RESEARCH ARTICLE

Executive Functioning in Men and Women with an Autism Spectrum Disorder

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Executive functioning (EF) is thought to be linked to autism spectrum disorders (ASD) specific symptoms. The majority of research has focused on children and adolescents with ASD and, therefore, little is known about EF in adults. Furthermore, little is known about gender differences. Ninety-nine men and forty women with ASD were compared with and 35 neurotypical men 25 neurotypical women. Participants were matched on age, total intelligence, and verbal ability. The following instruments were used to measure executive functioning: digit span and letter and number sequencing of the WAIS-III, Tower of Hanoi, WCST, and Verbal fluency. Multiple analysis of variance was conducted to determine group differences. Women with ASD performed worse on the working memory tasks of the WAIS-III than neurotypical women. Furthermore, women with ASD had more perseverations on the WCST than neurotypical women. The gender comparison in the ASD group showed differences in performance on mental flexibility (WCST), working memory (WAIS-III), generativity and self-monitoring (Verbal fluency). However, these differences were unequivocal and no gender specific cognitive profile could be pinpointed. Individual strengths and frailties should be highlighted in clinical practice, as impairments in EF can be under influence of the overall cognitive abilities of the individual. Furthermore, gender differences were found. This could explain differences in representation of ASD symptoms in both groups. These differences show how important thorough diagnostics are. ***Autism Res** 2016, 0: 000–000*. © 2016 International Society for Autism Research, Wiley Periodicals, Inc.

Keywords: autism; executive functioning; gender differences; females with autism

Introduction

Executive functioning refers to mental processes that are necessary to attain personal goals in an environment that is changing constantly [Jurado & Rosselli, 2007]. Executive functions include cognitive capacities like planning, working memory, impulse control, inhibition, and shifting set, as well as initiation and monitoring of action [Hill, 2004a]. Impairments in these capacities are observed in several psychiatric conditions, for example, attention deficit disorders, obsessive compulsive disorder, and schizophrenia [e.g., Pennington & Ozonoff, 1996; Rajendran & Mitchell, 2007]. There is broad evidence that impairments in executive functioning are also present in autism spectrum disorders (ASD). Executive functioning is thought to be linked to ASD specific symptoms [Lopez, Lincoln, Ozonoff, & Lai, 2005; Ozonoff, Pennington, & Rogers, 1991; Rajendran & Mitchell, 2007] and this theory is described as the "executive function theory of ASD."

The executive function theory of ASD describes that individuals with ASD have impaired mental control, which undercuts problem solving strategies that are needed to obtain a future goal [Hughes & Russell, 1993; Lopez et al., 2005; McEvoy, Rogers & Pennington, 1993; Prior & Hoffmann, 1990]. Executive dysfunction has been hypothesized to explain ASD typical behaviors like rigidity, preservation, specific interests and problems with changing environments [Lopez et al., 2005]. It may also account for the need for sameness, the preference of repetitive actions, inhibitory impairment and difficulties initiating and switching tasks, which are often seen in individuals with an ASD [Hill, 2004a; Rajendran & Mitchell, 2007].

A variety of studies has shown that many individuals with ASD experience impairments in executive functioning, compared with neurotypical individuals. However, the majority of studies suggesting this, only addressed executive (dys)function in children and adolescents. Diagnosing ASD in adulthood is relatively "new," wherefore it seems reasonable that research concerning adults is limited compared with research on children and adolescents. As executive functions develop over time (e.g., the ability to plan tends to improve after adolescence) [Hill, 2004a] research on the relationship of executive dysfunction and ASD specifically during adulthood is of great clinical relevance to optimize the diagnostic process and improvement of treatments.

