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A multi-method assessment of study strategies in higher education students with an autism spectrum disorder

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ABSTRACT

Recent research shows that the number of students with autism spectrum disorder (ASD) attending higher education (HE) is increasing. However, their academic success rates and chances of graduating are lower than reported for typically developing peers. Combining a self-report study-attitude and -strategies inventory and empirical think-aloud protocols, this study is the first to use a multi-method design to try and explain these differences in first-year undergraduates with and without ASD.

It was investigated whether, compared to typical controls, HE students with ASD find it more difficult to glean relevant information from their study material, have poorer academic-planning and purposeful-acting skills and are metacognitively less proficient.

No group differences were found for motivation, fear of failure or time management. The undergraduates with ASD did have more problems selecting relevant information from study materials than their typical peers and knew and used fewer relevant study strategies.

The results presented relate to the three dominant explanatory models of ASD. They contribute to the available evidence and to a profile of HE students with ASD detailing their academic strengths and weaknesses, allowing student guidance protocols to be tailored to their specific needs. Recommendations for such protocols are given.

1. Introduction

For many students higher education (HE) is a challenge because of the greater demands it places on them compared to secondary education. HE students are expected to study more independently, to take notes during lectures and to review and understand large quantities of complex text materials (Denissen, Léonard, Van den Brande, & Willems, 2008). They hence need more advanced study skills than before (Ten Dam, Van Hout, Terlouw, & Willems, 2004). For young adults with autism spectrum disorder (ASD), a growing group in HE, all or some of these study skills may pose a problem. As a result, they have significantly lower chances of graduating in comparison to their typically developing peers (Howlin, Alcock, & Burkin, 2005).

First-year undergraduates with ASD also encounter more difficulties with social communication and interaction in HE than they did during secondary school. Often preferring to work alone, they have problems adapting to others in group assignments (Roberts, 2010). Compared to their typical peers, they also seem weaker in planning their studies and

in processing large quantities of study material that are typically more complex than in secondary education (Van Bergeijk, Klin, & Volkmar, 2008), because - as a group - their self-regulation skills and metacognitive knowledge about learning strategies is less well developed (Roberts, 2010).

The ability to reflect on one's own learning process, often referred to as metacognition, is indeed an important factor in the development of good study skills (Brown, 1987; Flavell, 1979). Some researchers consider metacognition to be a specific form of Theory of Mind (ToM), i.e. Theory of Own Mind (ToOM; Lysaker et al., 2005). It is generally accepted that some people with ASD have difficulties with these higher-order processes (Erbaş, Ceulemans, Boonen, Noens, & Kuppens, 2013; Frith & Happé, 1999; Williams, 2010). In our study, we have adopted Efklides (2006), who defines metacognition as a multifactorial and conscious process, leading to three forms of metacognition: metacognitive knowledge (the knowledge people have about their thinking), metacognitive experiences (the feeling of knowing, of confidence, familiarity and difficulty) and metacognitive skills (conscious use of

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strategies to control cognition). Wilkinson, Best, Minshew, and Strauss (2010) argued that young adults with ASD have sufficient metacognitive knowledge but that they have difficulties using or regulating it. Grainger, Williams, and Lind (2014) found that their metacognitive control processes are less well-developed than they are in their typical counterparts and that they have problems recognising their own thoughts and feelings as well as those of others.

Apart from the problems with metacognition, students with ASD have difficulties with planning and purposeful acting. Breetvelt (2005) and Bramham et al. (2009) showed that adults with ASD have more difficulty with (study) planning and time management than peers without ASD. Also, (quickly) selecting efficient solution strategies seems difficult for people with ASD (Bramham et al., 2009). Van Eylen et al. (2011) observed that high-functioning children with ASD, moreover, appear less skilled at coming up with new ideas (also called generativity), making it harder for them to give personal meaning to tasks than is the case for typical age peers (Van Eylen et al., 2011). The latter authors also found their students with ASD to be more challenged by tasks requiring cognitive flexibility. In the study by de Jonge and Verbeek (2007) students with ASD showed more attention and concentration deficits, displaying problems ignoring distracting stimuli. All these difficulties point to weaker executive functions in ASD.

