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Local-global processing approaches in older autistic adults: A matched control study using RCFT and WAIS-IV

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ABSTRACT

Background: Research on information processing of older adults with autism spectrum disorder (ASD) is scarce, which is a caveat because findings in children may not apply to (older) autistic adults. This study examines visual local-global processing approaches in older autistic adults.

Method: The Rey-Osterrieth Complex Figure Test (RCFT) is a popular measure of visual-constructional ability, organisational strategy and memory. In this matched-control study, we explore if the qualitative and quantitative performance on the RCFT can be used as an operationalisation of central coherence in autistic older adults ($n = 36$; ages 50–84 years), and whether RCFT performance associates with autism-symptoms. WAIS-IV scores were also obtained to test for local-global differences in performance.

Results: No evidence was found for deviating processing approaches on the RCFT (both quantitative and qualitative) in the ASD group, although copying the RCFT was significantly slower. The WAIS-IV showed no differences between participant-groups, except for a significantly better performance on Visual Puzzles by autistic participants.

Conclusions: Using visual local-global processing tests common to clinical practice, this study provides no evidence for a weak central coherence but some support for enhanced perceptual functioning in late-diagnosed high functioning older autistic adults. There was no evidence for altered strategic approaches during the completion of a complex visual information processing task (RCFT). Combining a quantitative and a qualitative scoring system of visual information processing tasks (such as RCFT) can elucidate the preferred visual information processing style in autistic individuals.

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1. Introduction

1.1. Visual information processing in autistic older adults

The tendency for local (bottom-up) information processing over global (top-down) information processing, described as the weak central coherence (WCC) theory of autism (Happé & Frith, 2006), is one explanatory model for Autism Spectrum Disorder (ASD) symptoms. The WCC theory assumes reduced global integration in perceptual processing in ASD (Booth & Happé, 2018). In accordance with the WCC theory of autism, autistic individuals are expected to show superior performance on tasks demanding local (bottom-up) processing, and poor performance on tasks demanding global (top-down) processing (Behrmann, Thomas, & Humphreys, 2006; Wang, Mottron, Peng, Berthiaume, & Dawson, 2007). Alternatively, the (revised) Enhanced Perceptual Functioning (EPF) model by Mottron, Dawson, Soulières, Hubert, and Burack (2006) suggests intact global functioning in autistic people. The EPF model explains differences in perceptual processing due to a more locally oriented default setting and over-functioning of brain areas involved in primary perceptual functions in autistics compared to typically developing (TD) individuals.

A local (or less global) information-processing tendency can be both a strength and a weakness. Bottom-up information processing can be advantageous in activities demanding accuracy and attention to detail, such as in software development or engineering. However, when quick and appropriate responses to complex and (rapidly) changing information are required, this style may be a weakness (Happé & Frith, 2006). Top-down (centrally coherent) information processing may be more functional to perceive the overall picture and understand events and behaviour within a broader context. WCC may partly underlie social interaction difficulties in ASD, as it hinders perception of the social context as well as the ability to derive meaning from another's behaviour within this context. Alternatively, WCC may cause one to require more time to perceive and understand the broader context (Scherf, Luna, Kimchi, Minshew, & Behrmann, 2008).

However, a meta-analysis on local-global visual processing in autistic individuals (6–35 years of age) neither showed evidence for a general deficit in global processing nor for superior local processing (Van der Hallen, Evers, Brewaeys, Van den Noortgate, & Wagemans, 2015). Slower global visual processing was observed in autistic compared to TD-individuals, especially when incongruent local information was present within a global visual information processing task (Behrmann et al., 2006). Both the WCC and EPF model could hypothetically underlie slowed task performance, with WCC necessitating more time to integrate information and EPF necessitating more time to shift from local to global oriented perception.

Cross-sectional matched-control studies comparing autistic children and adults point to a delayed development from local to a more global visual information processing style that characterises typical development (Scherf et al., 2008). Autistic adults may not reach the same level of global information processing as TD adults (Kuschner, Bodner, & Minshew, 2009). This may underlie impairments in communication and social cognition (e.g. face perception, context perception), repetitive behaviours and restricted interests (RRBI) to avoid sensory overload (Bakroon & Lakshminarayanan, 2016; Jones, Lambrechts, & Gaigg, 2017), as well as adaptive skills in daily life (Davids, Groen, Berg, Tucha, & van Balkom, 2016).

Even though autism continues into adulthood (DSM-5®, American Psychiatric Association, 2013), clinical research on information processing in ASD has primarily focussed on children and young adults, leaving a gap of knowledge about older adults (Booth & Happé, 2018). To date it is unknown whether the WCC or EPF applies to older adults with ASD, who may have received late first-diagnosis (in adolescence, adulthood or even in old age). The current study extends our previous matched-control study in 50–84 year-old autistic adults, in which we assessed the neuropsychological domain of executive functioning (EF) (Davids et al., 2016). Even though the older autistic adults performed equally well on a battery of EF tests, they reported more EF problems in their everyday life compared to matched TD controls, which is in accordance with the findings of a recent study (Geurts, Pol, Lobbestael, & Simons, 2020). Interestingly, the older autistic adults in our study (Davids et al., 2016) needed more time, which may be explained as a compensation for difficulties with complex tasks. It has been suggested that autistic adults (partially) catch up with cognitive development, learn to use more compensation strategies or even possess more cognitive reserve that slows the aging process (Bathelt, Koolschijn, & Geurts, 2020; Lever & Geurts, 2016; Oberman & Pascual-Leone, 2014; Walsh, Baxter, Smith, & Braden, 2019). The current study further investigates the local-global visual processing approaches of this sample, to understand the autistic symptoms at older ages.

