SD)</i>	42.9 (13.1)	13.0 (8.1)	<.001 ^{*a}
ADHD-SR <i>M (SD)</i>	35.6 (8.6)	11.1 (7.5)	<.001 ^{*a}

Note. **ADHD** = attention-deficit/hyperactivity disorder; **ADHD-SR** = ADHD self-report scale; **WURS-K** = Wender Utah Rating Scale – childhood.

^a Group differences evaluated with t-tests.

^b Group difference evaluated with Pearson’s chi-square test.

* *p* < .01.

All participants were assessed with the ADHD-SR and the WURS-K. Adults with ADHD were excluded when they scored below the cut-off on both questionnaires (i.e., ADHD-SR < 18 and WURS-K < 30; Rösler et al., 2008), while healthy controls were excluded when they scored above the cut-off on both questionnaires (i.e., ADHD-SR ≥ 18 and WURS-K ≥ 30; Rösler et al., 2008). Three healthy controls with scores above the cut-off on one or both questionnaires and one adult with ADHD with scores below the cut-off on both questionnaires were, therefore, excluded from the sample. Furthermore, students were excluded from both samples (i.e., 34 healthy controls and 3 adults with ADHD) to reduce confounding effects, since students are often in a very particular life situation with regard to finances (e.g., no or low income and financial dependency).

Data of 45 adults with ADHD ($M_{\text{age}} = 36.6 \pm 10.2$ years; 57.8% males) and 51 healthy controls ($M_{\text{age}} = 38.9 \pm 13.2$ years; 51.0% males) were used for analysis. Groups did not differ significantly with regard to age, gender and years of education (Table 7.1). As expected, adults with ADHD reported significantly more often childhood and current symptoms of ADHD (WURS-K and ADHS-SR, respectively) than healthy controls (Table 7.1). Based on the clinical diagnoses, most adults with ADHD showed a combined presentation ($n = 26$), others showed a predominantly inattentive presentation ($n = 10$) or the presentation was not further specified ($n = 9$). Seven adults with ADHD were diagnosed with a comorbid adjustment disorder (unspecified), six with a depressive disorder, five with a personality disorder and three with substance dependency (i.e., cannabis, alcohol or coffee). None of the healthy participants was diagnosed with a neurological or psychiatric condition.

Measures

Personal financial situation. Nine questions about participants' financial situation were asked to evaluate differences in the personal financial situation of adults with ADHD and healthy controls. Most questions required a yes-or-no response, i.e., '*Do you have debts other than mortgage or study loans?*', '*Do you receive social security?*', '*Do you have a savings account?*', '*Do you save actively, i.e., do you put money on your savings account on a regular basis?*', '*Do you save for retirement?*' and '*Do you own a house?*'. Annual gross income was scored on a five-point scale, i.e., < €15,000; €15,000 - €25,000; €25,000 - €35,000; €35,000 - €45,000 and > €45,000. In addition, participants were asked to indicate the amount of money they retain each month after deduction of fixed expenses and, if applicable, the approximate amount of social security they receive each month.

Financial decision-making. A recently developed, objective and standardized FDM test battery was administered to all participants; see Bangma et al., (2017), or **chapters 2 and 3** of current thesis, for a comprehensive description of all tasks. Seven out of the eight tasks previously applied were used in this study.

The Financial Competence Assessment Inventory (FCAI) was used to evaluate *financial competence*. The test consists of 38 practical and theoretical questions about everyday FDM and gives an overview of strengths and weaknesses regarding six different domains of financial competence (Kershaw & Webber, 2004, 2008; Webber et al., 2002): 'Financial abilities' (range 0 – 36), 'Financial judgment' (range 0 – 32), 'Financial management' (range 0 – 22), 'Financial

cognitive functioning' (range 0 – 24), 'Debt management' (range 0 – 4) and 'Financial support resources' (range 0 – 16). The total score (range 0 – 134) gives an indication of the overall financial competence of an individual with higher scores indicating better financial competence. A previous study demonstrated a good to excellent internal consistency (i.e., Cronbach's $\alpha > .80$) for the total score and all domains with the exception of 'Financial support resources' (Cronbach's $\alpha = .54$; Kershaw & Webber, 2008).

The Financial Decision-Making Interview (FDMI) determines *financial decision-making capacity* using two hypothetical financial situations (i.e., 'repairing or selling a car' and 'selling and buying a house'). Using a semi-structured interview, participants are requested to answer questions in order to determine their decision-making capacity. Scores (range 0 – 4) are calculated for five different scales (Appelbaum & Grisso, 1988; Suto et al., 2005), i.e., 'Identification', 'Understanding', 'Reasoning', 'Appreciating' and 'Communication'. Furthermore, a total score (range 0 – 20) based on the sum of all scales was calculated with higher scores indicating better financial decision-making capacity. The internal consistency of the total score in the present study was, however, questionable (Cronbach's $\alpha = .67$).

The Financial Decision Style (FDS) questionnaire is used to evaluate to what extent participants make use of specific *financial decision styles* when making financial decisions (Loo, 2000; Scott & Bruce, 1995; Spicer & Sadler-Smith, 2005). The questionnaire consists of 24 questions scored on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Sum scores are calculated for five decision-making styles, i.e., 'rational' (range 5 – 25), 'intuitive' (range 5 – 25), 'dependent' (range 5 – 25), 'avoidant' (range 5 – 25) and 'spontaneous' (range 5 – 20). The internal consistency in the present study was acceptable to excellent with Cronbach's $\alpha = .82, .75, .79, .93$ and $.81$, respectively.

The Competence in Decision Rules (CDR) test is used to evaluate more complex FDM and assesses *the ability to make financial decisions using decision rules*. The CDR is originally a subtest of the Adult Decision-Making Competence battery (Bruine de Bruin et al., 2007; Parker & Fischhoff, 2005). In the current version, participants have to indicate for ten scenarios with increasing complexity which of five televisions they would choose using specific decision rules. For each correct decision a score of 1 was given. A total score, i.e., number of correct answers, was calculated (range 0 – 10). The internal consistency of the total score was found to be acceptable (Cronbach's $\alpha = .73$; Bruine de Bruin et al., 2007).

To evaluate the capacity to make *decisions with implications for the future* the Temporal Discounting Task (TDT) is used (Green et al., 1994). For eighteen different hypothetical scenarios, participants have to indicate the lowest amount of money they would accept today (or after one week or one month) instead of a higher amount of money later in time, i.e., in one week, one month or one year. For example, participants have to indicate how much money they would accept in one week instead of €500 in one year. Six different time intervals are presented (i.e., 'today vs. one week', 'today vs. one month', 'today vs. one year', 'one week vs. one month', 'one week vs. one year' and 'one month vs. one year'), which are combined with an amount of money participants can receive after a delay (i.e., €100, €500 or €1000). The percentages of the chosen amount of money relative to the amount of money participants can receive after a delay were calculated, e.g., if a participant chose to receive €75 today instead of

€100 in one week, a score of 75% was given. Finally, an average total score is calculated for all scenarios, which has been found to have an excellent internal consistency in the present study (Cronbach's $\alpha = .97$).

The Impulsive Buying Questionnaire (IBQ) was used to evaluate the *impulsive buying tendency* (Beatty & Ferrell, 1998; Coley & Burgess, 2003; Rook, 1987; Verplanken & Herabadi, 2001). The questionnaire contains 31 questions about impulsive buying behavior scored with a four-point scale from 'strongly disagree' to 'strongly agree' and assesses three components of impulsive buying, i.e., 'cognitive component' (15 questions), 'affective component' (12 questions) and 'situational component' (4 questions). The internal consistency of the 'cognitive component' and 'affective component' was found to be good (Cronbach's $\alpha = .82$ and $.82$, respectively). However, the internal consistency of the 'situational component' was low (Cronbach's $\alpha = .07$). The total score (range 27 – 108; Cronbach's $\alpha = .89$), which is calculated by adding up the scores on the cognitive and affective component, reflects an individual's overall impulsive buying tendency with higher scores indicating a stronger tendency to buy on impulse.

Finally, the Iowa Gambling Task (IGT; Bechara et al., 1994; Grasman & Wagenmakers, 2005) was included in the test battery. According to a review of Buelow and Suhr (2009) the IGT is considered to be a measure of affective or *emotional decision-making*. Using a computerized version of the IGT, participants have to choose 100 times between disadvantageous (A and B) and advantageous (C and D) decks that are associated with certain gains and losses of money. Participants receive a hypothetical startup capital of €2000 and are asked to make decisions as it concerns their own money. Participants are not informed, however, about which deck results in relatively high gains or losses; they therefore have to learn from trial and error. A total net score over 100 trials is calculated, i.e., number of times the advantageous decks were chosen minus the number of times the disadvantageous decks were chosen.

Cognitive functioning. The Cognitive Functions ADHD test battery (CFADHD; Tucha et al., 2014) of the Vienna Test System (Schuhfried, 2013) assesses cognitive functions in which adults with ADHD have been shown to present difficulties and was used in the present study to explore the association between cognitive impairments and FDM. Nine cognitive functions were examined, i.e., *information processing speed* (Trail Making Test – part A (TMT-A)), *vigilance and selective attention* (Perception and Attention Functions test: Vigilance and Selective Attention (WAFV and WAFS, respectively)), *inhibition* (response inhibition go/no-go task (INHIB)), *interference* (Stroop interference test (STROOP)), *figural fluency* (5-Point Test (5POINT)), *cognitive flexibility* (Trail Making Test – part B (TMT-B)), *task switching* (Task switching test (SWITCH)) and *verbal working memory* (N-Back Verbal test (NBV)). In addition to the CFADHD, the Arithmetic subtest of the Wechsler Adult Intelligence Scale IV (WAIS-IV Arithmetic; Wechsler, 2008; Wechsler, 2012) was included to assess *numeracy*.

Procedure and ethics statement

The Ethical Committee of the Medical Faculty of the University of Duisburg-Essen, Germany, approved this study. Participants were assessed individually. The total duration of the assessment was approximately 4.5 hours. Participants received as many breaks as needed and were given the opportunity to complete the second half of the assessment (i.e., the CFADHD) later in time. Prior to assessment, all participants were informed about the content and aim of the study and signed a written informed consent. Participation was voluntary and participants did not receive any compensation for participation.

Data analysis

Effect sizes were calculated for all group comparisons and converted to Cohen's *d*. Furthermore, 99% confidence intervals (99% CI) were calculated for effect sizes and results were considered significant when $p \leq .010$ to control for overoptimism or Type I errors. Effect sizes were interpreted (Cohen, 1988) as small: $d = .20$ ($1-\beta = .09$), medium: $d = .50$ ($1-\beta = .53$) and large: $d = .80$ ($1-\beta = .94$).

Cognitive performance. All cognitive variables were normally distributed. Group differences between adults with ADHD and healthy controls on measures of cognition (i.e., CFADHD and WAIS-IV Arithmetic) were determined by using t-tests. One healthy participant and eighteen adults with ADHD did not complete the second half of the assessment (i.e., the CFADHD) due to personal or logistic reasons, resulting in 27 adults with ADHD and 50 healthy controls for these analyses, who did not differ with regard to age ($p = .967$), gender ($p = .881$), years of education ($p = .781$) and work status ($p = .695$). The adults with ADHD ($n = 27$) and healthy controls ($n = 50$) in the remaining sample did significantly differ on the ADHD measures (i.e., WURK-S $p < .001$ and ADHS-SR $p < .001$). Furthermore, no differences were found regarding clinical and demographic variables between adults with ADHD who did and who did not complete the second half of the assessment (i.e., age $p = .033$, gender $p = .324$, years of education $p = .834$, work status $p = .962$, WURK-S $p = .751$ and ADHS-SR $p = .741$).

Personal financial situation. Group differences between adults with ADHD ($n = 45$) and healthy controls ($n = 51$) with regard to the personal financial situation of participants were evaluated using Pearson's chi-square tests. Differences in the range of income between groups were analyzed with a Mann-Whitney-U test and group differences on questions about 'Free money to spend' and 'Amount of social security' were analyzed with t-tests. The variable 'Free money to spend' was not normally distributed which was corrected by using a log transformation.

FDM performance. To compare the performances of adults with ADHD and healthy controls on FDM tests ($n = 45$ and 51 , respectively), t-tests were performed for each FDM test. All data was normally distributed except for the TDT. Therefore, an arcsine transformation for percentage data (i.e., $2 * \arcsine \sqrt{X_i/100}$; Cohen et al., 2003) was executed which resulted in a normally distributed variable.

FDM – clinical interpretation. Based on procedures used in previous studies on FDM (Giannouli & Tsolaki, 2014; Marson et al., 2000; Martin, Griffith, et al., 2008) and in the field of clinical neuropsychology in general, the individual performances of adults with ADHD on

FDM tests (i.e., total scores) were categorized using cut-off scores relative to the mean performance and standard deviation (SD) of healthy controls. Scores were classified as *normal* if scores were less than 1.5 SD below the mean. Scores were classified as *low* if scores were between 1.5 and 2.0 SD below the mean and as *very low/impaired* if the scores were more than 2.0 SD below the mean.

Cognition and FDM. To determine to what extent cognition influenced the performances of adults with ADHD (n = 27) and healthy controls (n = 50) on measures of FDM, bootstrapped mediation regression analyses (1000 random samples) were performed, using PROCESS version 3.0 (Hayes, 2013) for those measures of FDM which show significant group differences between adults with ADHD and healthy controls. Measures of cognition on which adults with ADHD showed significantly lower performances compared to healthy controls were included as mediation variables. A mediation effect of cognition is indicated when cognition is found to have a significant influence on the difference between adults with ADHD and healthy controls regarding FDM (path ab; Figure 7.1).

Results

Cognitive performance

Compared to healthy controls, adults with ADHD showed significantly lower scores (medium effect sizes) on measures of Vigilance (WAFV reaction time; $t = -2.85, p = .006, d = 0.68$), Interference (STROOP interference; $t = -2.98, p = .005, d = 0.77$) and Numeracy (WAIS-IV Arithmetic accuracy; $t = 2.84, p = .006, d = 0.57$). No significant group differences were found for the other measures of cognition (Appendix 7-1).

Personal financial situation

On five out of nine aspects of personal finances statistically significant group differences between adults with ADHD and healthy controls were found (Table 7.2). The median income

of adults with ADHD was between €15,000 and €25,000, which was significantly lower than the annual gross income of healthy controls (*Mdn.* = €35,000 to €45,000). Adults with ADHD also had significant less money to spend each month (*M* = €529.28, *SD* = €412.27) compared to healthy controls (*M* = €1096.17, *SD* = €798.56). Although one out of four adults with ADHD (i.e., 24.4%) reported to receive social security, group differences with healthy controls (i.e., 7.8% of healthy controls received social security) did not reach statistical significance. However, almost half of the adults with ADHD (i.e., 48.9%) reported to have debts other than mortgage and study loans which is significantly more often than healthy controls (i.e., 15.7% of healthy controls reported to have debts).

Furthermore, only 53.3% of adults with ADHD reported to have a savings account, which is significantly less often than 86.3% of healthy controls. No group differences were found, however, with regard to the active use of a savings account (i.e., 58.3% of adults with ADHD and 70.5% of healthy controls use their savings account actively) and with regard to saving for retirement (i.e., 44.4% of adults with ADHD and 62.7% of healthy controls save for their retirement). Significant group differences were found with regard to owning a house; healthy controls more often owned a house (i.e., 52.9%) compared to adults with ADHD (i.e., 13.3%; Table 7.2).

Financial decision-making

FDM performance. Adults with ADHD showed significantly lower scores on the FCAI total score compared to healthy controls (large effect size; Table 7.3). With regard to the subscales of the FCAI, adults with ADHD scored significantly lower on ‘Financial abilities’, ‘Financial judgment’, ‘Financial management’ and ‘Financial support resources’ compared to healthy controls (large effect sizes). No significant group differences were found for the subscales ‘Financial cognitive functioning’ and ‘Debt management’.

On the FDMI, adults with ADHD also obtained a significantly lower total score than healthy controls (large effect size; Table 7.3). More specifically, adults with ADHD had more difficulties with the identification and understanding of information (i.e., ‘Identification’ and ‘Understanding’; large effect sizes) than healthy controls. No group differences were observed for the other subscales of the FDMI (i.e., ‘Reasoning’, ‘Appreciating’ and ‘Communication’, Table 7.3).

Groups also did not differ with regard to their scores on the ‘rational’, ‘intuitive’ and ‘dependent’ FDS subscales (Table 7.3). However, adults with ADHD used significantly more often the ‘avoidant’ and ‘spontaneous’ financial decision styles than healthy controls (large effect sizes). Adults with ADHD also showed more temporal discounting than healthy controls (i.e., TDT total; large effect size). Furthermore, groups also differed regarding the total score of the IBQ (large effect size) and the ‘cognitive component’ of the IBQ (large effect size). No group differences were found for the other two components of impulsive buying (i.e., ‘affective component’ and ‘situational component’ of the IBQ; Table 7.3). Furthermore, no statistically significant group differences were found on the CDR and IGT (Table 7.3).

FDM – clinical interpretation. Based on the mean scores and SDs of the healthy control sample, one out of four (i.e., 26.7%) adults with ADHD was classified as scoring very low or

impaired (i.e., more than 2.0 SD below the mean) on the FCAI and 28.9% of the adults with ADHD showed a low performance (i.e., between 1.5 and 2.0 SD below the mean) on this measure. Less than half of the adults with ADHD (i.e., 44.4%) could be considered as normal or unimpaired (i.e., scoring less than 1.5 SD below the mean) on the FCAI. On the FDMI, 71.1% of the adults with ADHD showed a normal performance; 20.0% of the adults with ADHD had a low performance on the FDMI, while 8.9% of the adults with ADHD could be classified as impaired on this measure. Regarding the CDR, the performance of almost all adults with ADHD (i.e., 95.6%) could be classified as normal; two adults with ADHD showed either a low and very low/impaired performance. On the IBQ only one adult with ADHD (i.e., 2.2%) could be classified as very low/impaired. On the IGT none of the adults with ADHD could be classified as very low/impaired and of the adults with ADHD only one (i.e., 2.2%) and three (i.e., 7.0%) showed a low performance on the IBQ and IGT, respectively. On the TDT, the performances of 22.2% adults with ADHD were classified as very low/impaired. The performance of one other adult with ADHD was classified as low. All other adults with ADHD (i.e., 75.6%) showed a normal performance on the TDT. In contrast, normal performances on measures of FDM were obtained by healthy controls in more than 90% of the cases (Table 7.4).

When taking the FDM tests together, one out of three adults with ADHD (i.e., 34.2%) showed a normal performance on all measures of FDM. However, 36.8% adults with ADHD showed a very low/impaired performance and an additional 28.9% showed a low performance on one or more FDM tests. This is twice as often as in healthy controls (i.e., 19.6% and 7.8% of the healthy controls showed a very low/impaired or low performance, respectively, on one or more FDM tests).

FDM and cognition

The group difference regarding the FCAI total score was significantly associated with numeracy (WAIS-IV Arithmetic; Figure 7.1 – path ab). Significant associations were also found between numeracy and group differences regarding FCAI subscales (with the exception of Financial abilities) and the FDMI total score. The group differences for all these measures of FDM (Figure 7.1 - path c'), however, remained significant ($p < .010$). This indicates that the differences between adults with ADHD and healthy controls on the FCAI and FDMI can only partly be explained by numeracy. No significant effects of numeracy were found for the other measures of FDM nor for vigilance (WAFV reaction time) and interference (STROOP interference; Table 7.5).

Students

Since a large group of students ($n = 37$) was excluded from the current study, we repeated the group comparisons with regard to cognitive functioning, personal financial situation and FDM performance with the samples including the 37 students. This analysis revealed that group differences concerning annual gross income and the amount of money that could be spent freely were no longer significant. All other results were similar to the results of the analyses excluding students (appendices 7-2 to 7-5).

Table 7.2. Personal financial situation of adults with ADHD (n = 45) and healthy controls (n = 51).

Questions about participants' financial situation	ADHD	Healthy controls	Statistics	Group differences	
				p-value	d (99%CI)
'What is approximately your annual gross income?' <i>Mdn</i>	€15,000 to €25,000	€35,000 to €45,000	$U = 667.0$	.001*	
'How much money can you approximately spend each month after deduction of fixed expenses?' <i>M (SD)</i>	€529.28 (€412.27)	€1096.17 (€798.56)	$t(88) = 4.28$	< .001*	
'Do you receive social security?' % yes	24.4%	7.8%	$\chi^2(1) = 5.00$	.025	
'If you receive social security, how much money do you approximately receive each month?' <i>M (SD)</i>	€357.00 (€189.78)	€273.33 (€125.03)	$t(10) = -0.70$	.499	
'Do you have debts other than mortgage or study loans?' % yes	48.9%	15.7%	$\chi^2(1) = 11.86$	.001*	
'Do you have a savings account?' % yes	53.3%	86.3%	$\chi^2(1) = 23.07$	< .001*	
'Do you save actively, i.e., do you put money on your savings account on a regular basis?' % yes	58.3%	70.5%	$\chi^2(1) = 1.02$	.313	
'Do you save for retirement?' % yes	44.4%	62.7%	$\chi^2(1) = 4.13$	.042	
'Do you own a house?' % yes	13.3%	52.9%	$\chi^2(1) = 17.28$	< .001*

-1 0 1 2

Note. **ADHD** = attention-deficit/hyperactivity disorder; **CI** = Confidence Interval.

* $p < .01$.

Table 7.3. Performances on FDM tests of adults with ADHD (n = 45) and healthy controls (n = 51).

FDM tests	ADHD M (SD)	Healthy controls M (SD)	<i>t</i>	<i>p</i> -value	<i>d</i> (99%CI)
FCAI total	94.62 (9.51)	112.16 (12.10)	7.94	< .001*	
Financial abilities	23.44 (4.32)	29.63 (5.13)	6.34	< .001*	
Financial judgment	20.49 (4.45)	25.57 (4.85)	5.32	< .001*	
Financial management	16.38 (2.82)	18.96 (2.17)	4.98	< .001*	
Financial cognitive functioning	21.96 (1.67)	22.76 (2.10)	2.07	.041	
Debt management	2.53 (1.25)	3.06 (0.90)	2.33	.022	
Financial support resources	9.82 (2.39)	12.18 (2.58)	4.63	< .001*	
FDMI total	16.22 (2.47)	18.41 (1.73)	5.09	< .001*	
Identification	3.11 (0.94)	3.73 (0.49)	3.95	< .001*	
Understanding	2.82 (0.89)	3.63 (0.63)	5.07	< .001*	
Reasoning	3.49 (0.84)	3.82 (0.43)	2.40	.019	
Appreciating	3.11 (0.94)	3.39 (0.72)	1.66	.101	
Communication	3.69 (0.67)	3.84 (0.42)	1.34	.186	
FDS rational	17.47 (4.66)	19.12 (2.95)	2.01	.049	
FDS intuitive	14.86 (3.91)	14.65 (3.54)	-0.28	.778	
FDS dependent	15.63 (4.63)	16.37 (3.61)	0.88	.383	
FDS avoidant	15.26 (5.22)	10.49 (4.67)	-4.67	< .001*	
FDS spontaneous	11.64 (3.67)	8.35 (2.61)	-4.95	< .001*	
CDR total	6.92 (1.99)	7.25 (2.18)	0.75	.453	
TDT total	75.61 (18.96)	88.20 (11.41)	4.27	< .001*	
IBQ total	65.97 (12.61)	57.82 (8.87)	-3.45	.001*	
Cognitive component	38.78 (6.62)	32.63 (4.96)	-4.89	< .001*	
Affective component	28.00 (6.43)	25.20 (4.80)	-2.32	.023	
Situational component	9.77 (1.80)	9.75 (1.55)	-0.08	.936	
IGT total	15.67 (41.96)	11.88 (37.72)	-0.46	.646	

Note. **ADHD** = attention-deficit/hyperactivity disorder; **CDR** = Competence in Decision Rules; **CI** = Confidence Interval; **FCAI** = Financial Competence Assessment Inventory; **FDMI** = Financial Decision-Making Interview; **FDS** = Financial Decision Style questionnaire; **IBQ** = Impulsive Buying Questionnaire; **IGT** = Iowa Gambling Task; **TDT** = Temporal Discounting Task. * $p < .01$.