A third cluster of problems derives from a poor ability to select relevant and ignore irrelevant information. People with ASD tend to have problems making connections and transferring what they have learnt to new situations (Happé & Frith, 2006), finding it difficult to deal with the shift from local to global processing. This deficit is often related to their weaker central coherence. The weak central coherence theory states that people with ASD have problems with global processing in unrestricted tasks, which often results in a detail-oriented cognitive style (Booth & Happé, 2010; Evers et al., 2014; van Lang, Bouma, Sytema, Kraijer, & Minderaa, 2006). Breetvelt (2005) concluded that students with ASD have difficulty separating major from minor issues because they lack an overview of the whole question at hand, rendering reading comprehension, précis writing, schematising, giving a meaningful structure to and grasping the context of an assignment difficult for this group (Boswijk, Breetvelt, & Mensink, 2007; van Lang et al., 2006).

Apart from these three problem domains, which can be closely linked to the main causal models of ASD (the Executive Functioning and Central Coherence theories and ToM), there are other factors that can also impede academic participation and success in this population. Students with ASD sometimes find the curriculum and/or assignments either too complicated or not interesting enough, which can have a negative influence on their motivation (Kögel, Singh, & Kögel, 2010). Bellini (2004) argued that students with ASD have more fear of failure than typical students, which could be attributed to their difficulties with social interaction.

Empirical evidence regarding the study skills of young adults with ASD is as yet scarce (Magiati, Tay, & Howlin, 2014) and often heterogeneous in regard to intelligence (e.g., $70 < IQ < 130$) and age. The ASD groups are compared to other clinical populations, e.g. peers with attention-deficit/hyperactivity disorder (ADHD) or specific language impairment (SLI), but some studies lack a control group of typical peers. Qualitative research in this domain is abundant but studies are often performed by student coaches of local student services and mainly founded on their clinical and/or educational expertise. However valuable these studies may be, they are exclusively based on self-reports and not compared to the data of typical controls.

In the present study we compare the study skills of bachelor students with ASD to those of typically developing peers using a multi-method design. Although the validity of self-report questionnaires in ASD research was previously questioned but shown to be sufficient in (young) adults with ASD (Spek, Scholte, & Van Berckelaer-Onnes, 2010), Desoete (2008) and Veenman, Van Hout-Wolters, and Afflerbach (2006) argued that metacognition can best be gauged by a combination

of offline and online methods. We accordingly decided to apply both a self-report study-attitude and -strategies inventory and think-aloud protocols (TAPs) in which we asked the participants to articulate their thoughts, experiences and actions while executing several study assignments. This 'thinking aloud' process provides real-time and detailed information on the participants' processing and problem-solving skills during task performance (Desoete, 2008).

We addressed the following research questions: Compared to typically developing peers, do HE students with ASD have more difficulty selecting relevant information from their study materials? Are their skills pertaining to planning and purposeful acting in HE context poorer? And finally, are their metacognitive abilities weaker? Based on the literature, we expected the students with ASD to perform less well than the controls on all domains.

2. Method

The study was approved by the local ethics committee. All students gave their informed consent prior to study commencement and received a small financial compensation for their participation. They were also informed that they could terminate their participation at any time without explanation or negative (financial or other) consequences.

2.1. Part 1: Self-report inventory

2.1.1. Participants

A total of 79 first-year bachelor students completed the self-report inventory. General characteristics of the two study groups are given in Table 1.

Of the total, 26 (6 female students) met the DSM-IV-TR criteria for ASD (American Psychiatric Association [APA], 2000), with ASD being their sole or primary diagnosis. Their mean age was 19.9 years ($SD = 1.40$) [18.0–22.0 years]. All had been diagnosed prior to the study by multidisciplinary teams comprising at least one physician (paediatrician or child psychiatrist) and a psychologist. An independent child psychiatrist and the first author verified their diagnoses before inclusion based upon the available diagnostic reports using the same DSM-IV-TR criteria. Ten students (38%) had one or more comorbid disorders (7 SLI, 1 ADHD, 1 Developmental Coordination Disorder (DCC), and 1 Obsessive Compulsive Disorder (OCD)). The students were recruited with the help of student services, student coaches of the university and university colleges of the KU Leuven Association, and independent student coaches (who support students with special educational needs but can guarantee anonymity towards the HE institution if so desired by the student).

We derived the demographic and self-reported data of 53 first-year bachelors (32 female BAs) without known functional, neurological or neurobiological disorders whose fields of study largely matched those of the students with ASD from a pool of 100 controls from the study by Callens, Tops, and Brysbaert (2012). Mean age of the controls was 19.2 year ($SD = 0.77$) [17.9–21.10].