1.2. Neuropsychological assessment of CC

In clinical practice, visual information processing abilities and organizational strategy are often assessed by means of the Rey Osterrieth Complex Figure Test (RCFT; Brunsdon & Happé, 2014; Kuschner et al., 2009; Meyers & Meyers, 1995; Osterrieth, 1944) or the Block Design tests of the Wechsler Intelligence Scale for Children (Wechsler, 1991) or the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 2008). The RCFT was originally developed to investigate visual-constructional ability and visual memory in brain injured persons (Lezak, Howieson, Bigler, & Tranel, 2012). In ASD research, however, the RCFT has previously been used to assess visual local-global processing in matched-control studies in children (aged 7–18 years) (Rosa et al., 2017; Schlooz et al., 2006; Van Eylen, Boets, Steyaert, Wagemans, & Noens, 2018). On the RCFT, autistic children performed poorer than their TD peers; they displayed more omissions, errors and fragmentation in the RCFT copy and used a more detailed approach. To date, only few studies used the RCFT to study autism in adults, and neither differences in quantitative RCFT performance nor age effects were found in ASD and TD groups (Kuschner et al., 2009). An ASD group (18–35 years) performed only worse when medication use was included (Otsuka, Uono, Yoshimura, Zhao, & Toichi, 2017).

Rather than looking for impairments in different sensory and perceptual components, Iarocci and McDonald (2006) suggested looking for methods to assess the integration and organisation of sensory processes. Some studies indeed demonstrated that autistic

children perform poorly on tasks that combine visual information processing with other cognitive functions, such as the RCFT (Schlooz & Hulstijn, 2012). When executing the RCFT, planning and organisational strategies of TD adults were significantly better than those of TD children. This development into a more efficient global strategy use, reflected in a qualitatively different performance between TD children (aged 8–14 years) and adolescents/adults (aged 15–47 years) on the RCFT, was not seen in the ASD-groups (Kuschner et al., 2009). Therefore, qualitative measures may provide more insight into the local-global processing approach.

1.3. Visual information processing and autism symptoms

Studies investigating the relationship between WCC in the visual domain and autism-symptoms are scarce and yielded mixed results (Brunsdon & Happé, 2014; Spek, Scholte, & Van Berckelaer-Onnes, 2011; Stevenson et al., 2018; Van der Hallen et al., 2018). While some child and adult studies failed to find a link between WCC and autism-symptoms (Burnette et al., 2005; Pellicano, 2010), Chen, Rodgers, and McConachie (2009) found that children with a stronger preference for a local processing style displayed more RRBI. Van Eylen and colleagues (2018) observed significant associations between local-global processing and autism-symptom severity in RRBI and social responsiveness, measured with the Social Responsiveness Scale (SRS), but causality remains unclear.

1.4. Hypotheses of the present study

With the aim to understand local-global processing approaches in older autistic adults, we hypothesized that:

- 1) Autistic participants perform poorer than TD-individuals on the complex visual information processing task RCFT (as reflected in lower scores and/or longer execution time), but better on more local than global visual information processing tasks such as Block Design and Symbol Search of the WAIS-IV.
- 2) Autistic participants use a local and more fragmented style in copying and reproducing the RCFT than TD participants. Using a qualitative scoring system, this should be reflected in more fragmentation, as well as poorer organisation and planning scores of autistic participants in the RCFT 'copy and reproduction' conditions compared to TD-individuals.
- 3) More severe self-reported autism-symptoms are related to a more locally oriented processing style and poorer performance or longer execution time on the RCFT.

2. Method

2.1. Participants and measures

Autistic participants were recruited from a specialized outpatient clinic, Autism Team Northern-Netherlands (ATN), as well as from an outpatient clinic for Geriatric Psychiatry. TD participants were recruited through local newspapers, at educational settings for the elderly, and from the work- or family-networks of the researchers. Participants were matched according to age, sex and educational

Table 1

Participant information. Means and standard deviations of performance on the WAIS-IV indexes and subtests for the ASD and TD participants. Frequencies of impaired, average and high scores are given for ASD and TD participants.

	ASD N = 36	TD N = 36	statistics	ASD	TD
Gender	30 m/6f	30 m/6f	–	–	–
Age M (SD)	58.6 (7.8)	59.4 (8.3)	$d = 0.09$	–	–
Range	50–84				
Education ^a M (SD)	5.4 (1.3)	5.9 (0.8)	$Z = -1.46; p = .14$	–	–
WAIS index/ subtest	M (SD)	M (SD)	Cohen's d	frequencies I/A/H	frequencies I/A/H
FSIQ	106.33 (18.4)	107.11 (15.6)	–0.05	0/30/6	1/31/4
VCI	108.0 (18.2)	109.7 (13.5)	–0.11	1/26/9	0/32/8
PRI	109.1 (13.4)	103.8 (17.2)	0.34	3/26/7	2/29/5
WMI	103.1 (17.7)	104.4 (15.1)	–0.08	1/28/7	1/31/4
PSI	97.3 (17.0)	102.3 (15.1)	–0.31	5/26/5	2/32/2
BD	11.5 (3.3)	10.7 (3.6)	0.23	1/29/6	3/28/5
BDN	38.0 (8.4)	34.9 (9.4)	0.35	0/17/19	0/22/14
MR	10.7 (3.7)	10.8 (3.0)	–0.03	3/28/5	1/31/4
VP	12.2 (3.5)	10.4 (3.3)	0.56*	4/22/10	4/30/2
PC	10.4 (2.3)	10.1 (2.0)	0.14	0/34/2	0/35/1
SS	9.6 (3.3)	10.4 (2.6)	–0.27	2/31/3	1/34/1
DSC	9.4 (3.2)	10.4 (3.1)	–0.32	4/28/4	2/30/4