Table 7.4. FDM outcome classification of adults with ADHD (n = 45) and healthy controls (n = 51).

FDM tests	Adults with ADHD			Healthy controls		
	Impaired % (n)	Low % (n)	Normal % (n)	Impaired % (n)	Low % (n)	Normal % (n)
FCAI total	26.7% (12)	28.9% (13)	44.4% (20)	2.0% (1)	2.0% (1)	96.1% (49)
FDMI total	8.9% (4)	20.0% (9)	71.1% (32)	5.9% (3)	0% (0)	94.1% (48)
CDR total	2.2% (1)	2.2% (1)	95.6% (43)	5.9% (3)	0% (0)	94.1% (48)
TDT total	22.2% (10)	2.2% (1)	75.6% (34)	7.8% (4)	0% (0)	92.2% (47)
IBQ total	3.1% (1)	2.1% (1)	93.8% (30)	2.0% (1)	5.9% (3)	92.2% (47)
IGT total	0% (0)	7.0% (3)	93.0% (40)	0% (0)	2.0% (1)	98.0% (50)

Note. Results of the Financial Decision Styles questionnaire are not included, since lower/higher scores do not represent better or worse scores. **ADHD** = attention-deficit/hyperactivity disorder; **CDR** = Competence in Decision Rules; **FCAI** = Financial Competence Assessment Inventory; **FDMI** = Financial Decision-Making Interview; **IBQ** = Impulsive Buying Questionnaire; **IGT** = Iowa Gambling Task; **TDT** = Temporal Discounting Task.

Table 7.5. Bootstrapped mediation regression analyses of cognition on the difference between adults with ADHD (n = 27) and healthy controls (n = 50) regarding FDM.

FDM tests	Direct effect of <i>Group</i> on FDM (path c')		Indirect effect with <i>Vigilance</i> ^a as mediator (path ab)		Indirect effect with <i>Interference</i> ^b as mediator (path ab)		Indirect effect with <i>Numeracy</i> ^c as mediator (path ab)	
	<i>Effect (SE)</i>	99%CI	<i>Effect (SE)</i>	Bootstrapped 99%CI	<i>Effect (SE)</i>	Bootstrapped 99%CI	<i>Effect (SE)</i>	Bootstrapped 99%CI
FCAI total	-1.426 (2.63)	[-21.23; -7.28]*	-0.09 (0.95)	[-2.77; 2.77]	-0.39 (0.81)	[-3.37; 1.63]	-3.70 (1.38)	[-7.91; -0.17]*
<i>Financial abilities</i>	-5.93 (1.29)	[-9.24; -2.43]*	0.06 (0.41)	[-1.10; 1.27]	-0.04 (0.39)	[-1.42; 0.97]	-1.07 (0.48)	[-2.83; 0.54]
<i>Financial judgment</i>	-3.93 (1.11)	[-6.88; -0.99]*	0.03 (0.08)	[-0.18; 0.25]	-0.08 (0.72)	[-0.29; 0.08]	-0.24 (0.10)	[-0.55; -0.03]*
<i>Financial management</i>	-2.17 (0.61)	[-3.79; -0.56]*	-0.11 (0.29)	[-1.15; 0.57]	0.14 (0.20)	[-0.51; 0.79]	-0.84 (0.32)	[-1.85; -0.05]*
<i>Financial support resources</i>	-1.86 (0.65)	[-3.59; -0.14]*	0.06 (0.08)	[-0.11; 0.40]	-0.05 (0.09)	[-0.32; 0.17]	-0.19 (0.09)	[-0.47; -0.01]*
FDMI total	-1.58 (0.45)	[-2.77; -0.39]*	-0.08 (0.15)	[-0.56; 0.29]	0.02 (0.14)	[-0.50; 0.42]	-0.37 (0.18)	[-0.98; 0.03]*
<i>Identification</i>	-0.55 (0.19)	[-1.07; -0.04]*	0.00 (0.07)	[-0.43; 0.25]	0.02 (0.07)	[-0.16; 0.26]	-0.12 (0.08)	[-0.36; 0.04]
<i>Understanding</i>	-0.80 (0.19)	[-1.32; -0.29]*	-0.01 (0.05)	[-0.18; 0.14]	0.05 (0.06)	[-0.09; 0.26]	-0.10 (0.06)	[-0.27; 0.07]
FDS avoidant	5.35 (1.35)	[1.79; 8.92]*	0.02 (0.08)	[-0.21; 0.23]	-0.03 (0.09)	[-0.30; 0.24]	-0.02 (0.08)	[-0.27; 0.28]
FDS spontaneous	3.39 (0.86)	[1.12; 5.67]*	0.34 (0.39)	[-0.56; 1.62]	-0.07 (0.31)	[-0.96; 0.81]	0.02 (0.25)	[-0.73; 0.86]
TDT total	-0.31 (0.10)	[-0.59; -0.04]*	0.01 (0.09)	[-0.26; 0.23]	0.05 (0.08)	[-0.16; 0.28]	-0.15 (0.08)	[-0.41; 0.04]
IBQ total	7.98 (2.83)	[0.47; 15.49]*	1.18 (1.27)	[-1.51; 5.40]	-0.63 (0.65)	[-2.88; 1.16]	1.07 (1.02)	[-1.25; 4.84]
<i>Cognitive component</i>	6.48 (1.53)	[2.43; 10.52]*	0.68 (0.62)	[-0.53; 2.78]	-0.14 (0.49)	[-1.36; 1.56]	0.33 (0.47)	[-0.82; 1.83]

Note. **ADHD** = attention-deficit/hyperactivity disorder; **FCAI** = Financial Competence Assessment Inventory; **FDMI** = Financial Decision-Making Interview; **FDS** = Financial Decision Style questionnaire; **IBQ** = Impulsive Buying Questionnaire; **TDT** = Temporal Discounting Task.

^a *Vigilance* is evaluated with the Perception and Attention Functions test – Vigilance (WAIS-IV)

^b *Interference* is evaluated with the Stroop interference test (STROOP)

^c *Numeracy* is examined with the Arithmetic subtest of the Wechsler Adult Intelligence Scale IV (WAIS-IV)

*p ≤ .010.

Discussion

The goal of the present exploratory study was to investigate FDM in adults with and without ADHD, using a recently published comprehensive test battery (Bangma et al., 2017). The results show that the personal financial situation of adults with ADHD was less optimal than the financial situation of healthy controls. Furthermore, adults with ADHD showed significantly decreased performances compared to healthy controls in five out of seven tasks measuring FDM and on measures of vigilance, interference and numeracy. However, mediation analyses indicated that differences in cognitive functioning cannot fully explain the differences with regard to FDM between adults with ADHD and healthy controls.

Personal financial situation. The gross annual income of adults with ADHD was lower than that of healthy individuals, resulting in significant less money to spend each month for adults with ADHD compared to healthy controls. Previous research showed that income levels of relatively young adults with and without ADHD (i.e., younger than 24 years of age) are more or less similar (Altszuler et al., 2016; Barkley et al., 2006), but that adults with ADHD of 24 years and older have a lower gross annual income than healthy controls (Barkley et al., 2008; Biederman & Faraone, 2006). Fischer & Barkley (2006) found even higher income levels in adults with ADHD who were on average 21 years old compared to age-matched controls. However, they argue that this is probably due to the fact that healthy individuals are more often students at this age than young adults with ADHD. Furthermore, Altszuler et al. (2016) reported that, although income levels of adults with ADHD and healthy controls sometimes appear to be similar, young adults with ADHD receive more often social security from welfare systems or are financially dependent on parents or relatives than healthy controls. In the present study, it was found that one out of four adults with ADHD received social security, however, compared to 7.8% of healthy controls receiving social security this was not significantly more often than in healthy controls.

With regard to having debts, almost half of the adults with ADHD reported to have debts other than mortgages or study loans, which is significantly more frequent than in the healthy control group (i.e., 15.7%). Previous studies reported inconsistent findings with regard to debts of adults with ADHD (Altszuler et al., 2016; Barkley et al., 2006, 2008; Fischer & Barkley, 2006), which might be a result of the relatively young age of participants included in previous studies. Furthermore, despite the finding that adults with ADHD did not differ from healthy controls with regard to saving for retirement and actively saving money when they have a savings account, the present results indicate that financial future planning of adults with ADHD is not as optimal as the planning of healthy controls, i.e., significantly fewer adults with ADHD had a savings account or bought a house compared to healthy controls, which can both be understood as investments for the future.

Financial decision-making. Consistent with the findings described above, lower performances on various standardized objective tests of FDM were found in adults with ADHD compared to healthy controls, which are substantiated by mainly large effect sizes. With regard to two relatively fundamental aspects of FDM (i.e., financial competence and capacity) poorer performances were found in adults with ADHD compared to healthy controls. This shows that

adults with ADHD have more difficulties with the (mental) ability or capacity to make financial decisions and have less knowledge about the execution of relatively simple financial transactions than healthy controls. More specifically, adults with ADHD experienced it as more difficult to identify a financial problem and to consider the risks and benefits of the given problem (i.e., FDMI ‘Identification’ and ‘Understanding’). The results further show that in comparison to healthy controls adults with ADHD have more problems with financial judgment and management and are less capable to find financial support.

The mechanisms underlying the problems in financial competence and capacity in adults with ADHD are unclear. Numeracy seems to play a role in financial competence and capacity, which is consistent with previous research (Martin et al., 2012; Niccolai et al., 2017; Sherod et al., 2009) and group differences on these aspects of FDM were found to be mediated by numeracy. However, direct effects of the group differences between adults with ADHD and healthy controls on financial competence and capacity remained significant, which implies that group differences on these measures of FDM cannot be fully explained by difficulties with numeracy of adults with ADHD. Also, adults with ADHD were found to show impairments in vigilance and interference, however, these aspects of cognition did not mediate the group differences on measures of FDM. It is, however, important to keep in mind that not all participants completed the cognitive test battery, resulting in a relatively small sample size for the analyses including standard measures of cognition. Furthermore, the relative conservative p-value used for all analyses may have increased the likelihood of Type II errors and may have masked existing effects. Especially for small effects, the power of our analyses (i.e., 9% for small effects) is problematic and should be considered when interpreting non-significant results. Studies with large sample sizes on the influence of cognition on FDM in adults with ADHD are therefore desirable. The power for medium (i.e., 53%) and large effects (i.e., 94%) are, however, good considering the average power of studies in psychology (Bakker et al., 2012; Cohen, 1962). It is conceivable that the performances of adults with ADHD on financial competence and capacity are the result of motivational deregulation, since both aspects of FDM are considered as relatively basic and simple which is reflected by the high scores obtained by healthy individuals. It is therefore possible that boredom plays a role (Matthies et al., 2012) and may affect task performance adversely. This suggestion is consistent with the finding that adults with ADHD were found to show a decreased temporal discounting compared to healthy controls (i.e., adults with ADHD prefer immediate over delayed rewards, see below).

With regard to the use of decision styles, adults with ADHD more often used a spontaneous decision-making style than healthy controls, which corresponds with a stronger tendency of adults with ADHD to buy on impulse which was also found in the present study. These results indicate that adults with ADHD more often have difficulties with suppressing the urge to buy on impulse or to make decisions in a more deliberative manner. Interestingly, adults with ADHD also seem to avoid financial decisions more often than healthy controls. Previous research demonstrated that the use of both the avoidant and spontaneous decision-making style are negatively related to decision-making competence and might be a result of problems with (general) decision-making (Bavol’ár & Orosová, 2015).

Adults with ADHD also showed more difficulties with making financial decisions that have implications for the future compared to healthy controls. This means that adults with ADHD discounted the value of money that they could receive later in time (i.e., temporal discounting) stronger than healthy controls. The effect of temporal discounting has been frequently described in children and adolescents with ADHD (Barkley et al., 2001; Demurie et al., 2012; Scheres et al., 2013) and was attributed to a motivational deregulation or self-control problem (Scheres et al., 2013). However, research on temporal discounting of adults with ADHD is limited and results are inconsistent (see Mowinckel et al. (2015) for recent meta-analysis). This inconsistency may be the result of third variables that are likely to interact with someone's temporal discounting tendency, such as income or financial reserves (Green et al., 1996).

No differences were found between adults with ADHD and healthy controls regarding emotional decision making (i.e., IGT) and the ability to apply decision-rules in financial situations (i.e., CDR). These findings are in contrast with Mäntylä et al. (2012) who observed that adults with ADHD have difficulties with applying decision-rules. This inconsistency may be explained by the fact that the participants in our study received on average 5 years of education more than the participants in the study of Mäntylä et al. (2012) and the finding that years of education seems to be a significant predictor of the ability to apply decision-rules (Bangma et al., 2017). Inconsistent results are also found by previous studies that applied the IGT in adults with ADHD (Groen et al., 2013; Mowinckel et al., 2015). In the present study, no difference was found between healthy controls and adults with ADHD on this measure of emotional decision-making. Therefore, the present data adds evidence suggesting that adults with ADHD have no pronounced problems in risky or emotional decision-making. However, in this context third variables such as level of education might also play a role (Davis et al., 2008; Fry et al., 2009). Furthermore, the latter result appears to be in contrast with the difference found between adults with ADHD and healthy controls regarding temporal discounting, as it has been suggested that a preference for immediate over delayed rewards (i.e., a decreased temporal discounting) would result in increased risky behavior (Groen et al., 2013; Sonuga-Barke, 2003). A recent study in children with ADHD, however, indicates that the tendency to choose the least delayed option does not result in increased risk taking. Instead, children with ADHD were found to have more difficulties with adjustment in relation to changing risk probabilities than healthy controls (Sørensen et al., 2017), probabilities that do not change during the IGT that was used in the present study.

When interpreting the results of the present study, some limitations need to be taken into account. First, in the present sample, 19 adults with ADHD with comorbid disorder(s) of which three with substance dependency were included. These comorbid disorders may be relevant with regard to the differences found between adults with ADHD and healthy controls. Additional analyses excluding the adults with ADHD with substance dependency ($n = 3$ excluded, data of additional analyses not reported) replicated the results with regard to the objective measures of FDM. Also when excluding all adults with ADHD with comorbid disorders ($n = 19$), largely similar results were found (data not reported). Only the difference between adults with ADHD and healthy controls for IBQ total score was no longer significant

(when applying the conservative p -value of $p \leq .01$). There is thus no strong evidence that comorbid disorders, including substance dependency, account for the group differences between adults with ADHD and healthy controls found on objective measures of FDM.

A second limitation of the present study is that researchers were not blind to the diagnosis of participants, which might have led to an observer bias. However, the use of a protocolary and objective approach for both the assessment and scoring probably minimized this effect. Third, although all healthy controls indicated to not have ADHD, no clinical evaluation of ADHD has been performed in these participants. Self-report questionnaires for current and retrospective symptoms of ADHD were used to give additional support to the diagnostic status of the participants, however, due to underreporting of symptoms (Sibley et al., 2019) and the under-diagnosis of adult ADHD (Ginsberg et al., 2014) it is conceivable that adults with ADHD are included in the healthy control group. Fourth, adults with ADHD were off medication during assessment and it is, therefore, unclear what the effect of stimulants will be on their performances on measures of FDM. Not only the stimulant itself, but also the onset of medication use and other treatments (e.g., cognitive behavioral therapy or coaching) might have an influence on FDM. The influence of treatment use should, therefore, be explored in future research on FDM and adults with ADHD. Fifth, other confounding factors should be considered in more detail in future research. For example, childhood socioeconomic status and parental education level may be of influence on one's personal financial situation and the ability to make financial decisions. Also, the motivation of participants should be evaluated. Especially in adults with ADHD, less optimal decision-making seems to be related to experienced boredom while making a decision (Matthies et al., 2012). Boredom may play a role in the assessment of relatively simple aspects of FDM (e.g., financial competence or capacity). Furthermore, the personal financial situation of participants was evaluated using self-report measures and only approximate indications of income, free money to spend, and amount of social security were asked. These questions rely on a good insight of one's own personal financial situation, which may not always be sufficient in adults with ADHD as well as in healthy controls. Finally, it has to be pointed out that the ecological validity of the FDM test battery needs further investigation in order to determine to what extent these impaired test performances translate into problems of daily life.

Nevertheless, the current study is the first to explore FDM in adults with ADHD by using self-report as well as standardized objective FDM tests and by including a sample of adults with a broad age range as well as including males and females with ADHD alike. Adults with ADHD were found to have difficulties with several aspects of FDM, i.e., evaluating financial problems (i.e., financial decision-making capacity), understanding bank statements/protocols (i.e., financial competence), financial decisions with implications for the future and impulsive buying. Furthermore, adults with ADHD more often used an avoidant and a spontaneous decision-making style when making financial decisions than healthy controls. When applying a more clinical approach, 34.2% of adults with ADHD are classified as impaired on at least one aspect of FDM compared to 19.6% of healthy controls, with a large number of adults with ADHD showing impairment in financial competence (i.e., 26.7% of adults with ADHD have an impaired performance on the FCAI compared to 2.0% of healthy controls). These difficulties

with FDM and the use of disadvantageous decision-making styles presumably result in the less optimal personal financial situation that are commonly observed in adults with ADHD, such as having debts and not saving money. More research is needed to evaluate underlying mechanisms of these FDM problems and the daily life consequences of the observed difficulties with FDM in adults with ADHD. This knowledge may help in developing treatment approaches which may be offered to adults with ADHD to allow them a living in a more financially secure and less stressful situation.

Appendices

Appendix 7-1. Performances on measures of cognition of adults with ADHD (n = 27) and healthy controls (n = 50).

Cognitive tests	ADHD		Healthy controls		t	p-value	d (99%CI)
	M	(SD)	M	(SD)			
Selective attention (WAFS reaction time)	370.07	(83.77)	390.92	(85.69)	1.03	.308	
Vigilance (WAFV reaction time)	497.41	(89.85)	441.47	(77.35)	-2.85	.006*	
Interference (STROOP interference)	0.19	(0.09)	0.13	(0.07)	-2.98	.005*	
Verbal working memory (NBV accuracy)	12.22	(2.82)	12.30	(3.13)	0.11	.915	
Figural fluency (5POINT number correct)	22.50	(7.92)	23.78	(9.93)	0.57	.571	
Processing speed (TMT-A working time)	22.59	(4.83)	24.78	(8.03)	1.29	.200	
Cognitive flexibility (TMT-B working time)	31.83	(8.62)	35.95	(13.52)	1.43	.156	
Inhibition (INHIB reaction time)	0.30	(0.04)	0.28	(0.04)	-2.29	.025	
Task switching (SWITCH accuracy)	3.37	(6.08)	3.78	(5.64)	0.30	.768	
Numeracy ^a (WAIS-IV Arithmetic accuracy)	17.0	(3.95)	19.06	(3.31)	2.84	.006*	
							-1 0 1

Note. **ADHD** = attention-deficit/hyperactivity disorder; **CI** = Confidence Interval; **INHIB** = Response inhibition go/no-go task; **NBV** = N-Back Verbal test; **STROOP** = Stroop interference test; **SWITCH** = Task switching test; **TMT-A** = Trail Making Test – part A; **TMT-B** = Trail Making Test – part B; **WAFS** = Perception and Attention Functions test – Selective attention; **WAFV** = Perception and Attention Functions test – Vigilance; **WAIS-IV** = Wechsler Adult Intelligence Scale IV; **5POINT** = 5-Point test.

^a Analysis of numeracy based on the performance of 45 adults with ADHD and 51 healthy controls.

* $p < .01$.

Appendix 7-2. Demographics and clinical characteristics of adults with ADHD (n = 48) and healthy controls (n = 85), including students (n = 37).

Demographics and Clinical Characteristics	ADHD	Healthy controls	p-value
Age range in years	19 - 61	19 - 64	
Age M (SD) in years	35.8 (10.3)	32.5 (13.0)	.131 ^a
Gender male:female	28:20	36:48 [^]	.087 ^b
Education M (SD) in years	16.6 (3.2)	16.5 (3.5)	.893 ^a
Work status %			.001 ^b
Student	6.3	40.0	
Full-time	47.9	35.3	
Part-time	22.9	10.6	
Unemployed	12.5	7.1	
Other	10.4	7.1	
WURS-K M (SD)	42.5 (13.0)	13.1 (8.6)	< .001 ^{*a}
ADHD-SR M (SD)	35.2 (8.7)	11.1 (7.3)	< .001 ^{*a}

Note. **ADHD** = attention-deficit/hyperactivity disorder; **ADHD-SR** = ADHD self-report scale;

WURS – K = Wender Utah Rating Scale – childhood.

^a Group differences evaluated with t-tests.

^b Group difference evaluated with Pearson’s chi-square test.

* $p < .01$

[^] gender of one healthy control unknown

Appendix 7-3. Personal financial situation of adults with ADHD (n = 48) and healthy controls (n = 85), including students (n = 37).

Questions about participants' financial situation	ADHD	Healthy controls	Group differences		
			Statistics	p-value	d (99%CI)
'What is approximately your annual gross income?' <i>Mdn</i>	€15,000 to €25,000	€15,000 to €25,000	U=1888.50	.753	
'How much money can you approximately spend each month after deduction of fixed expenses?' <i>M (SD)</i>	€525.76 (€405.38)	€785.45 (€724.75)	t=2.58	.011	
'Do you receive social security?' % yes	22.9%	14.1%	χ ² (1)=1.66	.198	
'If you receive social security, how much money do you approximately receive each month?' <i>M (SD)</i>	€357.00 (€189.78)	€272.09 (€145.82)	t=-1.13	.272	
'Do you have debts other than mortgage or study loans?' % yes	47.9%	9.5%	χ ² (1)=25.06	< .001*	
'Do you have a savings account?' % yes	53.2%	92.3%	χ ² (1)=25.82	< .001*	
'Do you save actively, i.e., do you put money on your savings account on a regular basis?' % yes	56.0%	55.5%	χ ² (1)<0.01	.969	
'Do you save for retirement?' % yes	45.8%	49.4%	χ ² (1)=0.16	.694	
'Do you own a house?' % yes	12.5%	33.3%	χ ² (1)=6.93	.008*	
					-1 0 1 2

Note. **ADHD** = attention-deficit/hyperactivity disorder; **CI** = Confidence Interval.

* *p* < .01.

Appendix 7-4. Performances on FDM tests of adults with ADHD (n = 48) and healthy controls (n = 85), including students (n = 37).