There was a small but significant difference in age between the two groups, $U = 488.50$, $p = 0.04$, which was due to the fact that more students with ASD had doubled a year in secondary education.

There were no significant group differences as regards general intelligence, word reading or simple arithmetic, $p > 0.05$, $g < 0.45$ (small to medium effect sizes).

2.1.2. Instrument

We used the Learning Attitude and Study Strategies Inventory (LASSI), a computer-based multiple-choice questionnaire developed by Weinstein and Palmer (2002). Its 10 scales provide a 'strengths and weaknesses' profile of the respondents' metacognitive knowledge. Each scale has eight items except for the 'selecting main ideas' scale, which has five. Using a 5-point response Likert scale (ranging from 'I completely agree' to 'I completely disagree'), respondents indicate to what

Table 1

General information on the first-year bachelor students with and without autism spectrum disorder (ASD) having completed the self-report inventory (LASSI).

	Students with ASD (n = 26)	Typical students (n = 53)	χ^2	df	p
Gender			9.72	1	0.01
Male students	20 (77%)	21 (40%)			
Female students	6 (23%)	32 (60%)			
Number of college students	17 (65%)	32 (68%)	0.05	1	0.82
College fields of study			2.10	3	0.55
Educational sciences	7	14			
Health and behavioural sciences	1	5			
Management	0	5			
Sciences and Engineering	9	12			
Number of university students	9 (35%)	17 (32%)	0.05	1	0.82
University fields of study			2.17	2	0.34
Arts and humanities	2	5			
Health and behavioural sciences	3	9			
Sciences and Engineering	4	3			
Comorbidity	10	0			
Specific learning disorder (Dyslexia)	7 (5)				
(Dyslexia & dyscalculia)	(2)				
Developmental coordination disorder	1				
Attention-deficit/hyperactivity disorder	1				
Obsessive-compulsive disorder	1				

	M (SD)	M (SD)	Mann-Whitney U	Hedges' g	p
General intelligence (KAIT; Dekker, Dekker, & Mulder, 2004)					
Total IQ	113.31 (11.54)	110.43 (9.96)	577.50	0.27	0.24
Word reading (EMT; Brus & Voeten, 1991)					
No. of correct words per minute	92.23 (18.36)	98.74 (10.24)	583.50	− 0.48	0.27
Arithmetic (TTR, De Vos, 1992)					
No. of correct calculations in 5 min	138.31 (32.26)	146.34 (21.57)	611.00	− 0.31	0.42

Note. LASSI = Learning Attitude and Study Strategies Inventory; $p < 0.05$; χ^2 = Chi square; df = degrees of freedom; M = mean; SD = standard deviation; non-parametric group comparisons with Mann-Whitney U; effect size expressed as Hedges' g (a positive sign indicates a better performance by the ASD group).

degree each of the 77 statements applies to them. The ten scales gauge three areas of metacognitive knowledge:

Self-determination, with items assessing how students deal with various situations:

1. Motivation (e.g. "When work is difficult I either give up or study only the easy parts");
 2. Attitude (e.g. "I feel confused and undecided as to what my educational goals should be");
 3. Anxiety for failure (e.g. "I feel anxious when faced with an academic task").
- Self-regulation*, with items appraising how students manage, self-regulate and monitor their learning process:
4. Time management (e.g. "When I decide to do schoolwork, I set aside a certain amount of time and stick with it");
 5. Concentration (e.g. "I fully pay attention when studying");
 6. Self-testing (e.g. "I interrogate myself when learning or preparing for exams");
 7. Study techniques (e.g. "I change the material I am studying into my own words").

Processing strategies, with items evaluating knowledge of strategies used in various tasks and contexts:

8. Selecting main ideas (e.g. "I have a hard time finding the important points in my reading");
9. Information elaboration (e.g. "I make use of imagery, verbal elaborations, and reasoning skills to process new information");
10. Test strategies (e.g. "I know how to prepare for exams").

Alpha reliabilities for the different scales range from 0.68 to 0.86 (Lacante & Lens, 2005). We found an overall alpha reliability of 0.77, both for the ASD and typical group. Excluding one of the scales did not affect the alpha reliability significantly (range 0.72 to 0.79).