m = male; f = female; M = mean; SD = Standard Deviation; a = Dutch education scale, ranging from 1 (elementary school not finished) to 7 (university degree); d = Cohen's d ; Z = Z-score; I = Impaired ($\leq M - 1.5SD$); A = Average ($M - 1.5SD < \text{value} < M + 1.5SD$); H = High ($\geq M + 1.5SD$); FSIQ = Full Scale IQ; VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index; BD = Block Design; BDN = Block Design no time bonus; MR = Matrix Reasoning; VP = Visual Puzzles; PC = Picture Completion; SS = Symbol Search; DSC = Digit Symbol Coding; Impaired or High if scored $<$ or $>$ 1.5 SD using percentile $<$ 8 or $>$ 92, using IQ total/ index score $<$ 79 or $>$ 121, using norm scores $<$ 6 or $>$ 14, using T scores $<$ 36 or $>$ 65; * = $p < .05$.

level and did not differ on these variables (Table 1). The study sample consisted of two groups, 36 autistic older adults (30 males, 6 females) aged 50–84 years (older autistic adults, ASD), and 36 typically developing older adults (TD) aged 50–79 years. All autistic participants received an ASD diagnosis during adulthood (after 20 years old). Exclusion criteria were: 1) Verbal Comprehension Index (VCI) score of 2 SD below average (= VCI score < 70), 2) serious comorbid psychiatric conditions, 3) somatic conditions and/or medication expected to interfere strongly with neuropsychological performance. All participants were assessed in their regular on-state of psychotropic and/or somatic medication (anti-depressants, anti-hypertensives and stimulants were most common).

2.2. Ethics

The Ethics Committee of the Department of Psychology at the University of Groningen approved the study. Procedures performed were in accordance with the ethical standards of the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Prior to inclusion, all participants gave written informed consent.

2.3. Procedure

The neuropsychological assessment took about three hours and followed a fixed order of tests for: intelligence, verbal and visual memory, verbal fluency, EF, speed of information processing. Autistic participants were assessed at the ATN, while TD participants were assessed at the Department of Psychology at the University of Groningen. Beforehand, all autistic and TD participants completed two questionnaires, the BRIEF-A (Roth, Isquith, & Gioia, 2005) and the Social Responsiveness Scale-Adults (SRS-A) to assess autism-symptoms (Constantino & Todd, 2005; De la Marche et al., 2009). Participants invited a close relative or friend to complete a proxy version of these two questionnaires, and to submit these during their visit. This study includes only the results of the RCFT, WAIS-IV and the SRS-A for analysis.

2.4. Materials

2.4.1. Rey Osterrieth Complex Figure Test

The RCFT is a complex task to assess a variety of cognitive processes including visual-constructional ability, perceptual-motor strategies, organisational strategy, problem solving strategies and episodic memory functions (Osterrieth, 1944; Strauss, Sherman, & Spreen, 2006). The task requires participants to reproduce, without time restraint, a complex line drawing three times. Firstly, by copying it as carefully and accurately as possible from the sample copy. Secondly, by drawing it from memory immediately after copying (Immediate Recall, IR). Thirdly, by drawing it from memory after a 20–30 min delay (Delayed Recall, DR). In the recognition condition immediately following DR, participants need to identify 12 details of the line drawing by encircling these among 24 alternatives. Performance on the RCFT is usually analysed through a quantitative scoring method (Meyers & Meyers, 1995). However, the global and local strategies in copying and reproducing the complex figure can also be analysed through a qualitative method (Kuschner et al., 2009).

Here we used both quantitative and qualitative scoring methods. RCFT-performance was scored quantitatively according to manual instructions. The five dependent measures are: 1) execution time (in seconds) to copy the drawing, 2) raw scores of the correctly reproduced and placed details of the complex figure in the copy, 3) norm scores of the immediate recall (IR), 4) norm scores of the delayed recall (DR), and 5) recognition norm scores, namely the total number of correctly recognized details. All norm scores are corrected for age.

The qualitative scoring methods for the RCFT were the Boston Qualitative Scoring System (BQSS) and the Q-score (Bylsma, 2008 unpublished manuscript; Stern et al., 1999; Troyer & Wishart, 1997; Weider, Indredavik, Lydersen, & Hestad, 2016). Scoring is based on the assumption that in order to copy the figure most efficiently, the subject should draw the basic structural (global) components before adding the details.

The BQSS Comprehensive Scoring Method provides ratings of 17 qualitative features for each RCFT production (Copy, IR and DR), dividing the complex figure in three hierarchical groups, *Configural Elements*, *Clusters* and *Details*, of which configural elements are the most global parts of the figure and details the most local parts. These three parts are separately rated on presence, accuracy, placement and fragmentation according to the manual. Other Qualitative scales are: planning, fragmentation, neatness, perseveration, confabulation, asymmetry, size (horizontal expansion, vertical expansion, reduction), and rotation. All three hierarchical groups also have summary scores for presence and accuracy. Finally, the quality of reproduction is scored in the *Overall Planning Score*. For each of the RCFT-conditions (Copy, IR and DR) the 17 qualitative scores are determined, each rating a specific feature of the RCFT production. They are rated on a 5-point scale ranging from 0 (e.g. extreme perseveration, extremely poor planning) to 4 (e.g. no perseveration, good planning). There is one scale with categorical rating, namely Asymmetry (N = No Asymmetry, L = Left sided Asymmetry, R = Right sided Asymmetry). Raw scores are converted into cumulative percentage (CP) scores (according to sex and age range 18–39, 40–59, 60–69, 70–79 and 80–94). In addition to these 17 Qualitative scores, there are six Summary scales, each derived from combinations of the Qualitative scale scores. These six are: 1. Copy Presence and Accuracy, 2. Immediate Presence and Accuracy, 3. Delayed Presence and Accuracy, 4. Immediate Retention, 5. Delayed Retention and 6. Organisation. The BQSS has good interrater reliability (Nakano et al., 2006). The dependent scores of the BQSS were the age-related cumulative percentages and T-scores according to manual (Stern et al., 1999).