FDM tests	ADHD		Healthy controls		t	p-value	d (99%CI)
	M	(SD)	M	(SD)			
FCAI total	95.56	(10.27)	111.86	(10.67)	8.57	< .001*	
Financial abilities	23.71	(4.33)	29.71	(4.48)	7.50	< .001*	
Financial judgment	20.73	(4.61)	25.66	(4.41)	6.10	< .001*	
Financial management	16.42	(2.79)	18.35	(2.47)	4.15	< .001*	
Financial cognitive functioning	22.02	(1.64)	22.91	(2.16)	2.45	.015	
Debt management	2.56	(1.24)	3.05	(0.83)	2.79	.008*	
Financial support resources	10.13	(2.61)	12.19	(2.60)	4.39	< .001*	
FDMI total	16.33	(2.46)	18.25	(1.66)	5.34	< .001*	
Identification	3.17	(0.93)	3.62	(0.62)	3.05	.003*	
Understanding	2.88	(0.89)	3.64	(0.60)	5.29	< .001*	
Reasoning	3.50	(0.83)	3.79	(0.44)	2.25	.028	
Appreciating	3.08	(0.94)	3.38	(0.76)	1.96	.052	
Communication	3.71	(0.65)	3.82	(0.47)	1.08	.284	
FDS rational	17.49	(4.69)	18.71	(3.11)	1.57	.122	
FDS intuitive	15.00	(3.93)	15.08	(3.36)	0.13	.900	
FDS dependent	15.82	(4.63)	16.92	(3.54)	1.51	.135	
FDS avoidant	15.29	(5.14)	11.51	(4.64)	-4.24	< .001*	
FDS spontaneous	11.54	(3.66)	8.79	(2.90)	-4.42	< .001*	
CDR total	7.01	(2.00)	7.55	(2.05)	1.48	.141	
TDT total	75.63	(18.59)	87.24	(11.07)	4.62	< .001*	
IBQ total	65.65	(12.32)	59.94	(9.18)	-2.77	.007*	
Cognitive component	38.45	(6.71)	33.65	(4.92)	-4.12	< .001*	
Affective component	28.03	(6.26)	26.29	(5.09)	-1.61	.110	
Situational component	9.72	(1.79)	9.87	(1.45)	0.53	.595	
IGT total	15.04	(40.61)	14.00	(36.02)	-0.15	.880	

Note. **ADHD** = attention-deficit/hyperactivity disorder; **CDR** = Competence in Decision Rules; **CI** = Confidence Interval; **FCAI** = Financial Competence Assessment Inventory; **FDMI** = Financial Decision-Making Interview; **FDS** = Financial Decision Style questionnaire; **IBQ** = Impulsive Buying Questionnaire; **IGT** = Iowa Gambling Task; **TDT** = Temporal Discounting Task.

* $p < .01$.

Appendix 7-5. Performances on measures of cognition of adults with ADHD (n = 29) and healthy controls (n = 78), including students (n = 30).

FDM tests	ADHD		Healthy controls		t	p-value	d (99%CI)
	M	(SD)	M	(SD)			
Selective attention (WAFS reaction time)	369.10	(80.91)	373.44	(81.98)	0.24	.808
Vigilance (WAFV reaction time)	491.48	(92.87)	443.73	(85.32)	-2.51	.014
Interference (STROOP interference)	0.19	(0.09)	0.13	(0.07)	-3.26	.002*
Verbal working memory (NBV accuracy)	12.38	(2.78)	12.79	(2.69)	0.70	.483
Figural fluency (5POINT number correct)	22.63	(7.79)	26.62	(10.70)	2.07	.043
Processing speed (TMT-A working time)	22.19	(4.89)	22.61	(7.52)	0.28	.778
Cognitive flexibility (TMT-B working time)	32.22	(8.71)	32.48	(13.04)	0.57	.568
Inhibition (INHIB reaction time)	0.30	(0.04)	0.28	(0.04)	-2.90	.005*
Task switching (SWITCH accuracy)	3.34	(5.86)	3.96	(5.33)	0.52	.606
Numeracy ^a (WAIS-IV Arithmetic accuracy)	17.08	(4.00)	19.02	(3.02)	2.92	.005*
							-1 0 1

Note. **ADHD** = attention-deficit/hyperactivity disorder; **CI** = Confidence Interval; **INHIB** = Response inhibition go/no-go task; **NBV** = N-Back Verbal test; **STROOP** = Stroop interference test; **SWITCH** = Task switching test; **TMT-A** = Trail Making Test – part A; **TMT-B** = Trail Making Test – part B; **WAFS** = Perception and Attention Functions test – Selective attention; **WAFV** = Perception and Attention Functions test – Vigilance; **WAIS-IV** = Wechsler Adult Intelligence Scale IV; **5POINT** = 5-Point test.

^a Analysis of numeracy based on the performance of 48 adults with ADHD and 85 healthy controls.

* *p* < .01.

CHAPTER

8

FINANCIAL DECISION-MAKING IN
A COMMUNITY SAMPLE OF
ADULTS WITH AND WITHOUT
CURRENT SYMPTOMS OF ADHD.

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PlosONE (2020)

Abstract

Objectives: Research found that adults with attention-deficit/hyperactivity disorder (ADHD) have more problems with financial decision-making than healthy controls. The present study investigates the impact of symptoms of ADHD on impulsive buying and the use of financial decision styles. Furthermore, the influence of personality, symptoms of depression and demographics on the association between ADHD and these aspects of financial decision-making is evaluated.

Methods: A community sample of 1292 participants (age range 18–93 years, 45.4% male) completed questionnaires related to ADHD, impulsive buying, financial decision styles, personal financial situation, depression and personality. Four groups were formed based on self-reported ADHD symptoms: an ‘ADHD’ group ($n = 45$), an ‘Adult-only ADHD’ group ($n = 57$), a ‘Subthreshold ADHD’ group ($n = 162$) and a ‘No ADHD’ group ($n = 265$). Groups were compared using ANOVA and chi-square tests. Furthermore, multiple regression analyses in the complete sample were employed to examine the association between ADHD and financial decision-making.

Results: The ADHD and Adult-only ADHD groups reported significantly more impulsive buying, used more often an avoidant or spontaneous decision style and less often saved money compared to the No ADHD group. Regression analyses revealed that impulsive buying and financial decision styles were not significantly associated with ADHD symptoms when controlling for personality, symptoms of depression and demographics.

Conclusion: The present study confirms previous research on adults with ADHD by indicating more impulsive buying and a more frequent use of disadvantageous financial decision styles (i.e., avoidant and spontaneous styles) in individuals with an elevated number of current symptoms of ADHD compared to individuals without symptoms of ADHD. Personality and demographic variables were found to be related to both impulsive buying and the use of specific financial decision styles and might be of influence on the association between impulsive buying, the use of financial decision styles and ADHD.

Introduction

Attention-deficit/hyperactivity disorder (ADHD), characterized by symptoms of inattention, hyperactivity and impulsivity (American Psychiatric Association, 2013), is historically known as a developmental disorder that only affects children. However, in on average 50% of children with ADHD (32.8% – 84.1% cross-national variation; Lara et al., 2009), the condition persists into adulthood resulting in an estimated prevalence of adult ADHD of 3.4% internationally (range 1.2 – 7.3%; Fayyad et al., 2007). Adults with ADHD have more difficulties in daily life compared to adults without ADHD with, e.g., educational and occupational performances and social functioning (Barkley et al., 2008; Daley & Birchwood, 2010; Michielsen et al., 2015). Adults with ADHD are, furthermore, often involved in risky behavior, such as risky driving, risky sexual-behavior or substance abuse (Barkley et al., 2002; Flory et al., 2006; Fuermaier et al., 2017; Lee et al., 2011).

Although financial decision-making has hardly been investigated in adults with ADHD, there are indications that adults with ADHD also have problems with this important capability in everyday life. Financial decision-making describes several components related to the ability to manage or direct to manage financial affairs. It involves practical skills and abilities, e.g., counting coins, but also financial knowledge and judgment to perform financial actions (Appelbaum et al., 2016). The limited research available indicates an association between symptoms of hyperactivity-impulsivity and inattention and problems with financial decision-making (Altszuler et al., 2016; Barkley & Fischer, 2010; Das et al., 2012). Adults with ADHD are more often financially dependent (Altszuler et al., 2016) and report more financial problems compared to age-matched controls (e.g., debts, exceeding credit card limits, difficulties saving money and impulsive buying; Barkley et al., 2008). A recent study, using standardized objective measures in addition to self-report questionnaires, confirmed that adults with ADHD compared to healthy controls have difficulties with several aspects of financial decision-making, including problems with understanding bank protocols and evaluating financial problems, having debts, not saving money and problems with financial decisions with implications for the future. Furthermore, compared to healthy controls, adults with ADHD were found to have a stronger tendency to buy on impulse and more often used inadequate financial decision styles (i.e., avoiding decisions and spontaneously making a decision; Bangma et al., 2019).

In the dual-pathway model of decision-making, affective processing of information is described as one of two systems involved in decision-making (Evans, 2008; Kahneman, 2003; Peters et al., 2007). Together with deliberative/analytic processing of information, which strongly relies on cognitive control, both systems are considered to be crucial for adequate decision-making (Kahneman, 2003; Peters et al., 2007). Motivational/affective dysregulation in adults with ADHD (Shaw et al., 2014; Sonuga-Barke, 2003) might, therefore, underlie problems with financial decision-making in adults with ADHD. On the other hand, cognitive dysregulation of adults with ADHD (e.g., impairments in executive functions and numeracy (Bangma et al., 2019; Boonstra et al., 2005, 2010; Fuermaier et al., 2015) might also have an impact on (financial) decision-making (Bangma et al., 2019; Mäntylä et al., 2012).

Inadequate financial decision-making can have major negative consequences for individuals, such as debts and poverty, and further investigation of this topic in adults with ADHD is, therefore, important. According to the framework of Appelbaum et al. (2016), financial decision-making requires adequate financial competence (i.e., practical financial skills, knowledge and the ability to judge and make decisions), but also relies on financial performances. The latter describes the abilities and behaviors that affect the degree of success when making financial decisions, such as the use of specific decision styles or buying on impulse. For example, one may be financially competent but unable to make adequate financial decisions due to deficiencies in financial performance. Research should, therefore, not only focus on financial competence but also on financial performances when studying financial decision-making. Furthermore, according to the framework of Appelbaum et al. (2016), contextual factors might also be of influence on both financial competence and financial performances and need to be taken into account.

The aims of the present study are, therefore, (1) to investigate the impact of current symptoms of ADHD on two types of financial performance, i.e., impulsive buying and the use of financial decision styles, (2) to partly replicate a recent study on financial decision-making in adults with ADHD (Bangma et al., 2019) and (3) to determine whether symptoms of depression and personality traits are of influence on the association between impulsive buying, the use of financial decision styles and symptoms of ADHD. The latter are considered to be potentially influential contextual factors and are of interest as symptoms of depression are prevalent in adults with ADHD (Katzman et al., 2017) and because specific personality profiles have been linked to ADHD (see Gomez and Corr (2014) for a meta-analytic review). Moreover, personality and symptoms of depression, on itself, have both been discussed in the context of decision-making (Bishop & Gagne, 2018; Bratko et al., 2013; Dewberry et al., 2013; Verplanken & Herabadi, 2001; Weller et al., 2018). A community sample is used in the present study which allows a detailed exploration of the associations between impulsive buying, the use of financial decision styles and symptoms of ADHD since not only adults with and without ADHD can be compared, but also comparisons can be made with adults with signs of ADHD that are considered subthreshold for a clinical diagnosis but which still might be of influence on the use of financial decision styles and impulsive buying.

Based on previous research (Bangma et al., 2019), a positive relation is expected between the severity of symptoms of ADHD and the tendency to buy on impulse and the use of inadequate financial decision styles (i.e., an avoidant and a spontaneous decision style; Baval'ár & Orosová, 2015). Furthermore, it is expected that individuals who meet self-reported symptom criteria of adult ADHD show more problems with these types of financial performance and in their personal financial situation compared to individuals who do not meet a clinically relevant number of criteria of ADHD (American Psychiatric Association, 2013).

Materials and Methods

Participants. A community sample of 1292 participants (586 males and 706 females) with an age range of 18 to 93 years ($M = 48.8$, $SD = 18.5$) participated in the present study. Demographical characteristics of the participants are described in Table 8.1. The (para)medical history of participants, beside medication use, has not been recorded. Fifty-six participants (4.3%) reported to use antidepressants or antipsychotics, twenty-one participants (1.6%) reported to use benzodiazepines and four participants (0.3%) reported to use stimulants (e.g., methylphenidate). The reason for medication use was, however, not evaluated and, therefore, participants were not excluded on basis of their medication use.

Symptoms of ADHD. All participants were assessed with a self-report ADHD rating scale (ARS, see Materials). Based on their scores on the ARS, four groups were formed to use for group comparison analysis (see Data analyses). Group 1, named '*ADHD*' ($n = 46$), met the self-reported symptom criteria for both adulthood and childhood ADHD as defined in the DSM-5 (i.e., ≥ 5 symptoms of inattention and/or ≥ 5 symptoms of hyperactivity and impulsivity were reported to be present in the last six months and ≥ 6 symptoms of inattention and/or ≥ 6 symptoms of hyperactivity and impulsivity were reported to be present when 0 – 12 years old, respectively (American Psychiatric Association, 2013). According to the presentation of current symptoms of ADHD, 43.5% ($n = 20$) of the ADHD group showed an inattentive presentation of ADHD, 21.7% ($n = 10$) a hyperactive/impulsive presentation of ADHD and 34.8% ($n = 16$) a mixed presentation of ADHD. Group 2, named '*Adult-only ADHD*' ($n = 57$), met the DSM-5 classification for adulthood ADHD, but not for childhood ADHD. Group 3, named '*Subthreshold ADHD*' ($n = 162$), did not meet the DSM-5 criteria for adulthood ADHD, but reported 3 or 4 current symptoms of inattention and/or 3 or 4 current symptoms of hyperactivity and impulsivity. Retrospective symptoms of ADHD (i.e., when 0-12 years old) were not part of the inclusion criteria for this group. However, 20.4% of participants in the Subthreshold ADHD group met the DSM-5 self-reported symptom criteria of childhood ADHD (Appendix 8-1). Since the focus of the present study was on adults with current symptoms of ADHD, a non-persistent ADHD group (i.e., individuals who meet the self-reported DSM-5 symptom criteria for childhood ADHD but not for adulthood ADHD) was not taken into account. Finally, a matched control group was formed including participants classified as not having current ADHD symptoms (i.e., 0 or 1 current ADHD symptom(s) of inattention and 0 or 1 current ADHD symptom(s) of hyperactivity and impulsivity, irrespective of retrospective symptoms of ADHD). To control for age, sex and level of education, the 265 individuals of the ADHD, Adult-only ADHD and Subthreshold ADHD groups were matched with 265 participants without having current symptoms of ADHD, resulting in a matched '*No ADHD*' group ($n = 265$; Table 8.1). Participants who did not meet the matching criteria and/or inclusion criteria of one of the four groups ($n = 762$) were not taken into account when conducting group comparisons.

Table 8.1. Demographic characteristics of total sample and ADHD groups.

	Total sample	ADHD	Adult-only ADHD	Subthreshold ADHD	No ADHD	Group differences	
						Statistics	p
N	1292	46	57	162	265	-	-
Age M (SD)	48.8 (18.5)	31.5 (12.5)	36.7 (16.9)	38.1 (17.2)	37.1 (16.2)	F(3,529) = 2.0	.110
Age range	18 - 93	18 - 69	18 - 84	18 - 90	18 - 93	-	-
Sex % male / % female	45.4/54.6	60.9/39.1	40.4/59.6	45.7/54.3	45.7/54.3	$\chi^2(3) = 4.8$	.187
Level of education^{1,2}	-	-	-	-	-	$\chi^2(6) = 3.1$	.792
Lower %	9.1	4.3	10.5	6.2	6.5	$\chi^2(3) = 1.9$	.604
Intermediate %	27.9	30.4	19.3	24.7	24.3	$\chi^2(3) = 1.7$	.633
Higher %	63.0	65.2	70.2	69.1	69.2	$\chi^2(3) = 0.4$	.950
Employment status	-	-	-	-	-	$\chi^2(15) = 26.4$	.035*
Student %	14.7	30.4	40.4	33.3	24.9	$\chi^2(3) = 7.1$	.070
Employed (part-time) %	20.8	17.4	10.5 ^a	17.3	24.9	$\chi^2(3) = 8.0$	.047*
Employed (full-time) %	32.2	34.8	26.3	30.2	36.6	$\chi^2(3) = 3.3$	.351
Unemployed %	4.7	6.5	12.3 ^a	6.2	3.0	$\chi^2(3) = 8.7$	.034*
In retirement %	23.1	2.2	7.0	7.4	7.2	$\chi^2(3) = 1.7$	.635
Other %	4.5	8.7	3.5	5.6	3.4	$\chi^2(3) = 3.2$	.367

Note. **ADHD** = attention-deficit/hyperactivity disorder; **ARS** = attention-deficit/hyperactivity disorder rating scale.

¹ Levels of education are based on the Verhage coding system (Verhage, 1964) which ranges from 1 (primary school not finished) to 7 (university degree). Verhage classification 1 – 4 are equivalent to lower education, 5 is equivalent to intermediate education and 6 and 7 are equivalent to higher education.

² Missing data: n = 4 in Total sample and n = 2 in No ADHD group.

* $p < .05$. Post-hoc Bonferroni significant group differences: ^a versus No ADHD group.

Materials

ADHD rating scale. The ARS is a self-report questionnaire that was used to evaluate current and retrospective symptoms of ADHD (Kooij et al., 2005, 2008). The ARS was originally developed on the basis of the DSM-IV, however, can also be used with the current criteria as defined by the DSM-5 (American Psychiatric Association, 2013). Both the versions for current and retrospective symptoms of the ARS have 23 items evaluating 18 symptoms of ADHD. On a four-point scale (0 = *'rarely or never'*, 1 = *'sometimes'*, 2 = *'often'* and 3 = *'very often'*), participants had to indicate for each item which answer alternative described their behavior best in the past six months (i.e., current symptoms) or during childhood when being 0 – 12 years old (i.e., retrospective symptoms). Using the scoring system of Kooij et al. (2005), an ADHD symptom was classified as present when *'often'* or *'very often'* was answered on an item. Five criteria of ADHD as described in the DSM-5 (i.e., criteria 1a, 1d, 2a, 2d and 2e) were each represented by two items of the ARS and were classified as present when *'often'* or *'very often'* was answered on at least one of the two items. Total scores can be calculated based on all 23 items for both the current and retrospective version of the ARS. Furthermore, for each version, total scores can be calculated based on items representing symptoms of inattention (total of 11 items, *Cronbach's alpha* = .86) and hyperactivity/impulsivity symptoms (total of 12 items, *Cronbach's alpha* = .81; Kooij et al., 2008). Higher scores are indicative of more (severe) symptoms of ADHD.

Impulsive buying questionnaire. The Impulsive Buying Questionnaire (IBQ) consists of 31 items focused on the tendency to buy on impulse (Bangma et al., 2017, 2019). Participants have to indicate on a four-point Likert scale (ranging from 1 = *'strongly disagree'* to 4 = *'strongly agree'*) whether they agree with the statements. Three components of impulsive buying can be evaluated based on the sum of specific items; a cognitive component (i.e., the thoughts and urge to buy on impulse; 15 items; e.g., *'When I go shopping, I buy things that I did not intend to purchase'*; *Cronbach's alpha* = .80), an affective component (i.e., the emotions and feelings that lead to impulsive behavior; 12 items; e.g., *'I always buy it if I really like it'*; *Cronbach's alpha* = .83) and a situational component (i.e., the available time and money that is needed to buy on impulse; 4 items; e.g., *'I cannot afford unplanned purchases'*; *Cronbach's alpha* = .09). A total score based on the sum of the cognitive and affective component can be calculated to evaluate the impulsive buying tendency of an individual (*Cronbach's alpha* = .89). Higher scores represent a stronger tendency to buy on impulse.

Financial decision styles questionnaire. The Financial Decision Styles questionnaire (FDS) is used to evaluate five decision styles an individual can use when making financial decisions (Bangma et al., 2017, 2019). The FDS consists of 24 statements which differentiate a rational decision style (i.e., evaluating options before making a decision; 5 items; *Cronbach's alpha* = .69), an intuitive decision style (i.e., relying on feelings and emotions when making a decision; 5 items; *Cronbach's alpha* = .79), a dependent decision style (i.e., requiring the advice of others when making a decision; 5 items; *Cronbach's alpha* = .82), an avoidant decision style (i.e., avoiding or postponing making a decision; 5 items; *Cronbach's alpha* = .89), and a spontaneous decision style (i.e., being impulsive when making a decision; 4 items; *Cronbach's alpha* = .74). For each statement, participants have to indicate to what extent a situation applies

to them on a five-point scale (ranging from 1 = '*strongly disagree*' to 5 = '*strongly agree*'). Total scores are calculated as the sum of items related to a specific decision style. Higher scores indicate that a specific style is more frequently used.

Personal financial situation. Eight questions were asked to evaluate participants' personal financial situation. Six questions required a yes-or-no response and focused on debts (i.e., '*Do you have debts other than mortgage or study loans?*'), social security (i.e., '*Do you receive social security?*'), saving money (i.e., '*Do you have a savings account?*' and '*Do you save actively, i.e., do you put money on your savings account on a regular basis?*'), saving for retirement (i.e., '*Do/have you save(d) money for retirement?*') and owning a house (i.e., '*Do you own a house?*'). The annual gross income of participants was evaluated on a five-point scale (i.e., 1 = '< €15,000', 2 = '€15,000 - €25,000', 3 = '€25,000 - €35,000', 4 = '€35,000 - €45,000', and 5 = '> € 55,000'). Finally, participants had to indicate the amount of money they retained each month after deduction of fixed expenses (in Euros). A second income (of, e.g., a partner) was not taken into account.

Personality. To evaluate personality, the NEO – Five Factor Inventory (NEO-FFI) was used (Costa & McCrae, 1992). With 60 items, the NEO-FFI measures the Big Five personality traits: neuroticism, extraversion, openness, agreeableness and conscientiousness. Participants have to indicate to what extent each item reflects their opinion on a five-point scale ranging from '*strongly disagree*' to '*strongly agree*'. For each scale, a maximum score of 60 can be obtained, with high scores indicating that a personality trait fits a person. The internal consistency of the Dutch version of the NEO-FFI is acceptable to good (*Cronbach's alpha* = .57 to .88) and the inter-correlations of the scales are negligible to weak ($r = .00$ to .41; Hoekstra et al., 1996).

Symptoms of depression. Symptoms of depression were evaluated using the Dutch version of the Beck Depression Inventory II (BDI-II-NL; Beck et al., 1996; van der Does, 2002). For each of the 21 items, participants have to indicate which out of four descriptions reflects their mood in the last two weeks (e.g., 0 = '*I do not feel sad*', 1 = '*I feel sad*', 2 = '*I am sad all the time and I can't snap out of it*' and 3 = '*I am so sad or unhappy that I can't stand it*'). Total scores range from 0 to 63 with higher scores indicating more symptoms and/or more severe symptoms of depression. The internal consistency of the BDI-II-NL is good (*Cronbach's alpha* = .88 to .92) and the construct validity is strong ($r = .79$ to .85; van der Does, 2002).

Procedure and ethics

Data was collected between 2014 and 2019. Participants had to complete the questionnaires online which were distributed via Qualtrics (Qualtrics, 2019). Participants were recruited by using an online research panel and via the social networks of the researchers using social media, email or word of mouth. Participants recruited via the online research panel received a small financial compensation for participation, all other participants received no compensation. All participants had the Dutch nationality and were 18 years or older. Initially, 1475 participants were recruited for the study. Participation was voluntary and participants could withdraw from the study at any time. Consequently, 79 participants (5.4%) began but discontinued the questionnaire and were therefore not taken into account. Of the 79 participants who

discontinued the study, 51.9% ($n = 41$) were from the online research panel and 48.1% ($n = 38$) of the participants were from the social network source. Since a financial compensation as received by the participants from the online research panel could serve as an external motivation, a validation check was performed in this group. Based on the performances on three validity scales of the Behavior Rating Inventory of Executive Function Adults (BRIEF-A; i.e., negativity, infrequency and inconsistency; Roth et al., 2005; Scholte & Noens, 2011), 5.0% of participants ($n = 74$) were excluded from the sample. Another 2.0% of participants ($n = 30$) were excluded from the sample because of other reasons (i.e., age below 18, age was unclear or no Dutch nationality). The remaining sample of 1292 participants were used in current study, of which 36.7% ($n = 474$) were recruited via the online research panel. By using unique ID codes, it was not possible for participants that were recruited via the research panel to repeat the study for extra financial compensation. Participants had to sign an informed consent prior to participation and were debriefed after completing the questionnaires. Questionnaires were presented in a fixed sequence to all participants (i.e., personal financial situation, IBQ, NEO-FFI, BDI-II-NL, FDS and ARS). For the participants in the research panel the BRIEF-A was added after the ARS. The study was approved by the Ethical Committee of Psychology of the University of Groningen, the Netherlands.