2.1.3. Procedure

The test was administered individually in a quiet room. The test leader was present and available for any questions. Each item of the LASSI could be revisited and responses changed. There were no time constraints and students could ask for a break, which was always granted.

2.2. Part 2: Think-aloud protocols (TAPs)

2.2.1. Participants

Twelve first-year undergraduates (1 female student) with ASD participated in the TAPs, five of whom had also completed the LASSI. The seven new students were also recruited through the student disabilities service and student coaches of the KU Leuven Association. Mean age of the ASD group was 20.0 years ($SD = 1.2$) [18.3–22.8], with two students (17%) having a comorbid disorder (both a specific learning disability in reading and/or spelling).

The control group consisted of 12 (8 female) typical HE students with a mean age of 19.1 years ($SD = 1.70$) [17.9–23.5]. Table 2 provides an overview of both groups. We were unfortunately unable to retrieve the data about the general intelligence, word reading and simple arithmetic skills for the students in the TAP groups.

2.2.2. Instrument

We developed relevant learning material (8 tasks) with the help of two HE teachers per study task. To prevent students from becoming frustrated or demotivated and dropping out, the assignments were challenging but not too difficult. Table 3 lists the four tasks that were selected for presentation: (1) writing a précis of a short Dutch text, (2) studying new words in a foreign language (French), (3) solving word problems, and (4) interpreting a climate graph.

The teachers were subsequently asked to sum up all possible study strategies students could use to complete the tasks efficiently. These were supplemented with additional strategies that we found in previous studies about academic study skills in HE (Entwistle & Ramsden, 1983; Tait & Entwistle, 1996). Finally, a scoring list containing descriptions of all study strategies grouped in five categories was composed (Table 4) to safeguard standardised TAP coding.

2.2.3. Procedure

The TAPs were administered individually by the first two authors (WT, AV) in exactly the same way, using standardised instructions and the same set of additional questions, such as "What are you doing/thinking?" or "Why do you do this like that?". The test administrators recorded everything the students recounted in writing (verbatim accounts) and coded the study strategies (recounted and observed) using the standardised scoring list (Table 4). All sessions were also videotaped for potential review in case of uncertainty and to verify rater agreement (see Coding).

The protocols were conducted in a quiet room, with the student seated at a table and the test leader sitting on the opposite side. The students were informed they would be completing four tasks that would take about 20 min each. They were asked to execute each assignment

Table 2

General information on the first-year bachelors with and without autism spectrum disorder (ASD) having participated in the think-aloud protocol (TAP).

	Students with ASD (n = 12)	Typical students (n = 12)	χ^2	df	p
Gender			8.71	1	< 0.01
Male students	11 (92%)	8 (67%)			
Female students	1 (8%)	4 (33%)			
Number of college students	10 (83%)	12 (100%)	12.32	3	< 0.01
College fields of study					
Educational sciences	3	12			
Health and behavioural sciences	0	0			
Management	3	0			
Sciences and Engineering	4	0			
Number of university students	2 (17%)	0 (0%)	–	–	–
University fields of study					
Arts and humanities	2	0			
Health and behavioural sciences	0	0			
Sciences and Engineering	0	0			
Comorbidity	2	0			
Specific learning disorder	2	0			

Note. $p < 0.05$; χ^2 = Chi square; df = degrees of freedom; M = mean; SD = standard deviation; non-parametric group comparisons with Mann-Whitney U; effect size expressed as Hedges' g (a positive sign indicates a better performance of the ASD group).

Table 3

Overview of the study tasks presented in the think-aloud protocol (TAP).

Category	Course	Study task
Language	Dutch	Précis writing
	French	Studying vocabulary
Science	Mathematics	Problem solving
General information	Geography	Interpreting a climate graph

'as usual', i.e. as if they were doing them at home or at school, but to now think aloud, articulating what and why they were doing and thinking what they were doing or thinking. As soon as a student stopped doing so, the test leader encouraged him/her to continue to think aloud. Students were told they could ask as many questions as

they wanted and to freely make use of the aids that were available (a ruler, a calculator, a marker, pens and paper). It was also explained to them that the test leader might ask them to clarify their thought processes or actions. Without being suggestive, the test leader would, for instance, ask 'Why did you underline these words in your text? Do you do this often? (Précis writing); How can you remember which accent to use in this word? (Vocabulary foreign language); How did you arrive at this solution? (word problems); Why are you using a ruler?' (Climate graphs).