Compared to this BQSS, the Q-score is a less time-consuming qualitative scoring method. The Q-score, ranging from 0 to 24, is only calculated for the copy trial and consists of a *unit score* (0–17) and an *order score* (0–7). According to this method, the complex figure is

divided into 13 discrete units. Some units are considered more important and an efficient global strategy is awarded with bonus points. The more efficient the planning from global to detail, the higher the total scores. The dependent measures of the Q-score were the Unit score and the Order score.

2.4.2. WAIS-IV-NL

The Wechsler Adult Intelligence Scale-Fourth Edition, Dutch version (WAIS-IV-NL) yields Full Scale IQ-score (FSIQ) and four index scores: Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI), and Processing Speed Index (PSI) (Wechsler, 2008). To answer our research question, subtest scores of the PRI and PSI were analysed separately; all subtest scores of the WAIS-IV-NL are norm scores corrected for age. Subtest scores with and without time (bonus) were calculated for a task with time restraint, Block Design (BD). The WAIS-IV manual offers an option to a BD process score, the raw BD score without time bonuses, the BDN score. Each well-executed item for which time bonus points are possible receives a maximum of 4 points. Visual Puzzles (VP) and Picture Completion (PC) are time restraint subtests, while Matrix Reasoning (MR) has no time limit. VP, BD, PC and MR are perceptual reasoning subtests. Symbol Search (SS) and Digit Symbol Coding (DSC) are both time restrained after 120 s and together constitute the WAIS-IV-NL Processing Speed Index (PSI).

2.4.3. Adult Social Responsiveness Scale

Symptom severity was assessed with the Adult Social Responsiveness Scale (SRS-A) a quantitative self-report and proxy-report questionnaire consisting of 65 items to assess social responsiveness in natural settings during the last 6 months (Constantino & Todd, 2005). Participants filled in a self-report SRS-A, their close relative or partner used a proxy-report variant. There are four Subscales: 1) Social Awareness (SA); 2) Social Communication (SC); 3) Social Motivation (SM); and 4) Restricted Interests and Repetitive Behaviour (RR). According to the manual, a T-score > 60 , is associated with mild to moderate deficits of social responsiveness often seen in mild ASD or HFA, while a T-score > 76 is associated with severe deficits in social responsiveness and with a clinical ASD diagnosis. Validity and consistency are still under investigation, but in a German study the SRS-A showed high levels of sensitivity and specificity (Bölte, 2012; Constantino, 2011; Frazier et al., 2014; Ingersoll, Hopwood, Wainer, & Donnellan, 2011).

2.5. Statistical analysis

We used IBM SPSS Statistics 20A (Statistics I.I.S. 2014) for analysis. To test the first hypothesis regarding performance and execution time of participants on the RCFT and WAIS-IV BD, MR, VP, C, PC, a MANOVA was performed with group (ASD, TD) as the between subjects factor and task performance as the dependent variable. RCFT T-scores were used for the RCFT quantitative scores, except for RCFT copy, for which raw scores were used. Cumulative percentage scores were used for the quantitative RCFT scores. We analysed the influence of execution time by repeating the MANOVA with the execution time of the RCFT-copy as dependent variable. Norm scores were used for the WAIS-IV-NL. We analysed the influence of execution time by repeating the MANOVA with the execution time of BD without time bonuses (BDN) as dependent variable. The alpha level was set to .05 and partial eta squared (η^2) was used as an indicator of effect size. Furthermore, the frequencies of 'impaired'/'average'/'high' performance scores were counted. Scores were labelled 'impaired' if skill scales $\leq M - 1.5SD$ of published norm groups as provided by the test authors. Scores were labelled 'high' if skill scales $\geq M + 1.5SD$ of published norm. Chi-square tests were used to test whether the groups differed in these frequency distributions. To check for effects of medication, these analyses were repeated while excluding participants on a specific medication (only when more than 4 participants used a specific type of medication). The second hypothesis regarding the strategy of copying the RCFT was tested using ANOVA, dependent variables were Q-score, and BQSS scores and independent variables ASD/TD. For some variables (perseveration immediate and delayed recall, perseveration delayed recall, cumulative percentage and copy-immediate recall) unpaired t-tests had to be executed, because variances between groups were unequally distributed. The alpha level was set to a conservative .01 in order to correct for the number of comparisons. Due to missing values in two TD participants, only quantitative RCFT scoring was possible for these participants. Pearson correlations were computed between test scores, to gain insight into convergent validity. Interrater reliability of the BQSS-scoring and Q-scoring was computed by correlating (Pearson correlation) the scores of 19 participants (mixed ASD and TD) by two trained assessors.

For the third hypothesis, regarding the relationship between ASD-symptoms and the reproduction style, Pearson (for scale variables) or Spearman (for ordinal variables) correlations were computed between the SRS-A scales (total, SA, SC, SM, and RR) and the performance scores on the RCFT and the WAIS subtests BD, VP, MR, SS, C and PC). The alpha level was set to a conservative .01 in order to correct for the number of comparisons.

We used t-tests for independent samples in order to test for group differences in age, educational level, Full Scale IQ, and SRS-A self- and proxy scores. For the SRS-A, we tested the agreement between self- and proxy ratings through paired t-tests for the self- and proxy rating in each group and by computing Pearson correlation between the self and proxy ratings in each group. Scores on the SRS-A were labelled as "high social responsiveness" if T-scores < 40 ; "normal social responsiveness" if T-scores ≥ 40 and < 60 ; "moderate social deficiencies" if T-scores ≥ 60 and < 76 ; "severe social deficiencies" if T-scores ≥ 76 .