Data analyses

Group comparisons. To examine group differences in impulsive buying and the use of financial decision styles, Analyses of Variance (ANOVA) have been conducted with the total score and the scores on the subscales of the IBQ and of the FDS as dependent variables, respectively. Post-hoc Bonferroni analyses were conducted when significant group differences were found. In addition, to evaluate group differences in participants' personal financial situation, Pearson's chi-square analyses were conducted for variables related to debts, receiving social security, saving money, saving for retirement and owning a house. Differences in income between groups were evaluated using a Kruskal-Wallis test and group differences on the variable 'free money to spend' were evaluated with an ANOVA. For all post-hoc analyses, effect sizes and 95% confidence intervals (95% CI) were calculated and interpreted as small ($d = 0.20$), medium ($d = 0.50$) and large ($d = 0.80$; Cohen, 1988). Results were considered significant with an alpha of $\leq .05$. Besides a Bonferroni correction in the post-hoc analyses, no further correction for alpha was applied, since current analyses partly replicate previous research in adults with ADHD (Bangma et al., 2019) and smaller effects can be assumed because of the use of a community sample.

Predicting financial decision-making. To examine the relation between impulsive buying, the use of financial decision styles and symptoms of ADHD, and to determine the potential influence of personality and symptoms of depression on this relation, nine hierarchical linear regressions were performed in the whole sample ($n = 1292$) with the four IBQ and five FDS scores as dependent variables. First, to control for the potential effects of age (in years), sex (male/female), level of education (Verhage, 1964) and annual income on impulsive buying and the use of financial decision styles, these independent variables were included in the first model (method: enter). To evaluate the potential effects of symptoms of depression and the Big

Five personality traits, the total scores on the BDI and the five NEO-FFI personality traits, respectively, were included in the second model of the regression analyses (method: enter). Finally, the ARS total score reflecting current symptoms of ADHD was included in the third model. The ARS and BDI scores were LOG transformed to control for the strong positive skewness in these variables. After transformation, these variables showed a trend towards a normal distribution. R^2/sr^2 were used as measures of effect size and interpreted as small (R^2/sr^2 = below .08), medium (R^2/sr^2 = between .11 and .27) or large (R^2/sr^2 = above .30; Fritz et al., 2012). When the ARS total score significantly contributed to the model, the hierarchical regression was repeated including the ARS total scores (i.e., current symptoms) of the inattentive items and the hyperactive/impulsive items separately. Because of the explorative approach of the regression analyses with the use of a relatively large number of independent variables, the inclusion of a relatively large sample and in order to control for multiple testing, a conservative alpha ($p \leq .001$) was used for these analyses to reduce the change of overoptimism or type 1 errors.

Results

Group comparisons

Impulsive buying. Significant group differences were found on the IBQ total score and for both the cognitive and affective subscales of the IBQ (Table 8.2). The ADHD group obtained significantly higher scores on the IBQ cognitive subscale compared to both the No ADHD group (*Mean Difference (MD)* = 2.7; *Standard Error (SE)* = .88; p = .015; d = 0.54, 95% CI [0.22; 0.86]) and the Subthreshold ADHD group (MD = 2.5; SE = .92; p = .039; d = 0.40, 95% CI [0.07; 0.73]). Furthermore, the Adult-only ADHD group obtained significantly higher scores compared to the No ADHD group on the IBQ total score (MD = 4.3; SE = 1.5; p = .018; d = 0.47, 95% CI [0.18; 0.76]) and on both subscales (IBQ cognitive subscale: MD = 2.2; SE = .80; p = .033; d = 0.45, 95% CI [0.16; 0.73] and IBQ affective subscale: MD = 2.1; SE = .79; p = .046; d = 0.41, 95% CI [0.12; 0.70]). No significant differences were found regarding the other group comparisons and groups also did not differ in the situational subscale of the IBQ (Table 8.2).

Financial decision styles. Significant group differences were found on the FDS avoidant subscale and the FDS spontaneous subscale (Table 8.2). For the FDS avoidant subscale, significantly higher scores were obtained by both the ADHD group and the Adult-only ADHD group compared to the No ADHD group (MD = 1.8; SE = .62; p = .030; d = 0.48, 95% CI [0.16; 0.79] and MD = 3.3; SE = .57; p < .001; d = 0.90, 95% CI [0.60; 1.19]; respectively). The scores on the FDS avoidant subscale of the Adult-only ADHD group were also significantly higher compared to the Subthreshold ADHD group (MD = 2.3; SE = .60; p = .001; d = 0.56, 95% CI [0.25; 0.86]). No significant differences were found on the FDS avoidant subscale between the other groups. With regard to the FDS spontaneous subscale, the ADHD group obtained significantly higher scores compared to the Subthreshold ADHD group (MD = 1.3; SE = .42; p = .009; d = 0.50, 95% CI [0.17; 0.83]) and the No ADHD group (MD = 1.5; SE = .40; p =

Table 8.2. Impulsive buying and financial decision styles of total sample and ADHD groups.

	Total sample	ADHD	Adult-only ADHD	Subthreshold ADHD	No ADHD	Group differences	
						Statistics	<i>p</i> <i>d</i>
IBQ total score <i>M</i> (<i>SD</i>)	59.8 (10.0)	62.7 (10.5)	63.1 (11.3) ^a	59.6 (11.0)	58.8 (8.8)	$F(3,529) = 4.4$	.005* 0.316
IBQ Cognitive component <i>M</i> (<i>SD</i>)	32.6 (5.5)	34.6 (6.3) ^{a,b}	34.2 (6.3) ^a	32.1 (6.1)	31.9 (4.7)	$F(3,529) = 5.2$	.001* 0.343
IBQ Affective component <i>M</i> (<i>SD</i>)	27.4 (5.4)	28.1 (5.3)	28.9 (5.8) ^a	27.5 (5.9)	26.8 (5.0)	$F(3,529) = 2.8$	.039* 0.252
IBQ Situational component <i>M</i> (<i>SD</i>)	9.7 (1.6)	9.9 (1.5)	9.7 (1.7)	9.6 (1.8)	9.7 (1.5)	$F(3,529) = 0.6$	.615 0.117
FDS Rational <i>M</i> (<i>SD</i>)	18.8 (2.8)	18.4 (2.9)	18.5 (3.0)	18.9 (2.8)	18.8 (2.7)	$F(3,529) = 0.7$	.529 0.130
FDS Intuitive <i>M</i> (<i>SD</i>)	16.4 (3.2)	16.9 (3.1)	17.0 (2.9)	16.6 (3.2)	16.1 (3.2)	$F(3,529) = 1.9$	.135 0.208
FDS Dependent <i>M</i> (<i>SD</i>)	16.4 (3.6)	16.3 (3.6)	17.2 (3.4)	16.6 (3.8)	16.1 (3.6)	$F(3,529) = 1.7$	.161 0.196
FDS Avoidant <i>M</i> (<i>SD</i>)	12.0 (4.0)	13.0 (4.5) ^a	14.5 (4.5) ^{a,b}	12.2 (4.1)	11.2 (3.5)	$F(3,529) = 12.9$	<.001* 0.541
FDS Spontaneous <i>M</i> (<i>SD</i>)	8.7 (2.6)	9.9 (3.1) ^{a,b}	9.2 (2.9)	8.6 (2.5)	8.4 (2.3)	$F(3,529) = 5.5$	.001* 0.353

Note. ADHD = attention-deficit/hyperactivity disorder; IBQ = Impulsive Buying Questionnaire, FDS = Financial Decision Styles questionnaire.

* $p \leq .05$. Post-hoc Bonferroni significant group differences: ^a versus No ADHD group and ^b versus Subthreshold ADHD group

.002; $d = 0.60$, 95% CI [0.28; 0.91]), while no significant differences were found between the other groups. Furthermore, groups did not differ with regard to the rational, intuitive and dependent subscales of the FDS.

Personal financial situation. Group differences were found with regard to actively saving money and saving for retirement (Table 8.3). In the ADHD group, only 19.6% saved for their retirement which were significantly less individuals than in the No ADHD group (41.5%; $X^2(1) = 8.0$; $p = .005$; $d = 0.32$, 95% CI [0.13; 0.53]) and the Subthreshold ADHD group (37.0%; $X^2(1) = 4.9$; $p = .026$; $d = 0.31$, 95% CI [0.06; 0.57]). Comparable results were found for the Adult-only ADHD group: 22.8% of the Adult-only ADHD group saved for their retirement, which were significantly less individuals compared to the No ADHD group ($X^2(1) = 7.0$; $p = .008$; $d = 0.30$, 95% CI [0.06; 0.50]) and the Subthreshold ADHD group ($X^2(1) = 3.8$; $p = .050$; $d = 0.27$, 95% CI [0.01; 0.52]). Furthermore, compared to the No ADHD group, the Adult-only ADHD group significantly less often saved money actively (38.8% of Adult-only ADHD group and 63.3% of No ADHD group saved actively, $X^2(1) = 10.3$; $p < .001$; $d = 0.38$, 95% CI [0.14; 0.62]). Other group comparisons of these and other personal financial situation variables were not significant (e.g., annual year income, receiving social security or having debts; Table 8.3).

Predicting financial decision-making

Impulsive buying behavior. In total, 26.6% of variance of the IBQ total score could be explained in the third regression model ($F(11,1287) = 43.33$; $p < .001$; Table 8.4a). Symptoms of ADHD were, however, not a significant contributor to the model ($\Delta F(1,1276) = 4.0$; $p = .045$; $\Delta R^2 = .002$). Instead, a significant positive relation was found with extraversion and neuroticism. Conscientiousness and

agreeableness were significantly negatively related to the IBQ total score. Furthermore, being female and a lower age were also related to a stronger tendency to buy on impulse (Table 8.4a). With regard to the cognitive, affective and situational components of the IBQ, 23.3% ($F(11,1288) = 36.7$; $p < .001$); 24.2% ($F(11,1288) = 38.4$; $p < .001$) and 3.6% ($F(11,1289) = 5.4$; $p < .001$) of variance could be explained in the third regression model, respectively (Table 8.4a). Symptoms of ADHD, again, did not significantly contribute to these models (cognitive: $\Delta R^2 = .001$; $\Delta F(1,1277) = 2.2$; $p = .137$; affective: $\Delta R^2 = .003$; $F(\Delta F(1,1277) = 4.6$; $p = .032$; and situational: $\Delta R^2 = .001$; $F(\Delta F(1,1278) = 1.7$; $p = .192$). For the IBQ cognitive component, the significant predictors were similar to the contributors of the IBQ total score: while extraversion and neuroticism were significantly positively related, conscientiousness and agreeableness were significantly negatively related to the cognitive component. Also, being female and a lower age were significantly related to higher scores on the cognitive component of impulsive buying. For the IBQ affective component, extraversion and neuroticism were found to be significantly positively related, while other Big Five personality traits and symptoms of depression did not significantly contribute to this model. However, being female and a lower age were significantly related to the affective component of impulsive buying as well. Regarding the situational component of the IBQ, only conscientiousness was found to be a significant negative predictor (Table 8.4a).

Financial decision styles. Symptoms of ADHD did not significantly contribute to the third model of any of the five FDS decision styles (rational: $\Delta R^2 = .000$; $\Delta F(1,1278) = 0.3$; $p = .580$; intuitive: $\Delta R^2 = .000$; $\Delta F(1,1278) = 0.1$; $p = .827$; dependent: $\Delta R^2 = .006$; $\Delta F(1,1278) = 8.7$; $p = .003$; avoidant: $\Delta R^2 = .005$; $\Delta F(1,1278) = 7.6$; $p = .006$ and spontaneous: $\Delta R^2 = .001$; $\Delta F(1,1278) = 1.2$; $p = .278$). Decision styles could, however, be explained by other variables included in the regression model (Table 8.4b). In total, 21.0% of variance of the FDS rational subscale could be explained in the third regression model ($F(11,1289) = 32.2$; $p < .001$). The use of a rational decision style was significantly positively related to conscientiousness and openness and significantly negatively related to extraversion. In addition, level of education was also a significant positive predictor of the rational decision style (Table 8.4b). With regard to the FDS intuitive subscale, 9.8% of variance could be explained in the third regression model ($F(11,1289) = 13.7$; $p < .001$). The use of an intuitive decision style was significantly negatively related to level of education and significantly positively related to extraversion and symptoms of depression (Table 8.4b). The third regression model of the FDS dependent subscale was also significant ($R^2 = .115$; $F(11,1289) = 16.3$; $p < .001$) and the use of a dependent decision style was significantly positively related to neuroticism, extraversion and being female (Table 8.4b). With regard to the FDS avoidant subscale, 23.6% of variance could be explained in the third regression model ($F(11,1289) = 37.2$; $p < .001$). The use of an avoidant decision style was significantly positively related to age, neuroticism and extraversion and significantly negatively related to conscientiousness and agreeableness (Table 8.4b). Finally, 24.0% of variance could be explained in the third regression model of the FDS spontaneous subscale ($F(11,1289) = 37.9$; $p < .001$). The use of a spontaneous decision style was significantly positively related to extraversion and neuroticism and significantly negatively related to conscientiousness and agreeableness (Table 8.4b).

Table 8.3. Personal financial situation of the total sample and ADHD groups.

	Total sample	ADHD	Adult-only ADHD	Subthreshold ADHD	No ADHD	Group differences	
						Statistics	p
							d
'What is approximately your annual gross income?' <i>Mdn</i>	€25,000 to €35,000	< €15,000 ¹	€15,000 to €25,000	€15,000 to €25,000	€15,000 to €25,000	$\chi^2(3) = 4.6$	.206
'How much money can you approximately spend each month after deduction of fixed expenses?' ¹ <i>M (SD)</i>	€631.3 (€475.1)	€523.8 (€462.9)	€455.0 (€449.6)	€591.0 (€496.8)	€604.1 (441.0)	$F(3,490) = 1.8$	.145
'Do you receive social security?' % yes	33.0	30.4	31.6	30.9	26.0	$\chi^2(3) = 1.6$	.663
'Do you have debts other than mortgage or study loans?' % yes	7.7	8.7	3.5	9.9	5.3	$\chi^2(3) = 4.6$	.202
'Do you have a savings account?' % yes	91.1	87.0	86.0	92.0	94.7	$\chi^2(3) = 7.3$	.065
'Do you save actively, i.e., do you put money on your savings account on a regular basis?' % yes	58.8	55.0	38.8 ^a	54.4	63.3	$\chi^2(3) = 11.2$	.010*
'Do you save for your retirement?' % yes	45.4	19.6 ^{a,b}	22.8 ^{a,b}	37.0	41.5	$\chi^2(3) = 13.2$	.004*
'Do you own a house?' % yes	61.6	37.0	35.1	41.4	50.2	$\chi^2(3) = 7.2$	.066

Note. ADHD = attention-deficit/hyperactivity disorder.

¹ Mode income is described since median income was between '<€15,000' (n = 23) and '€15,000 to €25,000' (n = 8).

² Answering was not mandatory and outliers were excluded. Group size of the remaining samples: Total sample n = 1170, ADHD group n = 42, Adult-only ADHD group n = 55, Subthreshold ADHD group n = 144 and No ADHD group n = 253. Furthermore, income of (financial) partner was not taken into account.

* $p \leq .05$. Post-hoc Bonferroni significant group differences: ^a versus No ADHD group and ^b versus Subthreshold ADHD group.

IBQ affective	Model 1				Model 2				Model 3			
	B	β	p	sr^2	B	β	p	sr^2	B	β	p	sr^2
1st block												
Age	-0.09	-.32	< .001*	.084	-0.06	-.21	< .001*	.032	-0.06	-.20	< .001*	.027
Sex	2.00	.19	< .001*	.033	1.87	.18	< .001*	.023	1.89	.18	< .001*	.024
Level of education	-0.40	-.08	.003	.006	-0.25	-.05	.062	.002	-0.27	-.06	.048	.002
Income	-0.20	-.06	.032	.003	-0.05	-.02	.574	.000	-0.06	.02	.509	.000
2nd block												
Neuroticism					0.17	.26	< .001*	.033	0.17	.24	< .001*	.029
Extraversion					0.20	.23	< .001*	.037	0.18	.22	< .001*	.032
Openness					-0.02	-.02	.430	.000	-0.02	-.02	.379	.000
Agreeableness					-0.07	-.07	.009	.004	-0.06	-.06	.033	.003
Conscientiousness					-0.04	-.05	.101	.002	-0.03	-.03	.229	.001
Depression					1.03	.08	.009	.004	0.80	.06	.051	.000
3rd block												
Symptoms of ADHD									1.07	.07	.032	.008
Total R² adjusted			15.8%, p < .001*				24.0%, p < .001*				24.2%, p < .001*	
ΔR^2							8.5%, p < .001*				0.3%, p = .032	
IBQ situational												
	B	β	p	sr^2	B	β	p	sr^2	B	β	p	sr^2
1st block												
Age	0.01	.06	.065	.003	0.01	.07	.041	.003	0.01	.08	.023	.004
Sex	-0.24	-.08	.009	.005	-0.08	-.03	.409	.001	-0.08	-.03	.435	.000
Level of education	0.07	.05	.112	.002	0.10	.07	.033	.003	0.09	.07	.039	.003
Income	0.05	.05	.101	.002	0.06	.07	.050	.003	0.06	.06	.057	.003
2nd block												
Neuroticism					-0.02	-.10	.014	.005	-0.02	-.11	.008	.005
Extraversion					0.01	.03	.354	.001	0.01	.02	.521	.000
Openness					-0.02	-.06	.036	.003	-0.02	-.06	.031	.003
Agreeableness					-0.01	-.02	.567	.000	-0.00	-.01	.762	.000
Conscientiousness					-0.04	-.14	< .001*	.016	-0.04	-.14	< .001*	.014
Depression					-0.09	-.02	.501	.000	-0.13	-.04	.322	.001
3rd block												
Symptoms of ADHD									0.21	.05	.192	.001
Total R² adjusted			1.6%, p < .001*				3.5%, p < .001*				3.6%, p < .001*	
ΔR^2							2.4%, p < .001*				0.1%, p = .192	

Table continues on the next page

Table 8.4b. Hierarchical regressions of financial decision-making styles in the total sample.

FDS rational	Model 1				Model 2				Model 3			
	<i>B</i>	β	<i>p</i>	<i>sr</i> ²	<i>B</i>	β	<i>p</i>	<i>sr</i> ²	<i>B</i>	β	<i>p</i>	<i>sr</i> ²
1st block												
Age	0.02	.11	< .001*	.010	0.00	.01	.659	.000	0.00	.02	.583	.000
Sex	0.15	.03	.325	.001	-0.23	-.05	.123	.001	-0.23	-.05	.128	.001
Level of education	0.51	.21	< .001*	.038	0.34	.14	< .001*	.015	0.34	.14	< .001*	.015
Income	0.17	.11	.001*	.008	0.02	.02	.615	.000	0.02	.01	.633	.000
2nd block												
Neuroticism					-0.03	-.08	.020	.003	-0.03	-.09	.017	.003
Extraversion					-0.06	-.15	< .001*	.016	-0.07	-.16	< .001*	.016
Openness					0.07	.17	< .001*	.024	0.07	.17	< .001*	.024
Agreeableness					-0.00	-.00	.939	.000	0.00	.00	.973	.000
Conscientiousness					0.17	.38	< .001*	.108	0.17	.38	< .001*	.105
Depression					0.45	.07	.025	.003	0.42	.06	.043	.003
3rd block												
Symptoms of ADHD									0.14	.02	.580	.000
Total <i>R</i>² adjusted			0.7%, <i>p</i> < .001*				21.1%, <i>p</i> < .001*				21.0%, <i>p</i> < .001*	
ΔR^2							14.7%, <i>p</i> < .001*				0.0%, <i>p</i> = .580	
FDS intuitive												
	<i>B</i>	β	<i>p</i>	<i>sr</i> ²	<i>B</i>	β	<i>p</i>	<i>sr</i> ²	<i>B</i>	β	<i>p</i>	<i>sr</i> ²
1st block												
Age	0.01	.04	.239	.001	0.01	.07	.028	.003	0.01	.07	.036	.003
Sex	0.37	.06	.050	.003	0.29	.05	.150	.001	0.29	.05	.152	.001
Level of education	-0.65	-.21	< .001*	.038	-0.59	-.19	< .001*	.028	-0.58	-.19	< .001*	.027
Income	-0.18	-.09	.004	.005	-0.20	-.10	.002	.007	-0.20	-.10	.002	.007
2nd block												
Neuroticism					0.03	.06	.104	.002	0.03	.06	.101	.002
Extraversion					0.09	.17	< .001*	.020	0.09	.17	< .001*	.020
Openness					-0.02	-.03	.320	.001	-0.02	-.03	.325	.001
Agreeableness					-0.04	-.07	.029	.003	-0.04	-.07	.029	.003
Conscientiousness					0.04	.06	.037	.003	0.04	.06	.045	.003
Depression					1.02	.12	< .001*	.010	1.04	.12	< .001*	.009
3rd block												
Symptoms of ADHD									-0.08	-.01	.827	.000
Total <i>R</i>² adjusted			6.9%, <i>p</i> < .001*				9.9%, <i>p</i> < .001*				9.8%, <i>p</i> < .001*	
ΔR^2							3.4%, <i>p</i> < .001*				0.0%, <i>p</i> = .827	

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FDS dependent	Model 1				Model 2				Model 3				
	B	β	p	sr ²	B	β	p	sr ²	B	β	p	sr ²	
1 st block													
Age	-0.03	-.17	< .001*	.024	-0.02	-.08	.008	.005	-0.01	-.06	.049	.003	
Sex	1.12	.16	< .001*	.021	0.78	.11	.001*	.008	0.80	.11	< .001*	.009	
Level of education	-0.11	-.03	.254	.001	-0.10	-.03	.350	.001	-0.11	-.03	.278	.001	
Income	-0.06	-.03	.412	.000	0.02	.01	.786	.000	0.01	.00	.889	.000	
2 nd block													
Neuroticism					0.13	.27	< .001*	.035	0.12	.25	< .001*	.029	
Extraversion					0.12	.20	< .001*	.029	0.11	.18	< .001*	.023	
Openness					0.01	.01	.650	.000	0.01	.01	.737	.000	
Agreeableness					0.03	.05	.101	.002	0.05	.07	.028	.003	
Conscientiousness					-0.03	-.04	.146	.001	-0.02	-.03	.387	.001	
Depression					-0.33	-.04	.271	.001	-0.56	-.06	.067	.002	
3 rd block													
Symptoms of ADHD									1.10	.10	.003	.006	
Total R ² adjusted			5.7%, p < .001*				11.0%, p < .001*				11.5%, p < .001*		
ΔR ²							5.7%, p < .001*				0.6%, p = .003		
FDS avoidant													
Model 1	B	β	p	sr ²	Model 2	B	β	p	Model 3	B	β	p	sr ²
1 st block													
Age	-0.01	-.05	.099	.002	0.02	.09	.002	.006	0.02	.11	< .001*	.008	
Sex	-0.22	-.03	.328	.001	0.22	.03	.303	.001	0.24	.03	.261	.001	
Level of education	-0.26	-.07	.015	.004	-0.09	-.03	.361	.001	-0.10	-.03	.292	.001	
Income	-0.33	-.14	< .001*	.015	-0.04	-.02	.597	.000	-0.04	-.02	.513	.000	
2 nd block													
Neuroticism					0.15	.29	< .001*	.043	0.14	.28	< .001*	.036	
Extraversion					0.09	.14	< .001*	.014	0.08	.12	< .001*	.010	
Openness					-0.03	-.04	.106	.002	-0.03	-.05	.083	.002	
Agreeableness					-0.09	-.13	< .001*	.012	-0.08	-.11	< .001*	.008	
Conscientiousness					-0.20	-.29	< .001*	.067	-0.19	-.28	< .001*	.058	
Depression					-0.01	-.00	.966	.000	-0.23	-.02	.449	.000	
3 rd block													
Symptoms of ADHD									1.00	.08	.006	.005	
Total R ² adjusted			2.9%, p < .001*				23.2%, p < .001*				23.6%, p < .001*		
ΔR ²							20.6%, p < .001*				0.5%, p = .006		

FDS spontaneous	Model 1				Model 2				Model 3			
	<i>B</i>	β	<i>p</i>	<i>sr</i> ²	<i>B</i>	β	<i>p</i>	<i>sr</i> ²	<i>B</i>	β	<i>p</i>	<i>sr</i> ²
1st block												
Age	-0.03	-.24	< .001 *	.049	-0.01	-.10	.001 *	.006	-0.01	-.09	.003	.005
Sex	-0.27	-.06	.048	.003	0.32	.07	.019	.003	-0.33	-.07	.017	.003
Level of education	-0.11	-.05	.098	.002	0.01	.01	.819	.000	-0.01	-.01	.862	.000
Income	-0.05	-.04	.232	.001	0.07	.05	.123	.001	-0.06	-.04	.136	.001
2nd block												
Neuroticism					0.04	.13	< .001 *	.009	0.04	.13	< .001 *	.008
Extraversion					0.09	.23	< .001 *	.036	0.09	.22	< .001 *	.032
Openness					-0.03	-.07	.009	.004	-0.03	-.07	.008	.004
Agreeableness					-0.12	-.26	< .001 *	.048	-0.11	-.25	< .001 *	.044
Conscientiousness					-0.13	-.30	< .001 *	.068	-0.12	-.29	< .001 *	.063
Depression					-0.12	-.02	.512	.000	-0.17	-.03	.361	.001
3rd block												
Symptoms of ADHD									0.25	.03	.278	.001
Total <i>R</i>²-adjusted			6.0%, <i>p</i> < .001 *				24.0%, <i>p</i> < .001 *			24.0%, <i>p</i> < .001 *		
ΔR^2							18.3%, <i>p</i> < .001 *			0.0%, <i>p</i> = .278		

Note. Neuroticism, extraversion, openness, agreeableness and conscientiousness are measured with the Neuroticism-Extraversion-Openness Five Factor Inventory (NEO-FFI). Symptoms of depression are measured with the Beck Depression Inventory II (BDI-II-NL). Symptoms of ADHD are measured with the attention-deficit/hyperactivity disorder rating scale (ARS) current version.