After having completed each assignment, the students took a 5-min test to see what they had learnt and to verify whether they had applied themselves. Both groups achieved an accuracy rate of at least 80% on all tests; there was no significant group difference in performance.

Table 4

Overview of the study-strategies categories.

Study strategies	Substrategies	Description
Reduction of study material	Marking or underlining ^a	Marking unknown words or definitions creates a hierarchy reminding one what is still difficult/not mastered; Underlining titles and subtitles supports memory as it makes text more visual.
	Synopsis/schemas/mind maps ^b	Three ways to organise information to facilitate memorisation. A synopsis is an abridged version of a text using words and short sentences; a schema generally contains words and arrows to express relationships; a mind map is a visual schema to organise information starting from a main concept.
Memory support	Links with foreign languages	To study new words a link with a known word in another language is formed to facilitate memorisation.
	Mnemonics	A mental tool to make a connection between one idea and another.
	Use of a calculator	A calculator unburdens the memory as it helps arithmetic fact retrieval.
	Marking or underlining ^a	Marking unknown words or definitions creates a hierarchy of what is still difficult/not mastered; Underlining titles and subtitles supports memory as it makes text more visual.
	Synopsis/schema/mind map ^b	Three ways to organise information to facilitate memorisation. A synopsis is a condensed version of a text in words and short sentences; a schema generally contains words and arrows to express relationships; a mind map is a visual schema to organise information starting from a main concept
Repetition/memorising	Literally; by heart	Memorising study material word by word.
	In own words	Memorising by using one's own words; paraphrasing content using own words.
	By synopsis, schema or mind map	Memorising by reproducing synopsis, schema or mind map.
	Rereading	Repetition or memorising study materials by rereading text.
Relevance and context	Ignoring irrelevant information	To grasp the essence of a text, irrelevant information needs to be ignored.
	Selecting main ideas	When reading/studying, main ideas need to be identified and selected as containing the most important information and thus is relevant to remember.
Monitoring/processing control	Finding the thread	When reading/studying, one must find information and meaning that ties a story together.
	Noting interim steps/solutions	During tasks one notes down interim steps to monitor the problem-solving process.
	Spelling check	After completing a writing task, one checks one's spelling to avoid errors.
	Verify calculations	After completing a word problem, one verifies the calculations to avoid miscalculations.
	Making notes	When reading/studying, one makes notes in the margins to structure the text and to improve comprehension.
	Marking in questions	When reading questions, one marks important words or questions to avoid forgetting or misinterpretations.

^a Marking and underlining are ways to reduce the amount of learning material but also a strategy to support memorisation.

^b Making a synopsis, schema or mind map helps students to reduce the volume of study material but they also are effective memory-support techniques.

2.2.4. Coding

To guarantee standardisation and promote scoring fidelity, the TAP administrators each and independently observed the videotapes of the first two sessions of the other, making their own verbatim transcriptions and coding the (verbalised and observed) study strategies. The results were compared, any differences and potential future coding confusions discussed and consensus reached, after which the other TAPs were conducted. If students used study strategies other than those listed on the scoring sheet, these were not recorded or coded. If the study strategies used matched two or more (sub)categories of the list, they were scored in all the relevant (sub)categories (with synopsis/scheme/mind maps, for instance, being listed under Reduction of study material as well as under Memory support).

Interrater reliability was established by comparing the coding results for all students and found to be high (correlation coefficient 0.84).

3. Results

To compare groups, we used non-parametric Mann-Whitney *U* tests. Results are presented as Hedges' *g*, i.e. effect sizes corrected for the different sample sizes. Significance was set at $p < 0.05$. A positive effect size indicates a better performance of the ASD group. If $g < 0.40$ the effect is noted as small and if $0.40 < g < 0.80$ as medium. Effect sizes are large when $g > 0.80$ (Cooper & Hedges, 1994).

3.1. LASSI

As can be seen in the *Self-determination* cluster presented in Table 5, the students with ASD performed significantly poorer on the attitude subscale, with a medium effect size, $p < 0.05$, $g = -0.44$. For the motivation subscale and, surprisingly, also for the *Self-regulation* subscales (concentration, fear of failure and time management) no meaningful differences between the groups emerged. The most important differences were found in the *Processing strategies* cluster. Compared to the controls and with the exception of information processing, the students with ASD reported significantly more problems with selecting main ideas, $p = 0.05$, $g = -0.33$, test strategies, $p < 0.05$, $g = -0.42$, and self-testing, $p = 0.05$, $g = -0.40$, with effect sizes ranging from small to medium. As to study techniques, the effect size

Table 5
Results for the LASSI.