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Another important issue that needs to be addressed is possible gender differences regarding executive functioning in adults with ASD. Due to an apparent bias toward a male presentation of ASD symptoms, women are less likely to be identified with ASD, even when their symptoms are equally severe as in men [Dworzynski, Ronald, Bolton, & Happé, 2012; Gould & Smith, 2011]. ASD in women is often presented in different ways than in men, which might be explained by the "camouflage hypothesis," which yields that women with ASD are more successful in (sometimes unintentionally) masking their impairments with learned strategies compared to men with ASD [Dworzynski et al., 2012; Gould & Ashton-Smith, 2011]. Furthermore, there is evidence that the biological underpinnings of ASD are gender specific [Lai et al., 2013], which could also contribute to gender differences on the cognitive level and therefore influence the presentation of ASD typical symptoms. Further research is necessary to examine more thoroughly the differences in executive functioning between men and women with ASD.

One of the few studies focusing on gender differences in cognitive functioning in adults with ASD, has been conducted by Lai et al. [2011]. Lai and colleagues examined gender differences in four groups of 32 adults with above average intelligence: men and women with ASD and neurotypical men and women. Lai et al. [2011] concluded that "cognitive profiles in ASD are modulated by sex." Both sexes showed reduced sensitivity to signal detection and were slightly impaired in simple response inhibition in comparison to neurotypical subjects. Only the male subjects with ASD had impaired performance on a task measuring motor coordination, inhibition, planning, and motor speed. The results also showed that phonological memory and (word) generativity were not impaired in men and women with ASD. We expect to find the same differences in this study. An impairment of the study of Lai and colleagues [2011] is that the men had lower total IQ scores than the women. This may have influenced the gender specific differences in planning abilities. Research using better matched groups is needed to further examine the existence of gender differences. Further research is needed to identify whether differences found (or not found) in earlier studies are due to sample differences in cognitive abilities, or reflected real differences. In this study, we will examine EF in men and women with ASD and in male and female controls, taking into account the impairments of previous studies.

Methods

Participants and Procedure

All participants ($N = 199$) were recruited from the Adult Autism Center in Eindhoven, the Netherlands (participant characteristics are presented in Table 1). Experienced and trained psychologists diagnosed ASD based on the evaluation of historic and current symptomatology. Parents or siblings were also interviewed using the Dutch translation of the Autism Diagnostic Interview Revised [ADI-R: Lord, Rutter, & Le Couteur, 1994] to gather information about the early childhood and development of each subject. Furthermore, subjects took part in a semistructured interview to evaluate former and current symptomatology. The semistructured interview is based on the criteria of the DSM-IV-TR for ASD [American Psychiatric Association (APA), 2000] and has been used in previous studies for diagnostic classification [e.g., Spek, Scholte, & Van Berckelaer-Onnes, 2008, 2009]. The Autism Diagnostic Observation Schedule (ADOS) [Lord, Rutter, DiLavore, & Risi, 1999] is an instrument that also can be used to asses ASD characteristics. As research has shown that the ADOS is under-inclusive in diagnosing verbally able women with ASD [Lai et al., 2011], we decided to omit the ADOS from our assessment protocol. In concordance with the DSM-5, ASD are best represented as a single diagnostic category [APA, 2013]. Therefore, all participants with ASD (Autism, Asperger Syndrome, or PDD-NOS) were included. Participants were between 19 and 60 years. Participants were excluded if total intelligence score and scores on the scales measuring verbal comprehension and perceptual organization were below 90 points as measured by the Wechsler Adult Intelligence Scale III [WAIS-III, Dutch translation: Wechsler, 2001]. This was done to ensure normal cognitive abilities. The psychometric qualities of the Dutch version of the WAIS-III are sufficient [Commissie Testaangelegenheden Nederland [COTAN], 2002]. Participants were not allowed to take part in the study if they were institutionalized, suffered from other (genetic) conditions or neurodevelopmental disorders other than ASD or had a drugs and/or alcohol dependency.

Measures

Different tasks were used to investigate a variety of executive processes in the subjects. Psychology students who were experienced in the assessment of ASD and who were not involved in the treatment procedure administered the tasks. Participants were given instructions for each task as provided by the specific task manual. Executive functioning was assessed on the areas of planning, mental flexibility, working memory, generativity, and self-monitoring.

Planning. *Tower of Hanoi.* The Tower of Hanoi [Simon, 1975] is a typical task used to assess planning [Hill, 2004b]. The subject was presented three bars and five pegs. On the left bar, the five pegs were arranged by size. The participant had to move the disks from this prearranged sequence to one of the other two bars and pile them up in the same order as in the begin state.