3. Results

3.1. Participant characteristics

There were no significant differences between autistic and TD participants in age, educational level, Full Scale IQ score or the

separate indexes of the WAIS-IV (Table 1). Autistic participants showed significantly more symptoms on the SRS-A, as measured via self-report and proxy report, than TD participants (SRS-A self $F(1,71) = 55.1$, $p < .001$, SRS-A proxy $F(1,68) = 75.4$, $p < .001$). Self-ratings and proxy-ratings of the different SRS-A subscales did not differ from each other in both groups. Self- and proxy ratings on the SRS-A total score correlated moderately within the group of autistic participants as well as in the TD group (ASD: $r(36) = .42$, $p = .016$; TD: $r(36) = .32$, $p = .057$). This demonstrates reasonable agreement between the self- and proxy report of the SRS-A. We therefore decided to use the SRS-A self-rating for further analyses. Only 13.9 % of the autistic participants and none of the TD participants scored within the range of severe social deficiencies on the SRS-A Self-report. Mild to moderate social deficiencies were reported on the SRS-A by 50 % of the participants with ASD and only 2.8 % of the TD participants. Normal social responsiveness was reported by 80.6 % of TD participants, as could be expected, and by 33.3 % of the autistic participants.

3.2. WAIS PSI and PRI performance and execution time

When comparing performance scores between autistic and the TD participants on the WAIS-IV subtests (Table 1), only one significant group difference was found. Autistic participants outperformed the TD participants on Visual Puzzles. On this time restrained subtest, high scores were obtained by considerably more ASD- than TD-individuals (ASD $n = 10$, TD $n = 2$). The number of impaired scores were equal in both groups (ASD $n = 4$, TD $n = 4$).

3.3. Quantitative scores on the RCFT

Table 2 presents the participants' performance scores and execution time on the RCFT. Performance scores of autistic participants did not differ significantly from those of TD participants. The time required by autistic participants to copy the complex RCFT figure was significantly longer than the time required by controls. No participant had impaired Copy Time scores ($<$ percentile 6 impaired; $>$ percentile 6 not impaired). Two autistic participants and five TD participants had impaired Copy scores.

3.4. Qualitative scores on the RCFT

The inter-rater reliability of the qualitative scoring methods was good. High Pearson's r correlations were found for Q-score: $r = 0.98$ ($p < .01$) for Unit score and $r = 0.97$ ($p < .01$) for Order score. The correlation for total Q-score was 0.99 ($p < .01$). The BQSS inter-rater reliability ranged between $r = 0.72$ and 1.00 ($p < .01$) for the different subscales.

No significant RCFT Q-score or BQSS differences were found between autistic and TD participants (Table 3). Only one variable approached significance (the BQSS cumulative Perseveration score), which indicated a tendency for more perseverations by autistic participants in the Immediate Recall condition.

3.5. Correlations SRS-A and RCFT

Correlations were calculated to examine the relationship between autism-symptoms and RCFT performance in autistic participants (Table 4) and TD participants (Table 5). Following our hypothesis, a relationship between the SRS-A scales and the performance on the RCFT copy and reproducing style was expected. No significant ($p < .01$) correlations were found between the SRS-A scale scores and the RCFT performance scores in both groups. In the TD group correlations between autism-symptoms (especially social communication) and copy times were positive, and between symptoms and performance scores on the recognition task negative.

Table 2

Quantitative RCFT scores: Means and standard deviations of RCFT performance and RCFT copy execution time for ASD participants and TD participants. Frequencies of impaired, average and high scores are given for ASD participants and TD participants.

RCFT subtests	ASD M (SD)	TD M (SD)	Cohen's d	ASD frequencies I/A/H	TD frequencies I/A/H
Copy time (s)	170.9 (73.0)	137.8 (43.3)	0.55*		
Copy raw	33.2 (2.4)	32.6 (2.9)	0.21		
IR raw	21.2 (7.5)	19.0 (5.5)	0.33		
IR %	69.3 (32.5)	62.3(29.5)	0.22		
IR (T-score)	57.3 (15.5)	54.1 (12.0)	0.23	4/23/11 ^a	2/27/7 ^a
DR raw	20.3 (7.2)	17.8 (5.5)	0.38		
DR %	65.6 (33.3)	57.2 (33.1)	0.25		
DR (T-score)	55.9 (15.0)	51.6 (12.8)	0.31	4/22/10 ^a	3/29/4 ^a
Rec raw	20.1 (1.7)	20.2 (1.8)	0.24		
Rec %	55.3 (27.7)	48.5 (30.7)	0.23		
Rec (T-score)	51.5 (9.4)	49.0 (10.0)	0.24	1/34/1 ^a	4/31/1 ^a

ASD = Autism Spectrum Disorder; TD = Typically Developing; I = Impaired ($\leq M - 1.5SD$); A = Average ($M - 1.5SD < \text{value} < M + 1.5SD$); H = High ($\geq M + 1.5SD$); RCFT = Rey Osterrieth Complex Figure Test; raw = raw score; % = percentile score; IR = Immediate Recall; DR = Delayed Recall; Rec = Recognition; ^a = impaired if $> M + 1.5SD$, high score if $> M - 1.5SD$; * = $p < .05$.

Table 3

Overview Local-global Q-score and BQSS: Fragmentation, organisation & planning scores. BQSS preservation scores. Total Q- score and BQSS summary scores.