	ASD students (n = 12)		Controls (n = 12)				
	M	(SD)	M	(SD)	<i>U</i>	<i>p</i>	<i>g</i>
Self-determination							
Attitude	29.31	(4.87)	31.64	(3.82)	457.50	0.02	− 0.44
Motivation	26.13	(5.32)	26.70	(4.33)	678.50	0.60	− 0.08
Self-regulation							
Concentration	25.35	(5.67)	24.45	(5.21)	648.50	0.67	0.17
Fear of failure	26.62	(5.19)	26.11	(6.14)	664.50	0.80	− 0.14
Time management	23.38	(5.62)	23.51	(5.73)	678.50	0.91	− 0.05
Processing strategies							
Information processing	27.38	(5.40)	28.83	(4.72)	593.00	0.32	− 0.18
Selecting main ideas	16.58	(2.89)	17.85	(3.71)	504.50	0.05	− 0.33
Study techniques	23.12	(3.85)	25.96	(4.35)	421.50	0.01	− 0.78
Test strategies	27.23	(4.01)	29.23	(4.78)	478.50	0.03	− 0.42
Self-testing	22.46	(4.54)	24.68	(4.89)	497.50	0.05	− 0.40

Note. LASSI = Learning Attitude and Study Strategies Inventory; M = mean; SD = standard deviation; A positive effect size indicates a superior performance for the ASD students in comparison to the controls.

was even larger, again to the detriment of the ASD group, $p < 0.05$, $g = -0.78$.

3.2. TAPs

The results of the TAPs are presented in Table 6. The study strategies the students used (both recounted and observed) were listed per group in the relevant predefined clusters (see Table 2). We report the percentages and compared the group percentages using χ^2 . Significance was again set at $p < 0.05$.

Overall, the students with ASD and the controls used the same memory support strategies. The students with ASD did mark and underline significantly less during the study tasks than the typical students did, $\chi^2 = 5.94$, $p < 0.05$. They also made less use of synopsis, schemas and mind maps to reduce their study material than the controls, but this difference did not reach significance, $\chi^2 = 0.32$, $p = 0.57$. While both groups were just as likely to use mnemonics or links (e.g. with known foreign languages), the ASD students did make significantly more use of a calculator to do simple arithmetic, $\chi^2 = 3.95$, $p = 0.05$. Even though they seemed to learn less by heart and make more use of paraphrasing (own words) to memorise content than the controls, the differences were not significant, $p > 0.10$. Most notably, the students with ASD reread material far more often than the controls did, $\chi^2 = 7.67$, $p < 0.05$, which means that they reviewed the material more frequently without using other, more efficient memory strategies.

The third cluster relates to relevance and context, where the students with ASD had significantly more difficulties ignoring irrelevant information in the material than their typical peers, $\chi^2 = 5.24$, $p < 0.05$. They also had significantly more problems selecting the main ideas, $\chi^2 = 4.89$, $p < 0.05$, and finding the thread in a text, $\chi^2 = 4.40$, $p < 0.05$.

Finally, the two groups did not differ much as regards their monitoring strategies, with most students applying the same strategies to similar degrees. The students with ASD checked their spelling, $\chi^2 = 0.03$, $p = 0.87$, and their calculations as often as the controls did, $\chi^2 = 0.01$, $p = 0.93$. There were no differences in noting interim steps, $\chi^2 = 1.21$, $p = 0.27$, and the ASD students made as many notes, $\chi^2 = 3.22$, $p = 0.07$, and marked as much as the controls did, $\chi^2 = 2.16$, $p < 0.14$.

4. Discussion

In this study we used a self-report inventory (LASSI) and think-aloud protocols (TAPs) to investigate the differences in study strategies of first-year bachelors with ASD and typically developing peers. As hypothesised and assessed with the relevant LASSI subscale, the students with ASD had greater difficulty selecting the main ideas from the study material they were presented, while the TAPs revealed that they had more problems with relevance and context than the controls. More specifically, they had significantly more problems ignoring irrelevant information and finding the thread in a text. These results correspond with those of Happé and Frith (2006) who argued that people with ASD have a stronger focus on parts than on the whole. Our HE students with ASD indeed found it more difficult to ignore side issues and focus on the main topics than their typically developing peers did, which may be explained by the idea that individuals with ASD have weaker central coherence (Happé & Frith, 2006). However, and in contrast to Boswijk et al. (2007), we failed to find significant differences between the ASD students and the controls for making synopses, schemas or mind maps.