Table 1. Subject Characteristics and Matching Variables

	Males ASS (N = 99)	Females ASS (N = 40)	Neurotypical males (N = 35)	Neurotypical females (N = 25)
Age	38.03 (9.39)	34.92 (10.71)	39.16 (11.44)	36.14 (10.78)
TIQ	109.62 (12.44)	107.86 (12.14)	112.05 (9.31)	108.84 (8.39)
VCI	108.57 (14.26)	108.09 (11.31)	110.80 (9.83)	109.16 (10.91)

$^*P \leq 0.05$; $^{**}P \leq 0.01$; $^{***}P \leq 0.005$.

The participant had to obey three rules: (1) disks had to be arranged individually; (2) bigger disks had to be placed under the smaller disks (so a bigger disk would not be placed on a smaller disk); and (3) disks could only be placed on the bars (not on the table for example). The participants were asked to complete this task with as few as possible movements and as quick as possible. The time limit was set on 20 min. The experimenter counted the number of movements and errors and measured the time needed to achieve the goal state. The reliability analysis showed a Cronbach's alpha of .218 in this sample, which indicates poor reliability, therefore, the scores that can be derived from the test should be interpreted separately.

Mental flexibility. *Wisconsin Card Sorting Task (WCST).* The original version of the WCST has been developed by Heaton, Chelune, Talley, Kay, and Curtiss [1993]. The WCST can be used for the assessment of different cognitive abilities, for example, to determine perseverance, abstract thinking, and strategical planning. A computerized Dutch version of the Wisconsin Card Sorting Task [van Schijndel, 1994] was used to reduce social task demands, which can influence performance. During the task, the participant had to sort cards according to three different nonspoken rules (color, number, and shape) on a computer. After each choice, the participant received immediate feedback on whether his or her choice was right of wrong. The task stopped when all cards were used or when the subject used all six categories do sort the cars. The number of perseverative errors, nonperseverative errors and completed strategies were measured. The Cronbach's alpha of –.163 in this study indicates that the scores should be interpreted separately, since this value is unacceptable [George & Mallery, 2003].

Working memory. *WAIS-III tasks.* Working memory is assessed using the tasks of the working memory index scale (WMI) of the in Dutch translated WAIS-III (2001). The tasks used to assess working memory are: digit span and letter-number sequencing. The arithmetic subtest was omitted from the analysis since this subtest has been shown to have a poor contribution to the measurement of working memory in the WAIS-III [Hill et al., 2010]. The reliability analysis showed a Cronbach's alpha of .713 in this sample, which is acceptable [George & Mallery, 2003].

Generativity and self-monitoring. *Semantic and phonemic fluency.* To measure semantic fluency, subtasks of the Groninger Intelligentie Test [GIT 2: Luteijn & Barelds, 2004] were used. Subjects had to generate as many as possible words in a given category and within 60 sec. During the first part, participants had to name animals and during the second part professions had to be named. The reliability analysis showed a Cronbach's alpha of .709 for the semantic fluency task in this sample, which is acceptable [George & Mallery, 2003].

The second task, originally designed by Benton [1968] and adjusted for the use in the Netherlands and Flanders [Verté, Geurts, Roeyers, Oosterlaan, & Sergeant, 2006], measured phonemic fluency. The reliability analysis for phonemic fluency also showed an acceptable Cronbach's alpha of .782. The subjects had to name as many words as possible starting with a given letter within 60 sec. During the first part, they had to name words that started with the letter "K" and during the second part words that started with "M". Participants were not allowed to repeat words, use names of people or to only alter the stem of compounded words to create a new word (e.g. door, doormat, doorknob, etc.). When an error was made, the response in question was eliminated from the total score.

Matching

Participants were matched on age, total IQ (TIQ) and Verbal Comprehension (VCI), measured using the Dutch version of the WAIS-III [Wechsler, 2001], in order to make a reliable comparison on their performance on the executive tasks and to ensure normal levels of cognitive function. Subjects were matched on verbal ability since executive function is thought to be influenced by this ability [Crawford, Moore, & Cameron, 1992; Crawford, Obonsawin, & Bremner, 1993]. Means and standard deviations for each variable are presented in Table 1. The four groups were compared using one-way analysis of variance (ANOVA).