ADHD = attention-deficit/hyperactivity disorder, **IBQ** = Impulsive Buying Questionnaire; **FDS** = financial decision-making styles questionnaire.

* *p* ≤ .001 is considered significant.

Discussion

The primary goal of the present study was to further investigate the influence of current symptoms of ADHD on two types of financial performance, i.e., impulsive buying and financial decision styles which are of influence on the capability to make financial decisions (Appelbaum et al., 2016). Furthermore, it was investigated to what extent personality and symptoms of depression are of influence on the association between impulsive buying, financial decision styles and symptoms of ADHD. Based on a recent study (Bangma et al., 2019), symptoms of ADHD were expected to be related to impulsive buying, in particular to the cognitive component of impulsive buying. Furthermore, the use of an avoidant or a spontaneous decision style in situations requiring financial decisions, which are both negatively related to decision-making (Bavol'ár & Orosová, 2015), were expected to be related to symptoms of ADHD.

In the present study, the tendency to buy on impulse and/or components of impulsive buying were indeed stronger in individuals experiencing symptoms of ADHD in adulthood (i.e., the ADHD group and Adult-only ADHD group) compared to individuals without symptoms of ADHD. Furthermore, individuals who met the self-reported symptom criteria for ADHD (i.e., the ADHD group) showed higher scores on the cognitive component of impulsive buying compared to individuals without symptoms of ADHD and individuals with current subthreshold symptoms of ADHD. A similar result was found for individuals in the Adult-only ADHD group compared to individuals without symptoms of ADHD (i.e., the No ADHD group). Previous research reported a significant relation between current symptoms of ADHD and compulsive buying, a pathological form of impulsive buying (Black et al., 2012; Brook et al., 2015), particularly with ADHD symptoms of hyperactivity and impulsivity (Black et al., 2012). In the regression analyses, however, no association between symptoms of ADHD and impulsive buying was found. In contrast, the results of the present study suggest that personality traits seem to play a role when buying on impulse. The cognitive, affective and combined component (i.e., total score) of impulsive buying were found to be positively related to traits of neuroticism and extraversion and negatively related to traits of conscientiousness and agreeableness, with the exception of the affective component which was not related to conscientiousness and agreeableness. Comparable findings were found in previous research on impulsive buying and personality within a non-clinical adult sample (Bratko et al., 2013; Verplanken & Herabadi, 2001). Although the strength of relations found was weak, in previous and present research the strongest associations with impulse buying were most consistently found for extraversion and neuroticism: Individuals who are strongly focused on and engaged in the external environment (i.e., high on extraversion) and/or individuals who experience a strong tendency of emotional instability or negative emotions (i.e., high on neuroticism) tend to have a higher tendency to buy on impulse compared to individuals with low levels of these personality traits. In accordance with previous literature (Bangma et al., 2019; Verplanken & Herabadi, 2001), being female and a younger age were also associated with a stronger tendency to buy on impulse. Although the ADHD groups did not statistically differ with regard to age and sex, individuals in the ADHD group seem to be slightly younger compared to the other groups when focusing on the age range of these groups. This observation needs to be taken into account when

interpreting these results. The situational component of impulsive buying, i.e., having enough time and money to make an impulsive purchase, was not associated with symptoms of ADHD and could also not be explained by demographic variables, symptoms of depression and the majority of personality traits. Only conscientiousness was significantly negatively related with the situational component. It is, however, important to keep in mind that the internal consistency of this component of the IBQ was very weak.

The results with regard to the use of specific financial decision styles showed a similar pattern as found for impulse buying. In accordance with previous research (Bangma et al., 2019), significant group differences were found between the ADHD group and No ADHD group on the avoidant and spontaneous decision styles. The ADHD group also more often used a spontaneous decision style compared to the Subthreshold ADHD group. Furthermore, compared to the No ADHD group and Subthreshold ADHD group, an avoidant decision style was more often used by the Adult-only group. Symptoms of ADHD, however, could not predict the scores on the avoidant and spontaneous decision styles in the regression analyses. Instead, personality traits seem to explain a significant amount of variance of financial decision styles. The avoidant and spontaneous decision styles were found to be significantly positively related to traits of neuroticism and extraversion and significantly negatively related to traits of conscientious and agreeableness. The use of other financial decision styles was also not associated with symptoms of ADHD but was, besides personality traits, related to symptoms of depression (i.e., intuitive style), level of education (i.e., rational and intuitive style) and sex (i.e., dependent style).

When interpreting the results regarding impulsive buying and the use of financial decision styles, it is important to keep in mind that associations were found between symptoms of ADHD and personality traits (Appendices 8-1 and 8-2). ADHD symptoms seem to be specifically associated with high neuroticism and low conscientiousness and agreeableness. Previous research found that conscientiousness appears more strongly related to inattentive symptoms than to hyperactive/impulsive symptoms (see Gomez and Corr (2014) for a review and meta-analyses). The presence of significant group differences between the ADHD groups on financial decision-making leads to the expectation of an association between symptoms of ADHD and financial decision-making. However, the associations that were found between ADHD symptoms and personality traits (Appendices 8-1 and 8-2) might, at least partly, explain the absence of an association between symptoms of ADHD and financial decision-making in the regression analyses when controlling for demographic characteristics, symptoms of depression and personality traits. Interestingly, in the present study, an association between extraversion and both impulsive buying and the use of specific financial decision styles is most consistently found, however, no association has been found between extraversion and symptoms of ADHD (Appendices 8-1 and 8-2).

With regard to the personal financial situation, the ADHD group less often saved for their retirement compared to the No ADHD group. On all other aspects (e.g., income, debts, having a savings account) the financial situation of the ADHD group was comparable to individuals without symptoms of ADHD. Compared to the No ADHD group, the Adult-only ADHD group also made less often financial decisions for the future (i.e., they less often saved money for their

retirement and less often used their savings account). Previous research comparing a clinical ADHD group with healthy controls, however, revealed that adults with ADHD have various problems related to their personal financial situation (e.g., more often debts, exceeding credit card loans or less often saving money; Bangma et al., 2019; Barkley et al., 2008). The discrepancy between the current and previous studies could be explained by the fact that previous studies included clinical samples which most likely consisted of adults with ADHD with more (severe) ADHD symptoms and problems in daily life than participants with symptoms of ADHD in a community sample.

Besides a group meeting the self-reported DSM-5 symptom criteria of adult ADHD (i.e., ADHD group), two other ADHD groups were created based on the number of reported symptoms of ADHD: An Adult-only ADHD group meeting the self-reported symptom criteria of adult ADHD but not for childhood ADHD and a Subthreshold ADHD group reporting a subthreshold number of current symptoms of ADHD (i.e., 3 or 4 symptoms of either inattention or hyperactivity/impulsivity). Based on the results, no evidence has been found that individuals with a subthreshold number of ADHD symptoms have difficulties with financial decision-making, since no differences were found between the Subthreshold ADHD group and the No ADHD group with regard to impulsive buying and the use of financial decision styles. However, the Adult-only ADHD group showed inadequate financial performances on both the cognitive and affective domain of impulsive buying. Furthermore, the avoidant style was more often used by this ADHD group compared to individuals without symptoms of ADHD. This indicates that individuals with current symptoms of ADHD without the presence of retrospective symptoms of ADHD might have difficulties with financial decision-making, similar to individuals meeting the self-reported symptom criteria of adult ADHD. Previous research already found similar neuropsychological performances and personality profiles in individuals who met all DSM-IV criteria for childhood-onset ADHD and individuals having so-called late-onset ADHD (Faraone et al., 2009, 2006). These findings, and the findings in the present study, support the current discussion about the age of onset of ADHD and the possibility of a late-onset form of adult ADHD (Caye et al., 2017).

Limitations. An important limitation that needs to be taken into account when interpreting the results of the present study is the lack of clinical information about the participants (e.g., about current or previous diagnosis of ADHD). Consequently, results may not be generalized to a clinical ADHD population. Current findings with regard to impulsive buying and the use of financial decision styles are, however, comparable with and seem to confirm previous research using a clinical group of adults with ADHD (Bangma et al., 2019). Furthermore, comorbidities, such as other (psychiatric) disorders (with the exception of symptoms of depression), and the use of medication were not taken into account in the present study. In a previous study, however, no evidence has been found that comorbidities are of influence on the financial decision-making capabilities of individuals with ADHD (Bangma et al., 2019). The influence of current and previous use of medication on the capability to make financial decisions is unknown. In present study, only a small number of participants (i.e., 4.3%) used either antidepressants, antipsychotics, benzodiazepines or stimulants. Therefore,

the influence of these medication in current results is probably negligible. The use of other types of medications was not sufficiently studied in current study.

Another limitation is that the total administration time of the questionnaires was longer than initially expected. On average, participants needed 56 minutes to complete all questionnaires. The sequence of questionnaires was, however, equal for all participants (see Materials and Methods). Nevertheless, especially for individuals with attentional problems, this duration may have been of influence on the pattern of answers on the questionnaires. Participants were able to pause the program and complete the questionnaires at a later point in time, which on the one hand might have reduced the effects of inattention and fatigue, but, on the other hand, also contributed to the relatively long administration time of the questionnaires. In this respect, it is interesting that the ADHD groups did not differ in the average administration time ($F(3,506) = .33; p = .808$). A third limitation is that the use of different recruitment and compensation modalities might have resulted in differences in clinical or demographical characteristics and motivation between participants recruited via an online research panel ($n = 474$) and participants recruited via other modalities ($n = 818$). Additional analyses comparing participants recruited via these two modalities, however, indicated no significant differences between groups with regard to retrospective and current symptoms of ADHD. Furthermore, no marked differences in the main findings were found between these modalities (data not published).

Another limitation is that no direct causal conclusions can be drawn about the observed associations between the dependent and independent variables in current study. This is a common problem in cross-sectional studies and especially when studying personality and psychopathology (Trull, 2011; Widiger, 2011). In the current study, it is conceivable that there is an overlap in the studied constructs of personality, impulsive buying and decision styles, that these constructs simultaneously influence each other or that these constructs share an underlying etiology (Widiger, 2011). Prospective longitudinal research is, therefore, recommended to further investigate the causality between personality and financial decision styles and impulsive buying. A final limitation is that the use of a conservative alpha level for the regression analyses reduced the risk of type 1 errors but increased the possibility of type 2 errors. Furthermore, the use of a large sample with a relatively small percentage of individuals with symptoms of ADHD or individuals meeting the self-reported symptom criteria of adult ADHD in the regression analyses, may have contributed to potential type 2 errors. All relations found in the present study were, however, mostly weak which indicates a low likelihood of type 2 errors. Furthermore, additional regression analyses using only participants from the four ADHD groups ($n = 529$; data not published) showed again no significant association between financial decision-making and symptoms of ADHD, while results with regard to the relation with demographic variables, personality or symptoms of depression were comparable to the original analyses.

Conclusion. Despite the described limitations, the results of the present study appear to confirm previous research in adults with ADHD and indicate more impulsive buying and more frequent use of disadvantageous financial decisions styles (i.e., avoidant and spontaneous styles) in individuals fulfilling self-reported current ADHD criteria (i.e., individuals with

ADHD and adult-only or late-onset ADHD) compared to individuals without symptoms of ADHD. Contextual factors, i.e., personality and demographic variables, were also found to be related to both impulsive buying and the use of specific financial decision styles. Personality and demographic variables might (at least partly) be of influence on the association between impulsive buying, the use of financial decision styles and ADHD since no significant association between symptoms of ADHD and these types of financial performance could be found when controlling for personality characteristics, symptoms of depression and demographics. However, no direct causal conclusions can be drawn and prospective longitudinal research is suggested to further investigate causality between these variables. The evaluation of financial decision-making in adults with ADHD remains nevertheless a topic of major interest in both research and clinical practice, since problems with managing financial matters may have far-reaching consequences for both patients and their social environment, and more attention for this topic is therefore recommended.

Appendices

Appendix 8-1. Symptoms of ADHD, personality and symptoms of depression of the total sample and ADHD groups.

	Total sample	ADHD	Adult-only ADHD	Subthreshold ADHD	Group differences		
					Statistics	p	d
Current symptoms of ADHD <i>M</i> (<i>SD</i>)	13.1 (8.6)	34.5 (8.1) ^{ab,c}	29.8 (7.3) ^{ab}	20.7 (4.9) ^a	10.3 (5.4)	F(3,529) = 376.2	< .001*
DSM-5 ADHD classification ¹ %	7.9	100	100	0.0	0.0		
Retrospective symptoms of ADHD <i>M</i> (<i>SD</i>)	13.8 (11.7)	40.4 (8.1) ^{ab,c}	19.5 (9.3) ^a	20.1 (11.1) ^a	12.1 (10.0)	F(3,529) = 108.1	< .001*
DSM-5 ADHD classification ² %	10.1	100	0.0	20.4	6.7		1.566
Neuroticism <i>M</i> (<i>SD</i>)	29.9 (7.6)	36.1 (7.2) ^a	38.3 (7.6) ^{ab}	33.1 (7.9) ^a	29.6 (6.4)	F(3,529) = 31.7	< .001*
Very low (% stanine ≤ 1)	5.1	2.2	0.0	3.1	3.0		0.848
Very high (% stanine ≥ 9)	2.1	4.3	12.3	5.0	0.8		
Extraversion <i>M</i> (<i>SD</i>)	40.1 (6.1)	40.3 (7.2)	38.5 (7.3)	40.4 (7.4)	41.0 (5.6)	F(3,529) = 2.3	.075
Very low (% stanine ≤ 1)	3.5	6.5	3.6	6.2	1.2		
Very high (% stanine ≥ 9)	2.8	2.2	8.8	5.0	3.0		0.229
Openness <i>M</i> (<i>SD</i>)	36.9 (5.8)	37.5 (6.9)	37.3 (5.0)	37.0 (6.2)	36.8 (5.8)	F(3,529) = 0.3	.827
Very low (% stanine ≤ 1)	1.6	2.2	0.0	2.4	1.0		0.083
Very high (% stanine ≥ 9)	2.9	8.6	1.8	3.7	2.7		
Agreeableness <i>M</i> (<i>SD</i>)	44.0 (5.2)	38.9 (6.3) ^{ab}	41.1 (6.2) ^a	42.7 (5.5) ^a	44.3 (5.1)	F(3,529) = 16.4	< .001*
Very low (% stanine ≤ 1)	4.0	30.4	14.1	6.2	2.3		0.610
Very high (% stanine ≥ 9)	3.1	2.2	0.0	1.8	4.9		
Conscientiousness <i>M</i> (<i>SD</i>)	44.6 (5.5)	39.7 (5.7) ^{ab}	39.5 (6.2) ^{ab}	44.0 (6.0)	44.7 (5.2)	F(3,529) = 21.5	< .001*
Very low (% stanine ≤ 1)	5.1	23.9	22.8	6.8	3.7		0.698
Very high (% stanine ≥ 9)	4.2	0.0	0.0	4.3	4.2		
Symptoms of depression <i>M</i> (<i>SD</i>)	5.9 (6.4)	12.1 (9.8) ^{ab}	13.5 (10.1) ^{ab}	8.2 (8.1) ^a	3.8 (4.2)	F(3,529) = 45.7	< .001*
No to minimal (% score 0 – 13)	90.6	71.7	57.9	84.0	96.6		1.018
Mild (% score 14 – 19)	5.3	4.3	22.8	8.0	2.6		
Moderate (% score 20 – 28)	2.4	17.4	8.8	3.7	0.8		
Severe (% score 29 – 63)	1.6	6.5	10.5	4.3	0.0		

Note. Symptoms of ADHD are measured with the attention-deficit/hyperactivity disorder rating scale (ARS). Neuroticism, extraversion, openness, agreeableness and conscientiousness are measured with the Neuroticism-Extraversion-Openness Five Factor Inventory (NEO-FFI). Symptoms of depression are measured with the Beck Depression Inventory II (BDI-II-NL). ADHD = attention-deficit/hyperactivity disorder; **DSM-5** = Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition.¹ DSM-5 ADHD classification in adulthood when ≥ 5 symptoms of inattention and/or ≥ 5 symptoms of hyperactivity and impulsivity were classified as being present in the last six months.² DSM-5 ADHD classification in childhood when ≥ 6 symptoms of inattention and/or ≥ 6 symptoms of hyperactivity and impulsivity were classified as being present when 0 – 12 years old.* $p < .05$. Post-hoc Bonferroni significant group differences: ^a versus No ADHD group, ^b versus Subthreshold ADHD group and ^c versus Adult-only ADHD group.

Appendix 8-2. Pearson correlations in the total sample.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Symptoms of ADHD	-									
2. Age	-.329 **	-								
3. Sex ¹	-.034	-.040	-							
4. Education	.087 *	-.254 **	.000	-						
5. Income	-.109 **	.248 **	-.348 **	.213 **	-					
6. Neuroticism	.401 **	-.241 **	.209 **	-.055 *	-.324 **	-				
7. Extraversion	-.032	-.142 **	-.003	.084 *	.090 *	-.417 **	-			
8. Openness	.058 *	-.070 *	.083 *	.352 **	.072 *	-.030	.114 **	-		
9. Agreeableness	-.304 **	.137 **	.328 **	.042	-.032	-.238 **	.271 **	.124 **	-	
10. Conscientiousness	-.341 **	.183 **	.087 *	.046	.236 **	-.369 **	.231 **	-.009	.289 **	-
11. Depression	.339 **	.058 *	.136 **	-.082 *	-.141 **	.531 **	-.351 **	-.010	-.136 **	-.192 **

Note. Symptoms of ADHD are measured with the attention-deficit/hyperactivity disorder rating scale (ARS) current version. Neuroticism, extraversion, openness, agreeableness and conscientiousness are measured with the Neuroticism-Extraversion-Openness Five Factor Inventory (NEO-FFI). Symptoms of depression are measured with the Beck Depression Inventory II (BDI-II-NL).
ADHD = attention-deficit/hyperactivity disorder.

¹ Sex: 0 = male, 1 = female.

* $p < .05$, ** $p < .001$.

PART

DISCUSSION

IV

CHAPTER

GENERAL DISCUSSION AND
CONCLUSION

9

A careful and comprehensive evaluation of the financial decision-making (FDM) capability of individual's with - or at risk of - problems with making financial decisions is important to be able to provide protection and assistance (Appelbaum et al., 2016; Marson, 2016; Wood & Lichtenberg, 2016). FDM capability is the ability to manage or direct one's money and requires an adequate financial competence and financial performance (Appelbaum et al., 2016). Financial competence refers to the financial skills of an individual as determined with measures of financial knowledge and/or financial judgment (Appelbaum et al., 2016; Engel et al., 2016). Financial performance reflects the ability to execute financial actions in daily life and relies on an adequate financial competence but is also dependent on several personal and contextual factors, such as the tendency to buy on impulse, personality or income level. Previous studies on FDM capability mainly focused on either financial competence or the financial performance. In order to make (clinical) decisions about an individual's autonomy and independence with regard to FDM capability, it is, however, important to aggregate the examination of both financial competence and financial performance (Appelbaum et al., 2016). Therefore, a new FDM test battery has been introduced in the current thesis (see **chapter 2**), including performance-based FDM tests and questionnaires which examine financial competence, financial performance as well as contextual factors.

The aim of the current thesis was to investigate whether FDM capability could be measured more objectively in order to make (clinical) decisions about an individual's capability to make financial decisions. For this, the FDM capability of individuals with and without cognitive dysfunctions has been systematically and comprehensively studied. In specific, the capability to make (financial) decisions of patients with neurodegenerative diseases (NDDs) and adults with attention-deficit/hyperactivity disorder (ADHD) has been evaluated with the use of our new FDM tests and questionnaires (**chapters 5, 7 and 8**) as well as by reflecting on previous research using systematic review analyses (**chapters 4 and 6**). Furthermore, the relations between FDM capability and normal aging, cognitive functioning, and several other contextual factors have been studied (e.g., **chapters 3 and 8**). Below, the main results of these studies will be critically discussed and integrated.

Financial decision-making capability in patients with neurodegenerative diseases

Two studies in the current thesis (**chapters 4 and 5**) examined the capability to make financial decisions using performance-based tests and questionnaires of FDM in patients with NDDs. Previous research that used self- or proxy-reported questionnaires already reported that patients with NDDs have difficulties with financial management (Pérès et al., 2008; Wadley et al., 2003; Wicklund et al., 2007). Consistent with these findings, lower performances were found on performance-based FDM tests and questionnaires in patients with NDDs compared to healthy controls (**chapters 4 and 5**).