Although we assumed that undergraduates with ASD would also perform more poorly in terms of study planning and purposeful studying compared to typical peers, the LASSI did not show any significant differences for the *Time Management* and *Concentration* subscales and neither did the TAPs. The students with ASD put as much effort into reducing the study material and, overall, applied the same memory-supporting strategies as the controls did, although they did

Table 6
Results for the Think-Aloud Protocols (TAPs).

Study strategies		% ASD students	% Control students	χ^2	p
Reduction of study material	Marking or underlining	46.15	91.67	5.94	0.02
	Synopsis/schemas/mind maps	30.77	41.67	0.32	0.57
Memory support	Links with foreign languages	84.62	83.33	0.01	0.93
	Mnemonic	23.08	25.00	0.13	0.91
Repetition/memorising	Use of a calculator	92.31	58.33	3.95	0.05
	Marking/underlining	46.15	91.67	5.94	0.02
	Resumes/schemas/mind maps	30.77	41.67	0.32	0.57
	Literally; by heart	53.85	83.33	2.49	0.11
	In own words	76.92	50.00	1.96	0.16
	Use of schemas or drawings	0.00	25.00	3.69	0.06
	Rereading	61.54	8.33	7.67	0.01
Relevance and context	Ignoring irrelevant information	38.46	83.33	5.24	0.02
	Selecting main ideas	30.77	75.00	4.89	0.03
	Finding the thread	69.23	100.00	4.40	0.04
Monitoring	Noting interim steps/solutions	53.85	75.00	1.21	0.27
	Spelling check	61.54	58.33	0.03	0.87
	Verify calculations	15.38	16.67	0.01	0.93
	Making notes	30.77	66.67	3.22	0.07
	Marking in questions	46.15	75.00	2.16	0.14

mark and underline significantly less in the learning material. Such visual cues often help students to focus better on the learning content but we reason that they may be distracting for students with ASD. Compared to the controls, they used (re)reading more frequently as a strategy to memorise content, while switching rapidly and smoothly between different learning strategies also poses them problems: they tended to stick to their preferred strategy, perhaps as a result of their limited cognitive flexibility. Van Eylen et al. (2011), for instance, found that reduced cognitive flexibility impeded young adults with ASD from switching between different thoughts and behaviours. Such cognitive limitations might derive from the weaker executive functions often observed in people with ASD. Nevertheless, we remain cautious in this interpretation given that executive functioning appears to be very task-specific (Pennington & Ozonoff, 1996) and the self-report questionnaire we used was not specifically developed to gauge this aspect.

Finally, with our multi-method approach we were able to differentiate between metacognitive knowledge and metacognitive skills, a crucial element in optimising guidance services for HE students with ASD given that a student who may be aware of different study strategies does or can not necessarily apply them when studying and vice versa. The results confirmed the anticipated differences in both aspects. The LASSI outcomes showed that the students with ASD had less metacognitive knowledge of their study strategies than the controls and seemed less aware of the variety of study strategies available to them. The TAPs revealed that they indeed used fewer study strategies than the typical students. Our findings only partially correspond with previous research results. As already referred to in the introduction, young adults with ASD do appear to have metacognitive knowledge but have trouble using or regulating this knowledge adequately (Wilkinson et al., 2010) and have less metacognitive control than typical peers (Grainger et al., 2014). Erbas et al. (2013) argued they have less insight into their own difficulties and therefore are less willing to try to change.

Besides the results on our main research questions, several other interesting aspects merit discussion. First, rather than seeking to establish which study-related issues were ASD-specific, we wished to determine the nature of the problems HE students with ASD experience in practice that may explain their lower academic performance. We hence included ASD students with common comorbidities in our study primarily because comorbidity in developmental disorders such as ASD is the rule rather than the exception given that their aetiologies are probabilistic and multifactorial (Pennington, 2006). Also, the current diagnostic criteria for ASD themselves already incorporate a great deal of variation. We feel our sample thus reflected the heterogeneity in the wider high-functioning ASD population. But did the comorbid disorders

in our ASD students play a role in the nature and extent of their metacognitive knowledge and range of study skills? For instance, students with poor calculation skills might need to use a calculator more, while those struggling with reading may need to review a text more often than their peers (both with and without ASD) who have no such learning difficulties. However, having checked the use of strategies for each individual student, we found no support for any such biases.