Results showed no significant effect of diagnosis and gender on age ($F(1, 195) = .001$, $P = .977$, partial

$\eta^2 = .000$), TIQ (F(1, 195) = .157, $P = .693$) and VCI (F(1, 195) = .082, $P = .775$, partial $\eta^2 = .000$). These results indicate that assumptions to compare groups using analysis of variance are met.

Statistical Analysis

Statistical analyses were conducted using SPSS version 19 [IBM Corp., 2010]. Gender (1. Male; 2. female) and diagnoses (1. ASD; 2. control) were used as fixed factors. Multivariate analysis of covariance (MANCOVA) was conducted using TIQ and VCI scores as covariates in all analysis, wherefore no posthoc correction was needed. The scores retrieved from the tasks were used as dependent variables. The alpha-level was set at .05. First, the main and interaction effects for each domain were analyzed. If Box's Test of Equality of Covariance Matrices was calculated and the result was significant, this result is likely to be not robust and true as different sample sizes were compared [Tabachnick & Fidell, 2001]. However, the more conservative Pillai's Trace was used to interpret the main and interaction effects if the Box's test was significant. Pillai's trace offers the greatest protection against Type I errors with small sample sizes and is the most robust in interpreting effects. If no Box's Test could be conducted or the test was not significant, Wilks' Lambda was used for interpretation of the effects. Three comparisons were conducted between genders versus diagnoses. First, men with ASD and neurotypical men were compared. The same comparison was conducted for women. Third, men and women with ASD were compared.

Results

Planning

Table 2 shows the mean scores, standard deviations and levels of significance for group comparisons on the Tower of Hanoi task. Pillai's trace will be used to interpret main and interaction effects of the assessment of planning.

No main effects have been found for gender (F(8, 122) = 1.25, $P = .276$, partial $\eta^2 = .076$) and diagnosis (F(8, 122) = 1.087, $P = .377$, partial $\eta^2 = .067$). Furthermore, no interaction effect for gender and diagnosis on the planning measurements have been found (F(8, 122) = .780, $P = .621$, partial $\eta^2 = .049$). Analyses showed no main effects of the covariates TIQ ($P = .078$) and VCI ($P = .645$) on the performance on planning tasks.

Mental Flexibility

Table 3 shows the mean scores, standard deviations and levels of significance on the planning tasks. Multivariate analysis has been carried out for the total score on the WCTS and the results showed no main effects for diagnosis (F(7, 184) = .9, $P = .507$, partial $\eta^2 = .033$,) and gender (F(7, 184) = .677, $P = .691$, partial $\eta^2 = .025$). Also, no interaction effect for diagnosis and group has been found (F(7, 184) = 1.229, $P = .289$, partial $\eta^2 = .045$). A main effect was found for TIQ (F(7, 184) = .104, $P = .005$, partial $\eta^2 = .104$) which could indicate that the total IQ was related to the performance on the WCST in all groups. It has to be noted that men and women with ASD had slightly lower intelligence scores. Therefore, differences were investigated on group level to determine the directionality of the relationship.

Men with ASD had significant more perseverative errors than neurotypical men (F(3, 76) =3.798, $P = .014$, partial $\eta^2 = .13$). The same difference was found for women with ASD and neurotypical women (F(3, 46) = 2.814, $P = .05$, partial $\eta^2 = .155$). The gender comparison in the ASD group showed that men with ASD made fewer perseverative errors than women with ASD (F(3, 68) = 3.202, $P = .029$, partial $\eta^2 = 124.$). This indicates that the men and women with ASD performed worse than neurotypical subjects and men with ASD had lesser perseverations than the women with ASD.