The severity of FDM capability problems seems to be related to the presence and degree of cognitive decline in patients with an NDD. Significant group differences for the performances on performance-based FDM tests were found when cognitively impaired patients with Parkinson's disease (PD) or multiple sclerosis (MS) were compared with a healthy control group, while patients with PD or MS without cognitive impairment showed similar

performances on FDM tests as healthy controls (**chapter 4**). Performances on measures of global cognition (e.g., Mini-Mental State Examination or Dementia Rating Scale) were found to be significantly positively related to performances on FDM tests in patients with an NDD (i.e., patients with mild cognitive impairment (MCI), Alzheimer's disease (AD), PD, and Huntington's disease; **Table 4.3**). Furthermore, group differences were consistently found between healthy controls and patients with an NDD where cognitive impairment is part of the diagnostic criteria (i.e., patients with MCI, AD, or frontotemporal dementia), while this was not the case for patients with an NDD for which cognitive impairment is not part of the diagnostic criteria.

Based on the results as described in **chapters 4 and 5**, patient groups seem to differ with regard to the degree and/or severity of FDM capability problems. When comparing the pooled mean effect sizes and confidence intervals of the patient groups presented in the meta-analyses described in **chapter 4**, patients with AD and frontotemporal dementia seem to have more severe difficulties with FDM than patients with other NDDs (i.e., patients with MCI, PD or MS). Also, in the study described in **chapter 5**, which presents preliminary results of an ongoing study using tests and questionnaires from our new FDM test battery, patients with AD and MCI seem to have more and/or more severe difficulties with FDM than patients with PD, especially with regard to financial performance/contextual factors. Group differences were, however, not statistically evaluated in this latter study. Furthermore, patients with PD showed better performances on a measure of global cognition (i.e., Mini-Mental State Examination) compared to patients with MCI and AD, which might explain the differences on measures of FDM observed between these patients considering the role of (global) cognition on the severity of FDM capability problems (**chapter 5**).

An increase in disease severity in patients with AD, which is related to a decline in cognitive functioning, was furthermore found to be related to more difficulties with FDM (**chapter 4**). This is also supported by several longitudinal studies on financial competence in patients with AD or MCI (e.g., Lassen-Greene et al., 2017; Loewenstein et al., 1995; Martin et al., 2019; Niccolai et al., 2017; Pereira, Yassuda, et al., 2010) and emphasizes the role of cognition in FDM capability. Most longitudinal studies, however, evaluated patients only over a period of one- or two years and no longitudinal studies were performed in patients with an NDD other than AD or MCI. Due to the progressive course of NDDs, reassessment of FDM capability over longer periods of time is important both in research as well as in clinical practice. Reassessment is especially important in patients who perform in a borderline area where it is difficult to formulate decisions with regard to their financial autonomy and (in)dependence. This is illustrated by patients with MCI who showed similar performances on some relatively basic aspects of performance-based FDM tests as healthy controls (e.g., basic monetary skills, such as counting coins and simple transactions; **chapters 4 and 5**), but significant impairment on several other aspects of FDM capability. It is, therefore, conceivable that patients with MCI have difficulties, and need assistance, with some but not all aspects of FDM. Reassessment of the FDM capability in patients with MCI is, furthermore, of utmost importance since the course of the disease varies greatly between patients, with deterioration,

stabilization or even improvement of cognitive functioning over time (Manly et al., 2008; Visser et al., 2006), which in turn can have an influence on the FDM capability of these patients.

Financial decision-making capability in adults with attention-deficit/hyperactivity disorder

Besides the evaluation of patients with NDDs, several studies in this thesis (i.e., **chapters 6, 7 and 8**) focused on the (financial) decision-making capability of adults with ADHD. After systematically evaluating the literature (**chapter 6**), evidence was found that adults with ADHD have more problems with decision-making compared to healthy individuals. This evidence is, however, relatively weak and results were found to be mixed. Inconsistent findings between studies might be related to interindividual differences between patients with ADHD, both within and between studies, such as comorbidities and medication use. For example, methylphenidate improved the decision-making capability of adults with ADHD according to two double blind placebo-controlled medication studies (Mowinckel et al., 2017; Sethi et al., 2018), although this positive effect of methylphenidate was not found on two other decision tasks (Agay et al., 2010, 2014). Further evaluation of individual differences between adults with ADHD remains therefore an important topic within the field of decision-making research. Furthermore, most studies focused on risky decision-making whereas other domains of decision-making (e.g., deliberative/analytic decision-making, social decision-making or FDM) were underrepresented in the included studies. Therefore, more research on decision-making in adults with ADHD other than risky decision-making is needed.

The studies presented in **chapters 7 and 8** further elaborate on the evaluation of decision-making in adults with ADHD and focus specifically on FDM capability. Both studies provide evidence that adults with a clinical number of current symptoms of ADHD (i.e., ≥ 5 symptoms of inattention and/or ≥ 5 symptoms of hyperactivity and impulsivity, as described in the Diagnostic and Statistical Manual of Mental Disorders edition 5, were present in the last six months) have more difficulties with several aspects of FDM capability in comparison to individuals without current symptoms of ADHD. The study presented in **chapter 7** evaluated a group of clinically diagnosed adults with ADHD and found that 55.6% of the adults with ADHD performed more than 1.5 standard deviations below the mean of a healthy control group on one or more FDM tests or questionnaires; performances that can be classified as (very) low (Bouma et al., 2012). More specifically, lower performances of adults with ADHD were found on measures of financial knowledge and judgment (i.e., the Financial Competence Assessment Inventory and the Financial Decision-Making Interview) in comparison to the healthy control group. Both aspects of FDM are considered to be relatively fundamental aspects of FDM (Appelbaum et al., 2016) and problems on these aspects might reflect difficulties in everyday life, such as difficulties with budgeting, paying bills or with identifying and understanding financial information of own financial assets, a bank statement or a health insurance brochure. The results also indicate that adults with ADHD have a stronger tendency to buy on impulse and used more often an avoidant and a spontaneous decision style when making financial decisions compared to healthy controls. These results were confirmed in a study evaluating the relation between impulsive buying and the use of financial decision styles and current

symptoms of ADHD in a community sample (**chapter 8**). Using multiple regression analyses, no relation was however found between these two aspects of FDM and current symptoms of ADHD when controlling for personality traits, symptoms of depression, and demographical variables (**chapter 8**). This indicates that not only the symptomatology of ADHD, but also related contextual factors play a role and are of influence on the FDM capability (also see the discussion on contextual factors below).

Difficulties with FDM, as measured with performance-based tests and as found in adults with ADHD, are likely related to financial problems in everyday life, such as debts, difficulties saving money and financial dependency, which are more frequently found in adults with ADHD compared to healthy controls (**chapter 7**, also see Altszuler et al., 2016; Barkley et al., 2008). A direct association between the personal financial situation of adults with ADHD and their performances on performance-based measures of FDM capability was, however, not examined in the present thesis. Furthermore, financial problems in everyday life appeared less evident in individuals with current symptoms of ADHD who were identified in a community sample (**chapter 8**). This latter sample, however, included individuals without a verified clinical diagnosis of adult ADHD. Consequently, the results of our studies might indicate that individuals with a clinical diagnosis of ADHD, such as evaluated in the study presented in **chapter 7**, are more likely to experience everyday problems with FDM than individuals with only self-reported ADHD symptoms.

The dual-pathway model of ADHD may provide an explanation for the lower performances of adults with ADHD found in the field of (financial) decision-making. According to the dual-pathway model, ADHD can be described as a disorder of both cognitive dysregulation and motivational/affective dysregulation (Sonuga-Barke, 2003). This dysregulation might negatively affect either the deliberative/analytic processing of information or the affective/experiential processing of information, respectively, which are described as two systems of information processing important for adequate decision-making (Evans, 2008; Kahneman, 2003). In the studies presented in **chapters 6 and 7**, no evidence was found that decision-making problems in adults with ADHD could be explained merely by motivational/emotional dysregulation problems or by problems with regard to cognitive control, since deviating performances on both intuitive as well as deliberative/analytic decision-making tests were found in adults with ADHD. The evaluation of the dual-pathway model of ADHD in relation to decision-making deficits in adults with ADHD was, however, not part of the aims of these studies. Furthermore, in contrast to what can be expected based on the dual-pathway model, similar performances were found in adults with ADHD and healthy controls on a highly cognitive demanding FDM test (i.e., the Competence in Decision Rules test; **chapter 7**). Therefore, more research is needed to evaluate if there is indeed a relation between the dual-pathway model of ADHD and (financial) decision-making capability problems in adults with ADHD.

Nevertheless, evidence has been found that adults with ADHD symptomatology have more difficulties with several aspects of FDM capability compared to healthy controls, which might result in (more) financial problems in everyday life. Although financial problems were already demonstrated in adults with ADHD using self- and proxy reported questionnaires (e.g.,

Altszuler et al., 2016; Barkley et al., 2006, 2008), the study presented in **chapter 7** was the first study using performance-based tests in order to evaluate FDM capability in adults with ADHD. Because of the sensitive nature of this topic and the possible tremendous negative consequences of problems with FDM capability, it is of utmost importance that FDM capability is a topic that is acknowledged in scientific and clinical practice when investigating everyday functioning of adults with ADHD. Direct examination of FDM capability may contribute to the (early) detection of adults with ADHD with FDM capability problems, or at risk to develop financial problems, and to better assist and protect these patients.

Financial decision-making capability in relation to cognition

Three studies in this thesis, presented in **chapters 3, 4 and 7**, directly assessed specific cognitive functions in order to evaluate which cognitive functions were related to FDM capability. Numeracy, i.e., the ability to use basic mathematics as frequently measured with an arithmetic test, was most consistently found to be a significant predictor of FDM capability. Depending on the sample, numeracy mediated differences between groups in FDM capability on three aspects of FDM (i.e., financial knowledge or financial competence as measured with the Financial Competence Assessment Inventory; financial judgment as measured with the Financial Decision-Making Interview; and financial performance, specifically the ability to use decision rules, as measured with the Competence in Decision Rules test). Numeracy could, however, only explain a part of the problems with these aspects of FDM, since the direct effect remained significant in both healthy individuals (evaluating the effects of age on FDM capability; **chapter 3**) and adults with and without ADHD (evaluating group differences on FDM capability; **chapter 7**). Besides numeracy, also other cognitive functions were found to be related to FDM capability. Lower performances on measures of processing speed, working memory and verbal memory were found to be related to more difficulties with making financial decisions (**chapter 4**). It seems that the associations between these functions of cognition, including numeracy, and FDM capability are however not consistent for all aspects of FDM capability, since some aspects of FDM do not appear to be related to these cognitive functions (**chapter 3**). Furthermore, differences between studies (as presented in **Table 4.3**) might be dependent on the sample evaluated, the FDM aspect assessed and/or the measures used to determine FDM and cognitive functioning. Also, visuospatial memory, verbal fluency, attention and executive functions (including abstract reasoning, planning and cognitive flexibility) were found to be related to FDM, however, the evidence was limited and/or results were mixed. Finally, the studies presented in this thesis and in previous studies demonstrate that cognitive functioning, as measured with standard neuropsychological measures, cannot fully explain FDM capability, since only small to moderate amounts of variance could be explained by cognition. Other factors must therefore play a role as well.

Financial decision-making capability and the influence of contextual factors

Several contextual factors were found to be related to specific FDM capability aspects. In the present thesis, the associations between aspects of FDM capability and age, sex, level of education, gross annual year income, personality traits, symptoms of depression and disease

characteristics related to PD and MS were evaluated (**chapters 3, 4 and 8**). The first study presented in this thesis (**chapter 3**) specifically focused on the relation between age and FDM in a non-clinical sample of individuals of 18 years or older without significant physical or mental health issues. With regard to financial competence (as measured with the Financial Competence Assessment Inventory and the Financial Decision-Making Interview), the capability to make financial decisions seems to be stable while aging normally. According to the scaffolding theory of aging and cognition (STAC; Park & Reuter-Lorenz, 2009; Reuter-Lorenz & Park, 2014), an increased (pre-)frontal activation when becoming older enables individuals to adapt and compensate for cognitive decline related to information processing typical for normal aging. Furthermore, increased (financial) knowledge and experience and improved affective decision-making may compensate for decreased cognitive functioning that accompanies normal aging (Hess, 2015; Li et al., 2004; Mikels et al., 2013; Peters et al., 2007). Some studies, evaluating a clinical sample of patients with MCI or PD, did report that a higher age was associated with lower performances on tests of financial competence (**chapter 4**). Age was, however, also found to be related to an increase in disease severity which possibly mediates the relation between financial competence and age in these clinical samples. Several other studies including patients with an NDD have not found a relation between FDM and age (**chapter 4**). When an activity had a high cognitive demand, as is suggested for making decisions based on specific decision rules, compensation and adaptation however seemed to be inadequate since this activity got more difficult when becoming older (**chapter 3**). On the other hand, age was found to have a positive influence on the tendency to buy on impulse (**chapters 3 and 8**). Regarding sex, evidence was found that females have a stronger tendency to buy on impulse and more often use a dependent financial decision style than males (**chapter 8**). Furthermore, lower performances on financial competence tests in female patients with AD were observed compared to male patients, however, results were mixed and the effect of sex was not evaluated in patients with other NDDs (**chapter 4**). The influence of sex on other aspects of FDM was not examined in this thesis and it is, therefore, not possible to draw clear and reliable conclusions on the influence of sex on FDM capability.

A higher level of education was found to be related to a better financial competence in a non-clinical sample (**chapter 3**) and in patients with MCI and AD (**chapter 4**). Also, FDM based on specific decision rules was found to be positively influenced by level of education. Level of education was, furthermore, negatively associated with the use of an intuitive decision style while making financial decisions. A positive association was found between level of education and the use of a rational financial decision style, although results were inconclusive and depending on the sample evaluated (**chapters 3 and 8**). Consistent with these findings is the observation that individuals with a higher gross annual year income, which is in general related to higher levels of education (Moonen et al., 2011), seemed to have a better financial competence and made less frequently use of an intuitive decision style compared to individuals with lower income levels (**chapters 3 and 8**). With regard to the relation between income level and other aspects of FDM, such as the tendency to buy on impulse or the ability to make financial decisions with implication for the future, no relation or inconclusive results were found in a non-clinical sample (**chapter 3**). The influence of income on FDM was however not

well studied in clinical samples, in both patients with NDDs as well as adults with ADHD, in order to draw reliable conclusions.

The systematic review as presented in **chapter 4** revealed that FDM capability was related to disease severity and motor symptoms in patients with MS and in patients with PD. Furthermore, a negative influence of symptoms of depression on FDM tests measuring financial competence was found in patients with MCI and patients with PD. Within the context of other NDDs this relation between symptoms of depression and FDM capability was not found or studied. The number/severity of depressive symptoms was also found to be positively related to the use of an intuitive financial decision style (**chapter 8**). Symptoms of depression were, however, not sufficiently examined in the other studies included in this thesis in order to draw reliable and generalized conclusions about the influence of symptoms of depression on FDM capability.

The last study presented in this thesis (**chapter 8**) evaluated the relations between specific personality traits and two aspects of FDM (i.e., the tendency to buy on impulse and the use of specific financial decision styles) in a community sample. Personality was found to play an important role, explaining up to 20% of variance of these aspects of FDM. Specifically traits of neuroticism and extraversion were found to be positively related to impulsive buying and two decision styles that are considered to be less adequate (i.e., avoidant and spontaneous financial decision styles), while traits of agreeableness and conscientiousness were found to be negatively related with these aspects of FDM. Prospective longitudinal research is, however, needed to further evaluate these relations since no direct causal conclusions can be drawn. This also applies to contextual factors such as severity of depression. Nevertheless, the potential negative as well as positive influence on FDM capability of these and other contextual factors, such as financial experience and social support, is important to keep in mind when evaluating the capability to make financial decisions of an individual.

Conclusion, limitations and future directions

In summary, according to the performances on performance-based FDM tests and questionnaires, patients with NDDs and adults with ADHD are more likely to have FDM capability problems than healthy individuals. The capability to make financial decisions is (at least partly) related to the severity of cognitive impairment in these patients. As a result, the FDM capability of healthy individuals and patients without or with relatively mild cognitive deficits appears to be unaffected or patients have (mild) problems in some, but not all, aspects of FDM. Patients with more severe cognitive problems perform worse compared to cognitively intact patients and healthy controls on all aspects of FDM capability. In both patients and healthy individuals, several contextual factors (e.g., age, level of education or personality) seem to play a role which are of influence on the FDM capability of individuals in a negative (or positive) way.

Since problems with FDM capability can have serious negative consequences in everyday life, a careful and thorough evaluation of this capability appears paramount. Currently in clinical settings, mostly self- or informant-reports and/or standard measures of cognition are used in order to evaluate everyday functioning, including FDM capability (Loewenstein &

Acevedo, 2010). Indirect evaluations, such as self- and informant reports, are, however, not or only weakly correlated with performances on direct measures of FDM of cognitively impaired patients and healthy individuals (Gerstenecker et al., 2019; Okonkwo et al., 2009; Sunderaraman et al., 2018, 2020; Wadley et al., 2003). Furthermore, FDM performance was overestimated by both patients and informants, although informants also frequently tended to underestimate the FDM capability of their relatives (Sunderaraman et al., 2018). The validity and reliability of decisions based on solely informant- and/or self-reports about the FDM capability of an individual should therefore be questioned. Furthermore, standard measures of cognition are not able to predict everyday functioning, including FDM, properly. Only small to moderate amounts of variance of aspects of FDM can be predicted with performances on standard measures of cognition (**chapters 3, 4 and 7**). It is, therefore, also not recommended to use standard measures of cognition in order to make decisions about an individual's capability to make financial decisions. For these reasons, the (additional) use of more objective FDM tests and questionnaires in clinical practice in order to evaluate FDM capability in patients with neurological and psychiatric conditions should be considered. Nevertheless, more insight in the relation between cognition and FDM capability can help determine in which patients undergoing neuropsychological assessment further evaluation of the capability to make financial decisions is needed. The use of other outcome measures/modalities, such as across-task inter-individual variability and network analyses, might enhance the predictive value of standard measures of cognition to evaluate the FDM capability of an individual.

A strong point of the current thesis is that a new FDM test battery was introduced and studied (**chapter 2**) in order to objectively and comprehensively evaluate FDM capability. In accordance with the theoretical framework of Appelbaum et al. (2016), the FDM test battery evaluates not only the financial competence of individuals, but also their financial performance and related contextual factors. The FDM test battery was found to be sensitive in different (clinical) samples and is able to distinguish strengths and weaknesses on several aspects of FDM in patients with NDDs, adults with ADHD and individuals who age normally from 18 years and older. Most FDM tests and questionnaires showed adequate reliability (**chapters 7 and 8**). Also, the divergent validity of the current FDM tests and questionnaires seemed to be sufficient. Weak to negligible correlations between the FDM tests and questionnaires indicate that different and unique aspects of FDM are evaluated with each test (**chapter 3**). Furthermore, in general only relatively weak correlations were found between the FDM tests and questionnaires and standard measures of cognition (**chapter 3**) suggesting that the FDM test battery captures abilities that cannot be assessed with standard (neuro)psychological measures.

The current FDM test battery is, however, not yet suitable for clinical use because of several reasons. First, no normative data is available yet for most FDM tests and questionnaires, which makes the comparison and interpretation of individual performances not possible. Second, with a total administration time of approximately 2 to 2.5 hours, the current FDM test battery is rather extensive. It is possible to select specific FDM tests and questionnaires in order to minimize the administration time. However, for (clinical) decisions about an individual's FDM capability it is important to investigate a broad spectrum of aspects related to FDM with the use of several tests and questionnaires. Therefore, the development of shorter versions of

several tests is recommended. Recently, researchers presented a shorter version of the FCAI including 20 out of 38 items with sufficient reliability in both brain injured patients and healthy controls (Sunderaraman et al., 2018, 2020). Other psychometric properties of this short 20-item version, however, still need to be examined (Sunderaraman et al., 2018).

A third reason, and perhaps the most important reason, for why our FDM test battery cannot yet be used in clinical practice is that the psychometric properties of these tests and questionnaires also need further investigation. The convergent validity of the FDM test battery could not be evaluated since no comparable FDM tests or questionnaires are available. Most FDM tests that were previously developed (see **chapter 4** or Engel et al. (2016) for an overview) are not easily accessible or not suitable for the populations of interest. Furthermore, despite the finding that most cognitive functions showed no or only relatively weak correlations with the FDM tests and questionnaires, some cognitive functions were moderately correlated to FDM tests and questionnaires and cognition was consistently found to play a role in FDM capability problems (**chapters 3, 4 and 7**). Further examination of the divergent validity of the FDM test battery is therefore required. Also, the criterion and ecological validity of the FDM test battery has not been evaluated yet. This makes it difficult to predict everyday life functioning based on the current FDM tests and questionnaires. The evaluation of the relation between FDM in everyday life, including the personal financial situation of an individual (e.g., financial problems such as debts and poverty), and the tests and questionnaires included in the FDM test battery, would provide more insight in the ecological validity of the FDM test battery. Furthermore, the comparison of financially competent and financially incompetent individuals, as determined by an independent lawyer and/or physician, can provide valuable information about the predictive value of the FDM tests and questionnaires (i.e., sensitivity and specificity of the FDM test battery). A major problem in this context, however, is that there is no golden standard for when a person can be considered financially competent or incompetent. In addition, research on medical decision-making found that clinicians are not well able to estimate a person's competency to make adequate and deliberate medical decisions (Sessums et al., 2011).

Nevertheless, the development of the current FDM test battery is an important step forward in the development of a test battery for clinical practice. The FDM test battery evaluates not only financial competence, but also the financial performance and contextual factors of an individual. With this, the FDM test battery is an important improvement in FDM research since it meets the recommendation to investigate FDM capability in a broad and extensive manner (Appelbaum et al., 2016; Engel et al., 2016). FDM capability is, however, a very broad and difficult to define concept. It is therefore conceivable that not all aspects of financial competence and financial performance are covered with the current FDM tests and questionnaires. Also, more research is needed with regard to the contextual factors related to FDM capability. All these limitations need to be taken into account when interpreting the results of present thesis. Nevertheless, our pioneering research adds valuable information to contemporary FDM research in patients with NDDs and ADHD and provides important suggestions for future research.

Can we afford it?

FDM capability is a sensitive topic and (clinical) decisions regarding the financial autonomy of an individual can have far-reaching consequences for an individual and his or her environment. In clinical practice, it is therefore crucial to make (clinical) decisions about an individual's FDM capability in a careful and ethical manner. For this, it is important to find a balance between the four ethical principles that are important to health care: autonomy, beneficence, justice and non-maleficence (Beauchamp & Childress, 2001). In (Dutch) clinical practice, however, little or no standardized and valid assessments are currently being conducted in order to evaluate the financial capability of an individual. *We cannot afford this*, because wrong clinical decisions can on the one hand have major (financial) consequences for an individual, their environment and society (e.g., when a financially incompetent individual is incorrectly classified as financially competent). On the other hand, wrong clinical decisions can also lead to a wrongful loss of autonomy of the patient (e.g., when a financially competent individual is incorrectly classified as financially incompetent). A careful and comprehensive evaluation of the capability to make financial decisions is therefore utmost important to be able to draw careful clinical decisions and to provide adequate protection and assistance (Appelbaum et al., 2016; Marson, 2016; Wood & Lichtenberg, 2016). In the context of FDM capability, it is important to evaluate several aspects of FDM in order to provide a broad picture of both the financial competence and financial performance of an individual. Furthermore, influential contextual factors should be taken into account in this evaluation. For this, it is important to aggregate different sources of information, including both indirect and direct evaluations, in order to make decisions about an individual's FDM capability (Appelbaum et al., 2016). The addition of performance-based tests and questionnaires can therefore add to this decision-making process. More research is, however, needed in order to make the current FDM test battery applicable for this purpose. Nevertheless, the studies presented in current thesis provides important steps forwards *to afford* the use of the FDM test battery in clinical practice over time.