Scoring method	Score	ASD Mean (SD)	TD Mean (SD)	statistics
Q-score	Fragmentation	13.2 (2.9)	12.8 (2.6)	F(1.69) = 0.43, p = 0.52
	Planning	2.4 (2.5)	1.6 (2.0)	F(1.69) = 1.95, p = 0.17
	Total	15.6 (5.2)	14.4 (4.2)	F(1.69) = 1.13; p = 0.29
BQSS Fragmentation	Fragmentation RS	2.8 (1.1)	2.89 (0.98)	F(1.71) = 0.05, p = 0.82
	Fragmentation CP	68.1 (35.5)	67.3 (31.7)	F(1.70) = 0.01, p = 0.91
Planning	Planning RS	2.1 (1.1)	2.4 (1.2)	F(1.69) = 1.15, p = 0.29
	Planning CP	42.1 (6.8)	51.3 (38.1)	F(1.69) = 1.06, p = 0.31
Organisation	Organisation RS	4.9 (2.0)	5.3 (1.9)	F(1.69) = 0.56, p = 0.46
	Organisation (T)	43.7 (15.12)	47.0 (15.1)	F(1.69) = 0.79, p = 0.38
Accuracy and Presentation	AP copy (T)	54.6 (7.9)	52.5 (8.1)	F(1.71) = 1.19, p = 0.28
	AP IR	55.5 (10.3)	52.3 (7.3)	F(1.71) = 2.42, p = 0.12
	AP DR	54.4 (11.2)	52.8 (8.1)	F(1.71) = 0.46, p = 0.50
Mean Difference	MD Copy IR	54.4 (11.6)	51.3 (6.9)	t = 1.41, p = 0.17
	MD IR-DR	49.1 (9.9)	49.2 (6.2)	F(1.71) = 0.09, p = 0.75
Perseveration	Copy RS	3.8 (0.5)	3.8 (0.8)	F(1.71) = 0.32, p = 0.58
	Copy CP	86.9 (33.0)	87.2 (32.3)	F(1.71) < 0.01, p = 0.97
	IR RS	2.9 (1.3)	2.4 (1.1)	F(1.71) = 3.59, p = 0.06
	IR CP	66.1 (35.3)	50.2 (27.2)	t = 2.14, p = 0.04
				F(1.71) = 1.71,
	DR RS	2.7 (1.3)	2.3 (1.2)	p = 0.19
	DR CP	66.4 (32.6)	56.9 (26.4)	t = 1.35, p = 0.18
	Total RS	3.1 (0.9)	2.8 (0.8)	F(1.71) = 2.88, p = 0.09
	Total CP	73.2 (24.9)	64.8 (20.8)	F(1.71) = 2.39, p = 0.13

ASD = Autism Spectrum Disorder; TD = Typically Developing; RS = raw score; CP = cumulative percentage; AP = accuracy and presentation; IR = Immediate Retention; DR = Delayed Retention; T = t-score; MD = mean difference; m = mean; SD = standard deviation.

Table 4

Correlations SRS-A self and RCFT performance (Pearson & Spearman) ASD participants.

	SRS-A-Total	SA	SC	SM	RR
RCFT					
Copy	$r_s = -.02$	$r_s = .00$	$r_s = -.04$	$r_s = -.22$	$r_s = -.08$
CT	$r = -.25$	$r = -.18$	$r = -.23$	$r = -.23$	$r = -.15$
IR	$r = .10$	$r = -.01$	$r = .05$	$r = .24$	$r = .09$
DR	$r = .04$	$r = -.04$	$r = .02$	$r = .17$	$r = .03$
Rec	$r = -.17$	$r = -.18$	$r = -.23$	$r = -.22$	$r = -.15$

RCFT = Rey Osterrieth Complex Figure Test SRS-A = Adult Social Responsiveness Scale; SA = Social Awareness; SC = Social Communication; SM = Social Motivation; RR = Restricted Interests and Repetitive Behaviour; CT = Copy Time (in seconds); IR = Immediate Recall; DR = Delayed Recall; Rec = Recognition; r = Pearson's; r_s = Spearman's rho.

Table 5

Correlations SRS-A self and RCFT performance (Pearson & Spearman) of TD-participants.

	SRS-A-Total	SA	SC	SM	RR
RCFT					
Copy	$r_s = -.02$	$r_s = .01$	$r_s = -.11$	$r_s = .02$	$r_s = -.01$
CT	$r = .36$	$r = .26$	$r = .40$	$r = .27$	$r = .28$
IR	$r = .00$	$r = -.11$	$r = .06$	$r = .08$	$r = .01$
DR	$r = -.12$	$r = -.26$	$r = -.09$	$r = .08$	$r = -.08$
Rec	$r = -.35$	$r = -.39$	$r = -.42$	$r = -.05$	$r = -.22$

RCFT = Rey Osterrieth Complex Figure Test; SRS-A = Adult Social Responsiveness Scale; SA = Social Awareness; SC = Social Communication; SM = Social Motivation; RR = Restricted Interests and Repetitive Behaviour; CT = Copy Time (in seconds); IR = Immediate Recall; DR = Delayed Recall; Rec = Recognition; r = Pearson's; r_s = Spearman's rho.

3.6. Correlations WAIS and RCFT

Correlations were computed between the RCFT and WAIS-IV-NL variables (see Supplementary information Table 1). A significant correlation between FSIQ and the RCFT IR was found in TD group, but not in the autistic group. As expected, but only for the TD group, there were significant positive correlations between PRI and the RCFT recall conditions (IR and DR).