Our ASD students not only differed from the controls in their knowledge and use of study strategies, they also had a different, more negative attitude towards their studies. The LASSI *Attitude* subscale gauges the motivation behind a vocational choice and the resulting vocational perspectives. We found that our undergraduates with ASD seemed to find it harder to define the consequences of their vocational choice than the typical students and that they were more often unable to give concrete future perspectives. This is in line with the findings of Kögel et al. (2010). However, and in contrast to Bellini (2004), their self-reported fear of failure was not elevated compared the levels reported by the controls. Whether and which comorbid disorder(s) in our ASD group influenced these outcomes and in which direction is unsure but, again, we feel our results are likely to be representative of HE students with ASD although research in larger samples is needed to confirm this.

As to the limitations of our study, it needs to be mentioned that we selected study tasks that we deemed to be relevant for students in HE and then defined effective study strategies for these tasks. This approach was somewhat arbitrary and thus susceptible to critique but, using both off- and online assessments, this study can serve as a starting point for future research. All the students with ASD were high functioning, academically successful young adults who had progressed onto HE. They are hence not representative of other ASD populations. Moreover, as students are not obliged to make their disabilities public, only students that had contacted student disability services could be recruited, which may have created a bias towards highly motivated students or students with better self-insight. On the other hand, our sample may also have included students who were experiencing more than the average amount of problems, which is why they sought help. As we did not ask the students about their motivation for contacting student guidance services, these are aspects to keep in mind when interpreting our results. Also, it needs to be noted that female students are the majority in HE in Belgium but that in our sample more students with ASD were male. However, given that ASD is a condition that affects men more than it does women, this might not necessarily be a limitation, with our sample possibly being representative of the ASD population in HE.

We expected the students with ASD to have lower metacognitive knowledge and skills than the typical students, as would be expressed in the TAPs where the students were asked to verbalise their thoughts while completing the various assignments. However, precisely because of their reduced metacognitive knowledge and perhaps their deficient communicative and interactive abilities, ASD students will have more problems doing so, inevitably leading to a confirmation of our hypothesis. To deal with this potential circularity, we invested a great of time in preparing the protocols, devising a large set of helpful and stimulating questions for the test leader to encourage students to share their study strategies without being too suggestive. We believe that by using this approach we largely overcame this problem.

Finally, general intelligence, reading and mathematical proficiency will influence the student's range of study skills. Miller and Keenan (2009), for instance, found that poor decoding skills were associated with a greater difficulty differentiating central from peripheral information in texts. We hence calculated non-parametric correlations (Spearman R) for these skills and the different study strategies used (as assessed with both the LASSI and the TAPs), showing that for none of the students with ASD these reached significance ($p < 0.05$), not even when correlations were calculated separately for students with a comorbid reading and/or mathematical learning disorder.

Although preliminary, our results have several practical implications for student guidance protocols aimed at undergraduates with ASD and may help teachers and study coaches to optimise their didactic and counselling approaches for this particular group. The outcomes, for instance, suggest that teachers are advised to provide these students with a clear course plan and explain course demands detailing important deadlines, the precise aims of each course, the materials that will be used and other expectations. Ideally, they should also provide relevant information about the best study strategies for the various courses. Students with ASD will also benefit from synopses, resumes, mind maps and/or clear instructions about what to pay attention to during classes, as well as mock examinations. Providing oral feedback before or after an exam (e.g. on questions the students may have about the upcoming exam or about the answers (s)he has given) will also help students with ASD learn to reflect on and (re)structure their work. It is, moreover, essential that exams are conducted in quiet rooms without unnecessary distractions. Finally, since students with ASD often do not like to highlight or underline course material because, rather than being supportive, they feel these aids are distracting, it is recommended to use well-structured text books and other study materials that have a simple and clear layout. Importantly, many of these measures are not only useful for students with ASD but also for students with other disabilities and by extension for all students in HE and are examples of universal design for learning (Higbee, 2008).

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