To be continued...

PART

ADDENDA

V

REFERENCES

LIST OF TABLES AND FIGURES

SUMMARY

SAMENVATTING

CURRICULUM VITAE

LIST OF PUBLICATIONS

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Part I: General introduction

Financial decision-making (FDM) capability is the ability to manage or direct the management of one's finances. FDM capability can be determined by evaluating the financial competence of an individual (i.e., financial knowledge and judgmental abilities to make financial decisions). FDM capability is, however, also dependent on a person's financial performance in everyday life and on related contextual factors. In order to make (clinical) decisions about the FDM capability of an individual, the examination of both financial competence and financial performance is therefore required. For this, new FDM tests and questionnaires (**chapter 2**) have been developed which can be used to comprehensively assess different components of FDM capability (i.e., financial competence, financial performance and contextual factors). The aim of the current thesis is to systematically and comprehensively study the FDM capability of individuals with and without cognitive dysfunctions. The thesis focuses on the effects of normal aging on FDM capability and explores the FDM capability of individuals with neurodegenerative diseases (NDDs) and adults with attention-deficit/hyperactivity disorder (ADHD). Furthermore, the influence of several contextual factors, including cognition, on FDM are evaluated.

Part II: FDM capability in relation to normal and abnormal aging

As a result of age-related cognitive decline, older individuals are more vulnerable to experience problems with the deliberative processing of information and might therefore have more difficulties with some aspects of FDM compared to younger individuals. Nevertheless, the affective processing of information, which also relies on experience and learning, remains unaffected with normal aging and might result in similar or even better performances on some other aspects of FDM with advancing age. The study presented in **chapter 3** focuses on this topic and evaluates the effects of normal aging on FDM capability. By evaluating the performances of a large sample ($n = 180$, age range 18 - 87 years) on our FDM test battery and on several standard neuropsychological tests, it was found that a complex and cognitive demanding aspect of FDM (i.e., the ability to make financial decisions based on specific decision rules) was indeed negatively influenced by normal aging. Based on mediation analyses, numeracy and planning abilities were found to partly explain the effects of normal aging on this aspect of FDM. Furthermore, an advancing age was associated with a lower tendency to buy on impulse. Especially the affective component (and not the cognitive component) of impulsive buying was related to age. These results were confirmed by internal (i.e., bootstrap resampling analyses) as well as external validation (i.e., evaluation of a second, independent sample) analyses. The ability to make decisions with implications for the future and emotional decision-making or risk-taking were also found to be either positively and negatively related to age, respectively. However, the external consistency of these latter results could not be confirmed. On all other aspects of FDM assessed (i.e., financial competence, FDM capacity, the use of financial decision styles, and intuitive and deliberative FDM) no influence of age was found. Based on this study (**chapter 3**), it was concluded that normal aging influences some aspects of FDM capability (both positively and negatively), while other aspects appear to be unaffected by normal aging.

Patients with NDDs experience a degree of physical and/or cognitive impairment not associated with normal aging, which makes these patients even more vulnerable for problems with FDM. The study presented in **chapter 4** describes a systematic review and meta-analyses and focuses on the FDM capability of patients with NDDs in comparison to healthy controls. A comprehensive literature search was performed resulting in 47 studies meeting the inclusion criteria. Only studies using a performance-based test to evaluate FDM capability were included. Most studies evaluated the financial competence and did not assess the financial performance or contextual factors of patients. The included studies focused on patients with Alzheimer's disease ($k = 25$), mild cognitive impairment ($k = 26$), frontotemporal dementia ($k = 3$), Parkinson's disease ($k = 7$), multiple sclerosis ($k = 3$), and/or Huntington's disease ($k = 1$) and consistently reported lower performances on FDM measures in patients compared to healthy controls. This is confirmed by the medium to large pooled mean effect sizes found for each patient group in the meta-analyses (no meta-analysis could be performed for patients with Huntington's disease). Furthermore, the severity of cognitive decline seems to be related to the degree of problems with FDM. This is confirmed by the significant relation found between global cognition measures and performances on tests of FDM in different NDD patient groups. Furthermore, especially numeracy, working memory and processing speed were found to be relevant for an adequate FDM in patients with NDDs. Relatively simple or basic aspects of financial competence (e.g., 'basic monetary skills'), however, seemed to be less vulnerable to mild cognitive decline than other aspects of FDM. Some studies found significant influences of contextual factors (i.e., age, years of education, symptoms of depression or disease characteristics such as motor disturbances) on the FDM capability of patients with NDDs. However, results are mixed and more research is suggested. Nevertheless, based on the included studies, there is ample evidence that patients with NDDs are vulnerable for impairments in their capability to make financial decisions. In the discussion of **chapter 4** a critical evaluation of the nineteen performance-based tests that were used was included. Contextual factors and financial performances were both insufficiently assessed in the included studies. Furthermore, the ecological validity of the FDM tests was unknown and it is therefore unclear whether performances on these tests can be translated to strengths and weaknesses within the context of financial management in everyday life.

The study presented in **chapter 5** continues the evaluation of FDM capability in patients with NDDs. In this chapter, preliminary results are presented of the performances of nine patients with Alzheimer's disease, mild cognitive impairment or Parkinson's disease (three patients in each group) on our new FDM test battery. Performances of each patient were compared to an individualized healthy control group, matched based on age, sex and level of education. Lower performances were found for all patients on measures of financial competence (i.e., financial knowledge and financial judgment) compared to matched control groups. Lower performances on the other FDM tests, in particular tests focusing on financial performance and contextual factors, were less consistently present in these patients compared to the matched control groups. The overall performance of patients with Parkinson's disease seemed to be better than the performances of patients with Alzheimer's disease and mild cognitive impairment, however,

no clear performance profiles for the different NDDs could be identified based on current results. Finally, contextual factors and the financial performances in everyday life have been studied only to a limited extent. Therefore, caution is called for when using the FDM test battery on individual patients and drawing conclusions about their capability to make financial decisions. Nevertheless, the test battery has been shown to be sensitive to evaluate strengths and weaknesses of FDM capability in patients with NDDs.

Part III: FDM capability in adults with ADHD

Previous research reported money management problems in adults with ADHD based on indirect assessment of FDM capability. However, no study was performed using direct assessment (i.e., performance-based tests) to evaluate the FDM capability of adults with ADHD. Furthermore, problems with decision-making are frequently described in children with ADHD, but are less clearly objectified in adults with ADHD. The systematic review presented in **chapter 6**, therefore, aims to provide a comprehensive and objective overview of the decision-making capabilities (including FDM capability) of adults with ADHD in order to evaluate the nature and extent of problems with decision making in this patient group. For this, only studies using performance-based tests of decision making were included. In total, 31 studies met the inclusion criteria and focused on either risky decision-making ($k = 20$), deliberative/analytic decision-making ($k = 2$), delay discounting ($k = 9$), reward-related decision-making ($k = 3$), social decision-making ($k = 1$), decision making related to driving ($k = 1$) or decision making related to financial decisions ($k = 1$). In a small majority of studies (i.e., 55%), adults with ADHD showed lower performances on decision-making tests compared to healthy controls, providing careful evidence that adults with ADHD have more problems with several domains of decision-making compared to healthy controls. Nevertheless, for all decision-making domains assessed in the studies, the results were mixed. Differences between studies might be the result of covariates that are of influence on the decision-making capability of adults with ADHD, such as comorbidities, use of stimulant medication or boredom during testing. Furthermore, most domains (i.e., all except risky decision-making) were widely underrepresented in the currently available research. The systematic review as presented in **chapter 6** concludes with the evaluation of the potential underlying mechanism of decision-making problems in adults with ADHD, in particular the evaluation of the dual-pathway model of ADHD as basis of decision-making problems. Based on the included studies, it is conceivable that this model can be (partly) explanatory for the lower performances of adults with ADHD found in the field of decision-making.

The studies presented in **chapter 7 and 8** continue the evaluation of decision-making problems in adults with ADHD, but focus explicitly on FDM capability. For this, (parts of) the new FDM test battery was used.

In **chapter 7**, a study is presented that included 45 clinically diagnosed adults with ADHD (age range 19 – 61 year; 57.8% male). All were assessed with several (neuro)psychological tests, including FDM tests and questionnaires from the FDM test battery and the Cognitive Functions

ADHD test battery. In comparison to a healthy control group ($n = 51$; age range 20 – 64 year; 51.0% male), adults with ADHD showed significantly lower performances on the two tests of financial competence (measuring financial knowledge and financial judgment). A mediation effect of numeracy was found for this relation (indirect effect), however, group differences on these tests remained statistically significant after controlling for numeracy (direct effect). Adults with ADHD had also more difficulties with decision making with implications for the future, showed a stronger tendency to buy on impulse and made more often use of two inadequate financial decision styles (i.e., the avoidant and spontaneous decision style) compared to healthy controls. Numeracy and other cognitive domains assessed (e.g., processing speed, working memory or inhibition) could not explain the group differences that were found for these aspects of FDM. Compared to the mean scores and standard deviations of the healthy control sample, one out of three adults with ADHD (i.e., 34.2%) showed a normal performance on all measures of FDM. However, 26.7% adults with ADHD showed a very low/impaired performance and an additional 28.9% showed a low performance on one or more FDM tests. This is twice as often as in healthy controls (i.e., 19.6% and 7.8% of the healthy controls showed a very low/impaired or low performance, respectively, on one or more FDM tests). Furthermore, adults with ADHD reported to have a significantly poorer financial situation than healthy controls, including having less income, more often debts and less often using a savings account. Patients were off-medication 48 hours prior to participation; therefore, it is unclear if there were any effects of the use of stimulant medication on the FDM performances of patients. Furthermore, the onset of medication use and other ADHD treatments were not taken into account. Both can have an influence on the abilities of individuals with ADHD to develop adequate FDM capability skills. Nevertheless, taking several limitations into account, it can be concluded that adults with ADHD have difficulties with several aspects of FDM. These difficulties may at least partly explain the poorer financial situation of adults with ADHD.

The study presented in **chapter 8** further evaluates the effect of symptoms of ADHD on two aspects of FDM (i.e., the tendency to buy on impulse and the use of financial decision styles). Additionally, the influence of personality, symptoms of depression and demographics on the association between symptoms of ADHD and these aspects of FDM is evaluated. For this, a community sample of 1292 participants (age range 18–93 years) completed online questionnaires evaluating symptoms of ADHD, impulsive buying, financial decision styles, personal financial situation, symptoms of depression and personality traits. Consistent with previous results (**chapter 7**), individuals meeting the clinical criteria of adult ADHD based on a self-report ADHD questionnaire (i.e., ADHD group, $n = 45$) reported a stronger tendency to buy on impulse and more often used an avoidant or spontaneous financial decision style compared to individuals without symptoms of ADHD (i.e., No ADHD group, $n = 265$). However, using hierarchical multiple regression analyses, current symptoms of ADHD were found not to be related to impulsive buying and financial decision styles. Instead, traits of neuroticism and/or extraversion were positively related to these aspects of FDM. Traits of conscientiousness and agreeableness were also found to be related to the use of some decision styles (i.e., rational, avoidant and spontaneous decision style) and with more impulsive buying

(except with the affective component of impulsive buying). More (or more severe) symptoms of depression were related to the use of an intuitive decision style. Furthermore, an older age was found to be positively related to the use of an avoidant decision style when making financial decisions. Being female and a younger age were found to be negatively related to impulsive buying. With regard to the personal financial situation, the ADHD group less often saved for their retirement compared to the No ADHD group. In contrast to previous research, no group differences were found on all other aspects of the personal financial situation of participants, including income, debts and the use of a savings account. The use of a community sample also enabled the evaluation of two other ADHD groups: An Adult-only ADHD group ($n = 57$) meeting the self-reported symptom criteria of adult ADHD but not for childhood ADHD and a Subthreshold ADHD group ($n = 162$) reporting a subthreshold number of current symptoms of ADHD (i.e., 3 or 4 symptoms of either inattention or hyperactivity/impulsivity). No differences were found between the Subthreshold ADHD group and the No ADHD group with regard to impulsive buying and the use of financial decision styles. However, the Adult-only ADHD group reported a stronger tendency to buy on impulse on both the cognitive and affective component of impulsive buying and used more often an avoidant decision style when making financial decisions compared to the No ADHD group. Despite several described limitations, the results of this study indicate more impulsive buying and a more frequent use of disadvantageous financial decisions styles (i.e., avoidant and spontaneous styles) in individuals fulfilling self-reported current ADHD criteria (i.e., adults with ADHD and adults with adult-only or late-onset ADHD) compared to individuals without symptoms of ADHD. Contextual factors, i.e., personality and demographic variables, might (at least partly) be of influence on the association between impulsive buying, the use of financial decision styles and ADHD. However, no direct causal conclusions can be drawn and prospective longitudinal research is suggested to further investigate causality between these variables.

Part IV: Discussion

This thesis concludes with a critical discussion of the presented studies and a general conclusion (**chapter 9**). In summary, evidence has been found that patients with NDDs and adults with ADHD are more likely to show FDM capability problems than healthy individuals. The severity of cognitive impairment seems to be related to the degree of problems with FDM capability in these patients. Numeracy was most consistently found as significant predictor of aspects of FDM capability in healthy controls, patients with NDDs as well as in adults with ADHD. Furthermore, evidence has been found that processing speed, working memory and verbal memory are positively related to the ability to make (adequate) financial decisions. For other cognitive functions, results were inconclusive. Besides cognitive impairment, several contextual factors, such as age, level of education or personality, seem to play a role and relate to aspects of the FDM capability of an individual in a negative (or positive) way.

To make (clinical) decisions about the autonomy of an individual to make his or her own financial decisions, a careful and comprehensive examination is required which respects the ethical principles autonomy, beneficence, justice and non-maleficence. For this purpose, it is suggested to aggregate different sources of information, including both indirect and direct

evaluation, when making decisions about an individual's FDM capability. It is, furthermore, important to examine the financial competence, financial performance and influential contextual factors. Therefore, in the current thesis, a new FDM test battery has been introduced that evaluates not only the financial competence of an individual, but also their financial performance and related contextual factors. The FDM test battery showed adequate divergent validity and reliability and was found to be able to identify strengths and weaknesses regarding different aspects of FDM in both patients and healthy controls. The FDM test battery as proposed in this thesis is, however, not yet suitable for use in clinical practice, because of (1) the absence of normative data, (2) the extensiveness and duration of the test battery and (3) the fact that the psychometric properties of the FDM tests and questionnaires need further investigation. Therefore, more research is needed in order to increase the predictive value of the FDM tests and questionnaires which enables reliable, valid and ethical decisions about an individual's FDM capability and the use of the FDM test battery in clinical practice. Nevertheless, our research adds valuable information to contemporary FDM research. *To be continued...*

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Deel I: Algemene inleiding

Financiële besluitvormingsbekwaamheid (*financial decision-making capability; FDM-bekwaamheid*) beschrijft het vermogen om eigen financiën te beheren of te managen. Of iemand bekwaam is om financiële beslissingen te nemen kan worden beoordeeld door de financiële competentie van een individu te evalueren (namelijk de financiële kennis en het financieel beoordelingsvermogen om financiële beslissingen te nemen). FDM-bekwaamheid is echter ook afhankelijk van iemands financiële prestaties in het dagelijks leven en van gerelateerde contextuele factoren. Om (klinische) beslissingen te kunnen nemen over iemands FDM-bekwaamheid is daarom onderzoek naar zowel de financiële competentie als financiële prestaties vereist. Hiervoor zijn nieuwe FDM tests en vragenlijsten ontwikkeld (**hoofdstuk 2**) die kunnen worden gebruikt voor een uitgebreide beoordeling van verschillende componenten van de FDM-bekwaamheid (namelijk financiële competentie, financiële prestaties en contextuele factoren). Het doel van dit proefschrift is om systematisch en uitvoerig de FDM-bekwaamheid van personen met en zonder cognitieve stoornissen te onderzoeken. Het proefschrift richt zich op de effecten van normale veroudering op FDM-bekwaamheid en onderzoekt de FDM-bekwaamheid van personen met een neurodegeneratieve aandoening (*neurodegenerative diseases; NDDs*) en volwassenen met een aandachtstekortstoornis met hyperactiviteit (*attention-deficit/hyperactivity disorder; ADHD*). Verder wordt de invloed van verschillende contextuele factoren, waaronder cognitie, op FDM geëvalueerd.

Deel II: FDM-bekwaamheid in relatie tot normale en abnormale veroudering

Als gevolg van leeftijd-gerelateerde cognitieve achteruitgang zijn ouderen kwetsbaarder voor problemen met de weloverwogen verwerking van informatie dan jongere personen. Hierdoor hebben ouderen mogelijk meer moeite met sommige aspecten van FDM in vergelijking met jongere personen. Anderzijds blijft de affectieve verwerking van informatie, die ook berust op ervaring en leren, onaangetast bij normale veroudering, hetgeen kan resulteren in vergelijkbare of zelfs nog betere prestaties op sommige andere aspecten van FDM wanneer men ouder wordt. De studie gepresenteerd in **hoofdstuk 3** richt zich op dit onderwerp en evalueert de effecten van normale veroudering op de FDM-bekwaamheid. Door van een grote steekproef ($n = 180$, leeftijdsrange 18-87 jaar) de prestaties te evalueren op onze FDM-testbatterij en op verschillende standaard neuropsychologische tests, werd vastgesteld dat een complex en cognitief veeleisend aspect van FDM (namelijk het vermogen om financiële beslissingen te nemen op basis van specifieke beslissingsregels) inderdaad negatief werd beïnvloed door normale veroudering. Op basis van mediatie-analyses bleken rekenvaardigheid en planningsvaardigheid de effecten van normale veroudering op dit FDM-aspect gedeeltelijk te verklaren. Verder blijkt een hogere leeftijd samen te hangen met een lagere neiging om impulsieve aankopen te doen. Vooral de affectieve component (en niet de cognitieve component) van impulsief koopgedrag was gerelateerd aan leeftijd. Deze resultaten werden bevestigd door interne validatie analyses (middels *bootstrap-resampling-analyses*) en externe validatie analyses (middels evaluatie van een tweede, onafhankelijke steekproef). Het vermogen om financiële beslissingen te nemen met implicaties voor de toekomst en affectieve besluitvorming/het nemen van risico's bleken ook respectievelijk positief en negatief

gerelateerd aan leeftijd. De externe consistentie van deze laatste resultaten kon echter niet worden bevestigd. Voor alle andere beoordeelde aspecten van FDM (namelijk financiële competentie, FDM-capaciteit, het gebruik van financiële beslissingsstijlen en intuïtieve en weloverwogen FDM) werd geen invloed van leeftijd gevonden. Op basis van deze studie (**hoofdstuk 3**) werd geconcludeerd dat normale veroudering sommige aspecten van FDM-bekwaamheid beïnvloedt (zowel positief als negatief), terwijl andere aspecten van FDM niet beïnvloed lijken te worden door normale veroudering.

Patiënten met NDDs ervaren een mate van lichamelijke en/of cognitieve achteruitgang die niet samenhangt met normale veroudering, waardoor deze patiënten nog kwetsbaarder zijn voor problemen met FDM. De studie gepresenteerd in **hoofdstuk 4** beschrijft een systematische review en meta-analyses en richt zich op de FDM-bekwaamheid van patiënten met NDDs in vergelijking met gezonde controles. Een uitgebreid literatuuronderzoek werd uitgevoerd, resulterend in 47 onderzoeken die voldeden aan de inclusiecriteria. Alleen studies die prestatietaken hadden gebruikt om FDM-bekwaamheid te evalueren werden geïnccludeerd. De meeste studies evalueerden de financiële competentie en beoordeelden niet de financiële prestaties of contextuele factoren van patiënten. De geïnccludeerde studies evalueerden patiënten met de ziekte van Alzheimer ($k = 25$), milde cognitieve beperkingen ($k = 26$), frontotemporale dementie ($k = 3$), de ziekte van Parkinson ($k = 7$), multiple sclerose ($k = 3$) en/of de ziekte van Huntington ($k = 1$) en rapporteerden consistent lagere prestaties op FDM maten door patiënten in vergelijking met gezonde controles. Dit wordt bevestigd door de medium tot grote gepoolde gemiddelde effect groottes gevonden in de uitgevoerde meta-analyses voor alle patiëntengroepen (voor patiënten met de ziekte van Huntington kon geen meta-analyse worden uitgevoerd). Bovendien lijkt de ernst van cognitieve achteruitgang verband te houden met de mate van problemen met FDM. Dit wordt bevestigd door de significante relatie die is gevonden tussen de prestaties op globale cognitiematen en prestaties op FDM-tests in verschillende NDD-patiëntengroepen. Daarbij bleken vooral rekenvaardigheid, werkgeheugen en verwerkingssnelheid relevant te zijn voor een adequate FDM bij patiënten met NDDs. Relatief eenvoudige of basale aspecten van financiële competentie (bijv. 'monetaire basisvaardigheden') lijken minder kwetsbaar voor milde cognitieve achteruitgang dan andere aspecten van FDM. Sommige studies vonden significante invloeden van contextuele factoren (namelijk leeftijd, opleidingsjaren, symptomen van depressie of ziektekenmerken zoals motorische stoornissen) op de FDM-bekwaamheid van patiënten met NDDs. De resultaten zijn echter inconsistent en er meer onderzoek is geadviseerd. Desalniettemin is er op basis van de opgenomen studies voldoende bewijs dat patiënten met NDDs kwetsbaar zijn voor beperkingen in hun bekwaamheid om financiële beslissingen te nemen. In de discussie van **hoofdstuk 4** is een kritische evaluatie van de negentien prestatietaken die zijn gebruikt in de studies opgenomen. Contextuele factoren en financiële prestaties werden beide onvoldoende geëvalueerd in de geïnccludeerde studies. Bovendien was de ecologische validiteit van de FDM-tests onbekend en is het daarom onduidelijk of prestaties op deze tests kunnen worden vertaald naar sterke en zwakke punten binnen de context van FDM in het dagelijks leven.

De studie gepresenteerd in **hoofdstuk 5** zet de evaluatie van de FDM-bekwaamheid van patiënten met NDDs voort. In dit hoofdstuk worden voorlopige resultaten gepresenteerd van prestaties op onze nieuwe FDM-testbatterij van negen patiënten met de ziekte van Alzheimer, milde cognitieve beperkingen of de ziekte van Parkinson (drie patiënten in elke groep). De prestaties van elke patiënt werden vergeleken met een geïndividualiseerde gezonde controlegroep, gematcht op leeftijd, geslacht en opleidingsniveau. Lagere prestaties werden voor alle patiënten gevonden op het gebied van financiële competentie (namelijk financiële kennis en financieel beoordelingsvermogen) in vergelijking met de gematchte controlegroepen. Lagere prestaties op de andere FDM tests en vragenlijsten, in het bijzonder tests en vragenlijsten gericht op financiële prestaties en contextuele factoren, waren minder consistent aanwezig bij de patiënten in vergelijking met de gematchte controlegroepen. De algehele prestaties van patiënten met de ziekte van Parkinson leken beter te zijn dan die van patiënten met de ziekte van Alzheimer en milde cognitieve beperkingen, maar op basis van de huidige resultaten konden geen duidelijke prestatieprofielen voor de verschillende NDDs worden vastgesteld. Tevens zijn de contextuele factoren en de financiële prestaties in het dagelijks leven slechts in beperkte mate onderzocht. Daarom is voorzichtigheid geboden bij het gebruik van de FDM-testbatterij bij individuele patiënten en bij het trekken van conclusies over hun bekwaamheid om financiële beslissingen te nemen. Desalniettemin is aangetoond dat de testbatterij gevoelig is voor het evalueren van sterke en zwakke punten van FDM-bekwaamheid bij patiënten met NDDs.