3.7. Medication

Participants were assessed in their regular on-state of medication. To analyse if specific medication-use influenced the outcomes of this study, we also compared ASD- and TD-groups after excluding participants using the following specific medications: antidepressant, antihypertensive, anti-cholesterol, anti-allergy and stimulant medication (see Supplementary information Table 2). In general, the group results did not differ with or without excluding specific medication use. However, excluding participants with anti-allergens and anti-hypertensives showed that the TD group was no longer significantly faster than autistic participants on the copy trial of the RCFT. All excluded participants had scores within the normal range (percentile >16 %) and none of them had extremely high or low scores. None of the excluded TD participants' time to copy was ≥ 200 s, three of the excluded autistic participants' copy score was ≥ 200 s.

4. Discussion

This study aimed to investigate visual local-global processing style in older adults with and without ASD. The first hypothesis, in which better performance by autistic than TD participants was expected on more local than global information processing tasks, was rejected. The performance of older autistic adults on a test battery tapping local-global visual processing was similar to carefully matched older adults without autism. We had expected poorer performance on the RCFT and better performance on the WAIS-IV Block Design and Symbol Search subtests. The only unexpected performance difference found, was a significantly better performance on the WAIS-IV Visual Puzzles (VP) subtest, with more autistics than TD adults reaching high scores (10 opposed to 2). This finding may be consistent with the EPF model, as this subtest requires good visuospatial mental imagery to mentally rotate the pieces to verify whether they match with the model. Visual (mental) segmentation of the model is also thought to reflect better "local" abilities. VP does not contain distracting (incongruent) details, which are known to cause local-to-global interference in young autistics (Behrmann et al., 2006) and does not draw heavily on motor function and interaction between different cognitive domains. This may explain normal or even better performance of autistic older adults.

Even though quantitative performance on the RCFT of older autistic adults was comparable to their matched-TD adults, they needed significantly more time to copy the complex figure of Rey, which is in line with other studies showing slowed performance on complex visual tasks (Kuschnier et al., 2009). There may be several explanations for this finding. Firstly, it could be in line with both WCC-theory and the EPF-model, because slowing execution time on a complex task may be an adequate compensation strategy for locally-oriented information processing. However, on all time restraint WAIS-IV subtests the autistic group performed equal or even better than the TD group. No speed instruction nor time limit is given for the RCFT copy subtest, therefore participants had no specific indication that the speed of copying was of importance, which in itself could lead to differences between groups. For example, some autistic characteristics might lead these individuals to take more time (rigidity, attention to details, less consideration for the fact that the administrator is observing/waiting, etc.). Secondly, medication may influence speed of processing. Analysis of medication effects revealed that excluding participants with anti-allergens and anti-hypertensives indeed resulted in less pronounced differences between groups on the RCFT copy time. However, none of the excluded autistic participants had extremely slow scores and none of the excluded TD participants had extremely fast scores. Cognitive side effects were not anticipated for these medicines but were expected with psychotropic medication. Excluding participants using medication for psychiatric conditions had no effect on group differences. These checks for medication effects suggest that the longer execution time on a complex visual processing task is specific for ASD and not confounded by psychiatric comorbidity and its treatment.

A third explanation of increased RCFT copy time could be the use of a different drawing strategy, which led us to our second hypothesis. We had expected that (at least part of) the autistic participants would employ a local, more fragmented style of copying and reproducing the RCFT than TD older adults. To test this second hypothesis, we used two qualitative scoring methods for the RCFT to analyse the reproduction strategies, organisation, accuracy, style and type or errors of participants. No support was found for this second hypothesis, because no significant differences ($p < .01$) between groups were found on these qualitative scoring measures. Therefore, it is not likely that the longer RCFT copy time is due to a more fragmented style of copying, and it is more likely that other autistic characteristics lead these individuals to take more time.

All in all, this study provides no evidence for the WCC in older adult autistics, in contrast to positive findings in children/adolescents (Rosa et al., 2017; Schlooz et al., 2006; Van Eylen et al., 2018). The enhanced performance on the Visual Puzzles subtest supports enhanced local processing of the autistic participants, which is in line with the EPF model (in at least a subsample of the older autistic participants). Unlike in young autistics, there is a growing evidence that cognitive functioning is not impaired in older adult autistics with average or above average intelligence (Davids et al., 2016; Geurts et al., 2020; Tse, Crabtree, Islam, & Stott, 2019). One interesting explanation could be that autistics are (partially) 'growing out of deficit' due to the presence of protective factors and/or as result of an altered brain development across the lifespan (Campbell, Chang, & Chawarska, 2014; Hazlett et al., 2017; Oberman & Pascual-Leone, 2014; Walsh et al., 2019). In the presence of protective factors, autistic adults may start using different cognitive strategies activating different neural regions in visual-spatial tasks (Ring et al., 1999) and/or using compensatory strategy learning

(Livingston, Shah, Milner, & Happé, 2020; Tang, Chen, Falkmer, Bölte, & Girdler, 2019). Recently a new hypothesis was formulated by Oberman and Pascual-Leone (2014), stating that the cortex of the ASD brain is characterized by a relative hyperplasticity from an early age, which protects them from cognitive decline at a later age. The recent studies on cognition in older autistic adults, finding merely intact cognitive profiles (Davids et al., 2016; Geurts et al., 2020; Tse et al., 2019), are in line with this hypothesis.

Nevertheless, sixty-four percent of the autistic participants reported mild to moderate deficiencies in social responsiveness, and fourteen percent of the autistic participants reported severe deficiencies. Our included autistic group can be described as moderately severe, which is not likely to be the result of limited symptom insight of the autistic participants because the agreement between the proxy and self-report was acceptable. All included autistic participants had received their ASD diagnosis in adulthood and it is most likely that late first-diagnosed autistic individuals (after the age of 20 years) have less severe symptoms than adults with an early ASD-diagnosis (in childhood or adolescence) (Happé & Charlton, 2012; Hull et al., 2017; Jones, Goddard, Hill, Henry, & Crane, 2014; Lehnhardt et al., 2012). Factors explaining relatively less severe outcomes on the SRS-A may be related to the presence of protective factors; protective personal factors include effective coping skills, and protective environmental factors may be supporting partners/spouses, fitting work, or retirement (Frank et al., 2018; Howlin & Magiati, 2017; Lehnhardt et al., 2016; Stagg & Belcher, 2019). All of the included autistic participants, however, had a motive to seek professional help.