Deel III: FDM-bekwaamheid bij volwassenen met ADHD

Eerdere studies rapporteren, op basis van een indirecte beoordeling van FDM, problemen met financiën en financieel beheer bij volwassenen met ADHD. Geen enkel onderzoek heeft echter FDM-bekwaamheid onderzocht met behulp van directe beoordelingen (middels prestatietaken) bij volwassenen met ADHD. Bovendien worden problemen met de besluitvorming frequent beschreven bij kinderen met ADHD, maar deze problematiek is minder duidelijk geobjectiveerd bij volwassenen met ADHD. De systematische review die in **hoofdstuk 6** is gepresenteerd is daarom bedoeld om een uitgebreid en objectief overzicht te geven van de besluitvormingsbekwaamheid (inclusief FDM-bekwaamheid) bij volwassenen met ADHD om zodoende de aard en omvang van problemen met het besluitvormingsproces bij deze patiëntengroep te evalueren. Hiervoor zijn alleen onderzoeken opgenomen die gebruik maken van prestatietaken gericht op het nemen van beslissingen. In totaal voldeden 31 onderzoeken aan de inclusiecriteria. Deze studies waren gericht op risicovolle besluitvorming ($k = 20$), bewuste/analytische besluitvorming ($k = 2$), *delay discounting* ($k = 9$), beloningsgerelateerde besluitvorming ($k = 3$), sociale besluitvorming ($k = 1$), besluitvorming met betrekking tot autorijden ($k = 1$) of besluitvorming met betrekking tot financiën ($k = 1$). In een kleine meerderheid van de onderzoeken (namelijk 55%) vertoonden volwassen met ADHD lagere prestaties op beslissingstaken in vergelijking met gezonde controles, wat voorzichtig bewijst dat volwassenen met ADHD meer problemen hebben met verschillende domeinen van besluitvorming in vergelijking met gezonde controles. Desalniettemin waren de resultaten met betrekking tot alle besluitvormingsdomeinen die in de studies werden beoordeeld inconsistent.

Verschillen tussen de studies kunnen het gevolg zijn van covariabelen die van invloed zijn op de besluitvormingsbekwaamheid van volwassenen met ADHD, zoals comorbiditeit, gebruik van stimulantia of verveling tijdens het onderzoek. Bovendien waren de meeste domeinen (namelijk alle domeinen behalve risicovolle besluitvorming) sterk ondervertegenwoordigd in de huidige beschikbare literatuur. De systematische review zoals gepresenteerd in **hoofdstuk 6** wordt afgesloten met de evaluatie van een mogelijk onderliggend mechanisme voor problemen op het gebied van besluitvorming bij volwassenen met ADHD, namelijk de evaluatie van het *dual-pathway model of ADHD* als basis voor besluitvormingsproblemen. Op basis van de geïnccludeerde studies is het denkbaar dat dit model (deels) verklarend kan zijn voor de lagere prestaties van volwassenen op gebied van besluitvorming.

De onderzoeken die in **hoofdstuk 7 en 8** zijn gepresenteerd zetten de evaluatie van besluitvormingsproblemen bij volwassenen met ADHD voort, maar richten zich expliciet op FDM-bekwaamheid. Hiervoor is (delen van) de nieuwe FDM-testbatterij gebruikt.

In **hoofdstuk 7** wordt een studie gepresenteerd met 45 klinisch gediagnosticeerde volwassenen met ADHD (leeftijd range 19-61 jaar; 57,8% man). Allen werden beoordeeld met verschillende (neuro)psychologische tests, waaronder tests en vragenlijsten uit de FDM-testbatterij en de *Cognitive Functions ADHD* testbatterij. In vergelijking met een gezonde controlegroep (n = 51; leeftijd range 20-64 jaar; 51% man), lieten volwassenen met ADHD significant lagere prestaties zien op twee financiële competentie tests (gericht op financiële kennis en financiële beoordelingsvermogen). Voor deze relatie werd een mediatie effect van rekenvaardigheid gevonden (indirect effect), maar groepsverschillen op deze tests bleven statistisch significant na correctie voor rekenvaardigheid (direct effect). Volwassenen met ADHD hadden ook meer moeite met het nemen van financiële beslissingen met implicaties voor de toekomst, vertoonden een sterkere neiging tot impulsief koopgedrag en maakten vaker gebruik van twee inadequate financiële beslissingsstijlen (namelijk een vermijdende en spontane beslissingsstijl) in vergelijking met gezonde controles. Rekenvaardigheid en andere onderzochte cognitieve domeinen (bijv. verwerkingssnelheid, werkgeheugen of inhibitie) konden de groepsverschillen die werden gevonden voor deze FDM-aspecten niet verklaren. Vergeleken met de gemiddelde prestaties en standaarddeviaties van de gezonde controle sample, vertoonde één op de drie volwassenen met ADHD (namelijk 34,2%) een normale prestatie op alle FDM-taken. Echter, 26,7% van de volwassenen met ADHD vertoonden een zeer lage of verminderde prestatie en nog eens 28,9% vertoonde een lage prestatie op één of meer FDM-taken. Dit is twee keer zo vaak als bij de gezonde controles (namelijk 19,6% en 7,8% van de gezonde controles vertoonden respectievelijk zeer lage/verminderde of lage prestaties op één of meer FDM-taken). Bovendien gaven volwassenen met ADHD aan een significant slechtere financiële situatie te hebben dan gezonde controles, waaronder het hebben van minder inkomen, het vaker hebben van schulden en minder vaak gebruik maken van een spaarrekening. Patiënten hadden 48 uur voorafgaand aan deelname geen medicatie gebruikt; daarom is het onduidelijk of er effecten zijn van het gebruik van stimulantia op de FDM-prestaties van patiënten met ADHD. Verder werd geen rekening gehouden met de start van het medicatiegebruik en andere ADHD-

behandelingen. Beiden kunnen van invloed zijn op het vermogen van patiënten met ADHD om adequate vaardigheden op gebied van FDM te ontwikkelen. Desalniettemin kan, rekening houdend met verschillende beperkingen, worden geconcludeerd dat volwassenen met ADHD problemen hebben met verschillende aspecten van FDM. Deze moeilijkheden kunnen mogelijk, op z'n minst gedeeltelijk, de slechtere financiële situatie van volwassenen met ADHD verklaren.

De studie gepresenteerd in **hoofdstuk 8** onderzocht de effecten van symptomen van ADHD op twee aspecten van FDM verder (namelijk de neiging tot impulsief koopgedrag en het gebruik van financiële beslissingsstijlen). Daarnaast is de invloed van persoonlijkheid, depressieve symptomen en demografische gegevens op de associatie tussen ADHD-symptomen en deze aspecten van FDM onderzocht. Hiervoor vulde een sample van 1292 deelnemers (leeftijd range 18-93 jaar) online vragenlijsten in om symptomen van ADHD, impulsief koopgedrag, financiële beslissingsstijlen, persoonlijke financiële situatie, depressieve symptomen en persoonlijkheidskenmerken te evalueren. In overeenstemming met eerdere resultaten (**hoofdstuk 7**), meldden personen die op basis van een zelfrapportage vragenlijst voldeden aan de klinische criteria voor ADHD bij volwassenen, *ADHD*-groep ($n = 45$), een sterkere neiging tot impulsief koopgedrag en vaker het gebruik van een ontwijkende of spontane financiële beslissingsstijl in vergelijking met personen zonder symptomen van ADHD (de *No ADHD*-groep, $n = 265$). Met behulp van hiërarchische meervoudige regressieanalyses bleken huidige symptomen van ADHD echter niet gerelateerd te zijn aan impulsief koopgedrag en financiële beslissingsstijlen. In plaats daarvan waren kenmerken van neuroticisme en/of extraversie positief gerelateerd aan deze aspecten van FDM. Eigenschappen van consciëntieusheid en vriendelijkheid bleken ook gerelateerd aan het gebruik van sommige beslissingsstijlen (namelijk rationele, vermijdende en spontane financiële beslissingsstijlen) en met meer impulsief koopgedrag (behalve met de affectieve component van impulsief koopgedrag). Meer (of ernstigere) depressieve symptomen waren gerelateerd aan het gebruik van een intuïtieve beslissingsstijl. Bovendien bleek een hogere leeftijd positief samen te hangen met het gebruik van een vermijdende financiële beslissingsstijlen. Vrouw zijn en een jongere leeftijd bleken negatief gerelateerd te zijn aan impulsief koopgedrag. Wat betreft de persoonlijke financiële situatie: de *ADHD*-groep spaarde minder vaak voor hun pensioen dan de *No ADHD*-groep. In tegenstelling tot eerder onderzoek zijn er geen groepsverschillen gevonden op alle andere aspecten van de persoonlijke financiële situatie van deelnemers, waaronder inkomen, schulden en het gebruik van een spaarrekening. Het gebruik van een gemeenschapssample maakte ook de evaluatie van twee andere ADHD-groepen mogelijk: een *Adult-only ADHD*-groep ($n = 57$), die voldeden aan de zelf-gerapporteerde criteria voor ADHD bij volwassenen, maar niet aan de criteria voor ADHD bij kinderen, en een *Subthreshold ADHD*-groep ($n = 162$), die op een subdrempel niveau aan aantal huidige symptomen van ADHD rapporteren (namelijk 3 of 4 symptomen van onoplettendheid of hyperactiviteit/impulsiviteit). Er werden geen verschillen gevonden tussen de *Subthreshold ADHD*-groep en de *No ADHD*-groep met betrekking tot impulsief koopgedrag en het gebruik van financiële beslissingsstijlen. De *Adult-only ADHD*-groep rapporteerde echter een sterkere neiging tot het doen van impulsieve aankopen op zowel

de cognitieve als de affectieve component van impulsief koopgedrag en gebruikten vaker een vermijdende beslissingsstijl bij het nemen van financiële beslissingen in vergelijking met de groep zonder ADHD-symptomen. Ondanks verschillende beschreven beperkingen, wijzen de resultaten van dit onderzoek op meer impulsief koopgedrag en een frequenter gebruik van inadequate financiële beslissingsstijlen (namelijk vermijdende en spontane beslissingsstijlen) bij personen die voldoen aan zelf-gerapporteerde huidige ADHD-criteria (namelijk volwassenen met ADHD en volwassenen met *adult-only* of *late-onset* ADHD) in vergelijking met personen zonder symptomen van ADHD. Contextuele factoren, namelijk persoonlijkheid en demografische variabelen, kunnen (in ieder geval gedeeltelijk) van invloed zijn op de associatie tussen impulsief koopgedrag, het gebruik van financiële beslissingsstijlen en ADHD. Er kunnen echter geen directe causale conclusies worden getrokken en prospectief longitudinaal onderzoek wordt voorgesteld om de causaliteit tussen deze variabelen verder te onderzoeken.

Deel IV: Discussie

Dit proefschrift wordt afgesloten met een kritische bespreking van de gepresenteerde studies en een algemene conclusie (**hoofdstuk 9**). Samenvattend is er bewijs gevonden dat patiënten met NDDs en volwassenen met ADHD meer kans hebben op problemen met FDM-bekwaamheid dan gezonde personen. De ernst van cognitieve stoornissen lijkt verband te houden met de mate van problemen met FDM-bekwaamheid bij deze patiënten. Rekenvaardigheid werd het meest consistent gevonden als een significante voorspeller van aspecten van FDM-bekwaamheid bij gezonde controles, patiënten met NDDs en volwassenen met ADHD. Verder is er bewijs gevonden dat verwerkingssnelheid, werkgeheugen en verbaal geheugen positief gerelateerd zijn aan het vermogen om (adequate) financiële beslissingen te nemen. Voor andere cognitieve functies waren de resultaten niet doorslaggevend. Naast cognitieve stoornissen lijken verschillende contextuele factoren, zoals leeftijd, opleidingsniveau en persoonlijkheid, een rol te spelen en op een negatieve (of positieve) manier verband te houden met aspecten van de FDM-bekwaamheid van een individu.

Om (klinische) beslissingen te nemen over de autonomie van een individu om zijn of haar eigen financiële beslissingen te nemen, is zorgvuldig en uitgebreid onderzoek vereist dat de ethische principes respecteert (namelijk *autonomy*, *beneficence*, *justice* en *non-maleficence*). Voor dit doel wordt voorgesteld om verschillende informatiebronnen samen te voegen, inclusief zowel indirecte als directe evaluatie, bij het nemen van beslissingen over de FDM-bekwaamheid van een persoon. Het is tevens belangrijk om de financiële competentie, financiële prestaties en invloedrijke contextuele factoren te onderzoeken. Daarom is in dit proefschrift een nieuwe FDM-testbatterij geïntroduceerd die niet alleen de financiële competentie van een individu evalueert, maar ook hun financiële prestaties en gerelateerde contextuele factoren. De FDM-testbatterij heeft voldoende divergente validiteit en betrouwbaarheid en bleek in staat om sterke en zwakke punten van verschillende aspecten van FDM bij zowel patiënten als gezonde controles te kunnen onderscheiden. De FDM-testbatterij zoals voorgesteld in dit proefschrift is echter nog niet geschikt voor gebruik in de klinische praktijk, vanwege (1) het ontbreken van normatieve gegevens, (2) de omvang en duur van de testbatterij en (3) het feit dat de psychometrische eigenschappen van de FDM tests en

vragenlijsten nader onderzocht moeten worden. Er is meer onderzoek nodig om de voorspellende waarde van de FDM tests en vragenlijsten te verhogen, waardoor betrouwbare, valide en ethische verantwoorde beslissingen kunnen worden genomen over de FDM-bekwaamheid van een individu en het gebruik van de FDM-testbatterij in de klinische praktijk. Desalniettemin voegt ons onderzoek waardevolle informatie toe aan hedendaags FDM-onderzoek. *Wordt vervolgd...*

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Dorien Frederike Bangma was born on June 2, 1989, in Hengelo, the Netherlands. In 2007, she completed her secondary education at Twickel college in Hengelo. In the same year, she started with the propaedeutically year of Life Science and Technology at the Faculty of Mathematics and Natural Sciences (currently Science and Engineering) at the University of Groningen. In 2008, she started studying Psychology at the Faculty of Behavioural and Social Sciences at the same university. She obtained her Bachelor's degree in Psychology in 2012 and her Master's degree in Clinical Neuropsychology in 2013. After her graduation she worked a few months as a research assistant under supervision of dr. Janneke Koerts. From 2013 till 2020 she worked at the department of Clinical and Developmental Neuropsychology at the University of Groningen. In this period, she performed scientific research on financial decision-making as an external PhD student under supervision of prof. dr. Oliver Tucha, dr. Janneke Koerts and dr. Lara Tucha. She conducted this research in her own time, next to her work as a teacher at the same department. She taught and supervised students of both the bachelor Psychology and master track Clinical Neuropsychology from 2013 till 2019. Additionally, between 2016 and 2018, she worked as a researcher for two independent subsidised studies. She was able to present her research at several national and international conferences and has received a travel grant and an award for the best poster (see also list of publications). In 2020, Dorien started as a researcher and teacher at the faculty of Social and Behavioural Sciences at the University of Amsterdam.

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Presentations on conferences, symposia and research meetings

6th World Congress on ADHD (Canada, 2017)

11th International Congress on Non-Motor Dysfunctions in Parkinson's Disease and Related Disorders (Slovenia, 2016).

5th World Congress on ADHD (United Kingdom, 2015)

Heymans Symposium (The Netherlands, 2015 and 2016).

Joint meeting of the British Neuropsychological Society and the Dutch Neuropsychological Society (United Kingdom, 2015).

10th International Congress on Non-Motor Dysfunctions in Parkinson's Disease and Related Disorders (France, 2014).

Research meeting of the Department of Clinical and Developmental Neuropsychology, University of Groningen (The Netherlands, 2013, 2016 and 2018).

Awards

Travel grant (6th World Congress on ADHD, 2017)

Nominated for best poster (6th World Congress on ADHD, 2017)

Winner best poster (Heymans Symposium, 2016)

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DANKWOORD

De weg naar dit proefschrift was een heel avontuur, een interessante en bewogen reis met soms wind mee en soms wind tegen. Gelukkig heb ik deze reis niet alleen hoeven maken. Daarom wil ik graag een aantal mensen bedanken die mij op een directe of indirecte manier hebben ondersteund tijdens deze reis.

Allereerst gaat mijn dank uit naar mijn (co-)promotoren, prof. dr. Oliver Tucha, dr. Janneke Koerts en dr. Lara Tucha. Dank voor jullie vertrouwen in mij en dat jullie het aandurfd en om mij na mijn afstuderen een baan als docent aan te bieden alsmede mij de gelegenheid te geven om promotieonderzoek te doen. Ik vond het een leuke en interessante uitdaging om samen met jullie vanuit een breed idee het FDM-project uit te werken. Janneke, als mijn dagelijks begeleider hebben we vele uren samengezeten, gepraat, gediscussieerd en gefilosofeerd. Het is dankzij jou dat ik destijds de stap durfde te wagen om (promotie)onderzoek te gaan doen. Je hebt me helpen groeien in mijn rol als docent en onderzoeker. Dankjewel dat ik altijd bij je terecht kon, zowel voor inhoudelijke als persoonlijke vragen. Lara, dankjewel voor je kritische blik, doortastende vragen en creatieve ideeën. Ik heb onze samenwerking altijd zeer gewaardeerd en als heel prettig ervaren. Oliver, als promotor gaf je mij sturing en ruimte om me te ontwikkelen tot de onderzoeker die ik nu ben. Veel dank voor je inzichten, gemoedelijke woorden en het geven van vertrouwen. Ik heb veel van je mogen leren.

Daarnaast wil ik graag mijn andere RUG collega's van de afdeling Klinische en Ontwikkelingsneuropsychologie bedanken voor de fijne tijd en prettige samenwerking. In het bijzonder wil ik mijn 'roomies' bedanken: Stefanie en Geraldina. Jaren hebben we met z'n drieën niet alleen een kamer, maar ook lief en leed gedeeld. Ik had me geen betere kamergenoten en directe collega's kunnen wensen. Inmiddels gaan we alle drie onze eigen weg, maar voor mij zijn jullie onlosmakelijk verbonden aan mijn tijd aan de RUG en mijn promotieonderzoek. Voor mij was het dan ook niet meer dan logisch jullie als mijn paranimfen te vragen. Veel dank dat jullie deze taak op jullie wilden nemen. Anselm, je bent nauw betrokken geweest bij meerdere FDM onderzoeken. Heel veel dank voor het meedenken over onderzoeksdesigns, het brainstormen over de juiste statistische analyses en gewoon voor wie je bent als collega. Jouw inbreng bij meerdere artikelen is van grote waarde geweest. Verder wil ik graag Jolanda bedanken. Je stond altijd voor me klaar voor kleine of grote vragen of gewoon een goed gesprek. Je hebt ook veel geholpen bij het ontwikkelen van het testmateriaal, zoals wel honderd A4'tjes voor me plastificeren. Heel veel dank daarvoor! Yvonne en Tessa, we liepen geregeld even bij elkaar langs en ik kon altijd bij jullie terecht voor een gezellig of goed gesprek. En Josje, we werken alweer een hele tijd niet meer samen, maar ook jou wil ik bedanken voor de fijne samenwerking. Ook wil ik mijn collega's bij de UvA bedanken voor hun vertrouwen, interesse en geduld het afgelopen jaar met betrekking tot de afronding van mijn proefschrift. Ik kijk uit naar onze verdere samenwerking.

Verder gaat mijn dank uit aan eenieder die op een directe manier betrokken is geweest bij de uitvoering van het FDM-project en de totstandkoming van dit proefschrift. Allereerst onze collega's in Essen, prof. dr. Christian Mette en dr. Marco Zimmermann, die het mogelijk

maakten het onderzoek te implementeren in Duitsland. Hoewel ons contact voornamelijk per mail verliep, heb ik onze samenwerking als heel prettig ervaren. Daarbij gaat tevens mijn dank uit naar Alexandra, Annika en Philippa, die de praktische uitvoer en dataverzameling van het onderzoek in Essen op zich namen. Ook gaat mijn dank uit naar prof. dr. Peter de Deyn voor zijn bijdrage bij de patiëntenwerving en het mogelijk maken van de uitvoer van het FDM-onderzoek in Antwerpen. In het bijzonder ook dank aan Leen Tollenaere en de medewerkers van ZNA Hoge Beuken te Antwerpen voor het faciliteren van de metingen.

Tevens gaat mijn dank uit naar de vele bachelor- en masterthesestudenten die direct of indirect een bijdrage hebben geleverd aan het FDM-onderzoek. Anna, Simon en Thessa, dank dat jullie mij hebben vergezeld naar Antwerpen om daar metingen uit te voeren. Het waren soms lange dagen, maar jullie gezelschap maakte dat het goed vol te houden was. Josephien, tijdens je studie ben je heel nauw betrokken geweest bij het FDM-onderzoek en heb je vele metingen verricht zowel in Nederland als in België. Het is ongekend wat jij allemaal voor het project hebt betekend, heel erg veel dank daarvoor. Ik vind het dan ook heel leuk dat je inmiddels begonnen bent aan een PhD-traject dat in het verlengde ligt van dit proefschrift. En Akke-Marij, ook jij bent begonnen als masterthese student bij mij en inmiddels werk je als onderzoeksassistent voor het FDM-project. Fijn dat ik het stokje aan je heb mogen overdragen. Ik hoop voor je dat de metingen snel weer van start kunnen gaan.

Ook een speciale dank aan de vele deelnemers die hebben meegedaan aan het onderzoek. Jullie bijdrage is van onschatbare waarde geweest.

Tevens wil ik hierbij graag de leden van de beoordelingscommissie bedanken, te weten prof. dr. Richard Bruggeman, prof. dr. Lydia Krabbendam en prof. dr. Wiesje van der Flier.

Tot slot wil ik mijn naasten, (schoon)familie en vrienden bedanken die mij op een meer indirecte manier hebben ondersteund tijdens deze reis. Jullie bleven altijd met interesse vragen naar mijn onderzoek en gaven me de afleiding die ik af en toe nodig had. Klaas, lieve papa, het onderzoekende en analytisch denken heb ik van jou. Het spijt me dat je de afronding van mijn proefschrift niet hebt mee kunnen maken. Je was zo trots op het feit dat ik deze weg was ingeslagen, stimuleerde me om ermee door te gaan toen je ziek werd en ik weet zeker dat je trots zou zijn geweest op het eindproduct. Paula, lieve mama, ook jij bent een grote stimulans geweest om door te gaan als ik het even niet meer zag zitten. Doorzettingsvermogen en het niet opgeven als het even tegenzit heb ik niet van een vreemde. Dank voor je steun en het geven van vertrouwen. En tot slot, lieve Robin... Ik was net één week in dienst bij de RUG toen we elkaar leerden kennen. Jij kent me dan ook niet anders dan dat ik met promotieonderzoek bezig ben. Wat moet het voor jou een verademing zijn dat deze reis nu is afgerond. Je hebt me altijd gesteund, je was een luisterend oor als ik er even doorheen zat en een stimulans wanneer nodig. Met de komst van Gijs, de afronding van dit proefschrift en de wind weer in onze rug kijk ik uit naar de nieuwe avonturen die op ons liggen te wachten.