The severity of self-reported autism-symptoms of the ASD group were not associated with RCFT performance (all correlations $p \geq .01$), and therefore our third hypothesis was also rejected. This finding is not in line with the WCC hypothesis, that assumes weaker CC to be predictive of more autistic symptoms. However, findings to date have been mixed (Van der Hallen et al., 2015), which may be related to the adopted task paradigm. Neufeld et al. (2020), for example, assessed global processing with the Fragmentary Picture Test (FPT; Kessler, Schaaf, & Mielke, 1993) in which subjects were shown fragmented pictures and could gradually ask for more information (10 steps per item) to form into a meaningful whole. This task seems more suitable than the RCFT (see also limitations section) to investigate CC because it taps on global information processing, visual imagination and the process of concept formation. A higher level of ASD characteristics were related to a greater need for visual information to recognize the FPT figures. Generally, this finding could also be due to the ecological validity of neuropsychological assessments: the test situation is more structured and less complex than everyday life in which symptoms occur. Nevertheless, self-reported complaints by means of questionnaires and cognitive test performance provide valuable complementary information in the diagnostic process (Davids et al., 2016; Geurts et al., 2020).

4.1. Strengths and weaknesses

This study performed extensive neuropsychological assessment of an understudied age group; late-diagnosed high functioning older autistic adults. The careful matching of TD adults by age, sex and educational level is also a strength of the study design. Furthermore, we took a clinical approach, using various instruments commonly used in clinical neuropsychological practice. In addition to the traditional quantitative measures of local-global visual processing, we also gained insight into strategic approaches to task performance by using qualitative scoring systems of the RCFT.

Even though our choice of tests is clinically relevant, they may not be optimally suitable to measure local-global information processing. Both the RCFT and the WAIS-IV subtests have been designed for other purposes. The WAIS-IV subtests are part of an intelligence test with the purpose of measuring non-verbal abstract reasoning. The RCFT was originally developed to assess visual memory and visual-constructional ability in adults with brain damage. Even though local-global processing is captured by these tests, they also call upon other cognitive domains, a phenomenon called task impurity. It is therefore difficult to disentangle the performance components and one should be careful to draw conclusions about visual information processing based on these tasks alone. Future research needs to replicate our findings with experimental tasks, that have been designed to measure CC, such as the FPT (Kessler et al., 1993).

Because we included a rare diagnostic group, our findings have limited generalizability. Our study sample had a male/female ratio of 30/6, and all participants had at least average verbal abilities and all received their first ASD diagnosis in adulthood. Precise age at first diagnosis of autistic participants was not recorded at inclusion; this could have provided information about changes in cognitive functioning or severity of autism-symptoms over time.

4.2. Implications

We found no evidence that neuropsychological tests measuring local-global processing that are commonly used in clinical practice are sensitive to late-diagnosed older autistic adults. Using such tests in the diagnostic process is therefore only advised for describing the strengths and weaknesses of individual patients. Using the combination of a quantitative and a qualitative scoring system of the RCFT can elucidate the preferred visual information processing style. The qualitative scoring delivers several interesting variables related to WCC, but are demanding and time-consuming for the neuropsychologist during the assessment (coding of the drawing order) and scoring (many variables have to be scored) of the test. Compared to the BQSS, the Q-score is least time-consuming and provides quick information about the planning and fragmentation strategies.

The execution time of older autistic adults was slowed in a complex visual processing task requiring top-down processing. As daily life often calls upon top-down information processing, autistic adults presumably need more time than their TD peers for optimal performance.

Longitudinal research is needed to unravel the relationship between brain development and autistic symptoms across the lifespan, including old age. We recommend long-term case-control studies with a balanced male/female ratio and comparing early and late diagnosed individuals to improve understanding of the development of (visual) information processing of autistic individuals.

4.3. Conclusion

Using visual local-global processing tests common to clinical practice, this study provides no evidence for a weak central coherence but some support for enhanced perceptual functioning in late-diagnosed high functioning older autistic adults. There was no evidence for altered strategic approaches during the completion of a complex visual information processing task (RCFT). These findings are in line with previous matched-control studies, finding intact cognitive profiles in older autistic adults (Davids et al., 2016; Geurts et al., 2020; Tse et al., 2019). Together, these first studies raise interesting neurodevelopmental hypotheses regarding ageing in autism that warrant testing by means of longitudinal studies. Do older autistic adults (partially) "grow out of deficit" because of a hyperplastic brain (Oberman & Pascual-Leone, 2014), do they apply more adequate compensation strategies or does a late diagnosed group possess more cognitive reserve?

CRedit authorship contribution statement

Roeliena C.D. Davids: Conceptualization, Formal analysis, Methodology, Project administration, Investigation, Writing - original draft. **Yvonne Groen:** Conceptualization, Formal analysis, Methodology, Supervision, Writing - original draft, Writing - review & editing. **Ina J. Berg:** Conceptualization, Methodology, Supervision, Writing - review & editing. **Oliver Tucha:** Conceptualization, Supervision, Writing - review & editing. **Ingrid D.C. van Balkom:** Conceptualization, Methodology, Supervision, Writing - review & editing.

Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.rasd.2020.101655>.

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