Compared with neurotypical men, men with ASD also made more non-perseverative errors (F(3, 76) = 3.781, $P = .14$, partial $\eta^2 = .13$). Women with ASD, however, did not differ from neurotypical women (F(3, 46) = 1.958, $P = .134$, partial $\eta^2 = .113$). Women with ASD made fewer nonperseverative errors than men with ASD (F(3, 68) = 4.813, $P = .004$, partial $\eta^2 = .175$).

Men with ASD made more nonperseverative errors compared with women with ASD and neurotypical men. Furthermore, men with ASD completed fewer strategies than neurotypical men (F(3, 76) = 5.275, $P = .002$, partial $\eta^2 = .172$). Women in both groups had a roughly equal number of completed strategies (F(3, 46) = 2.456, $P = .\ 075$, partial $\eta^2 = .138$). But, women with ASD completed more strategies than men with ASD (F(3, 68) = 4.813, $P = .004$, partial $\eta^2 = .175$). As for nonperseverative errors, men with ASD completed significant fewer strategies compared to women with ASD and compared to neurotypical men.

Working Memory

Means, standard deviations and levels of significance on the working memory tasks are presented in Table 4. Pillai's trace will be used to interpret main and interaction effects of the assessment of working memory. There was no main effect of gender (F(2, 192) = 1.96, $P = .144$, partial $\eta^2 = .020$) and diagnosis (F(2, 192) = .007, $P = .993$, partial $\eta^2 = .000$). No interaction effect was found (F(2, 192) = .058, $P = .994$, partial $\eta^2 = .001$). TIQ was shown to be of influence on the

Table 2. Mean Scores, Standard Deviations and Level of Significance regarding the Planning Task

Tower of Hanoi	Men with ASD	Neurotypical men	Women with ASD	Neurotypical women
Number of movements	57.89 (27.11)	59.29 (20.39)	54.65 (20.56)	60.71 (21.75)
Total time	275.54 (195.42)	288.41 (236.35)	286.92 (188.93)	333.54 (203.36)
Level of significance	Men ASD versus neurotypical men	Women ASD versus neurotypical women	Men ASD versus women ASD	
Number of movements	.426	.743	.692	
Total time	.531	.058	.227	

$*P \leq 0.05$; $**P \leq 0.01$; $***P \leq 0.005$.

Table 3. Mean Scores, Standard Deviations and Level of Significance on the Mental Flexibility Task

	Males ASD	Neurotypical males	Females ASD	Neurotypical females
Perseverative errors	11.26 (13.51)	9.21 (9.19)	12.12 (17.71)	11.67 (13.63)
Non-perseverative errors	17.48 (14.93)	13.12 (13.33)	11.65 (12.16)	13.29 (13.52)
Completed strategies	4.15 (2.49)	5.18 (1.7)	4.92 (2.13)	4.5 (2.3)
Level of significance	Men ASD versus neurotypical men	Women ASD versus neurotypical women	Men ASD versus women ASD	
Perseverative errors	.014*	.050*	.029*	
Non-perseverative errors	.014*	.134	.004***	
Completed strategies	.002***	.075	.004***	

$*P \leq 0.05$; $**P \leq 0.01$; $***P \leq 0.005$.

Table 4. Mean Scores, Standard Deviations and Level of Significance on Working Memory Tasks

	Males ASD	Neurotypical males	Females ASD	Neurotypical females
Digit span	10.3 (3.29)	10.74 (2.37)	10.81 (2.3)	10.96 (2.14)
Letter-number sequencing	11.15 (3.24)	11.32 (3.14)	10.88 (2.83)	11.08 (2.65)
Level of significance	Men ASD versus neurotypical men	Women ASD versus neurotypical women	Men ASD versus women ASD	
Digit span	.000***	.009**	.000***	
Letter-number sequencing	.000***	.006**	.000***	

$*P \leq 0.05$; $**P \leq 0.01$; $***P \leq 0.005$.

performance on the working memory tasks (F(2, 192) = 36.321, $P = .000$, partial $\eta^2 = .274$). Men and women with ASD had slightly lower intelligence scores compared to neurotypical subjects. Therefore, the differences for gender and diagnosis were investigated on single measurement level to determine the directionality of the relationships.

Men with ASD reproduced shorter digit spans than neurotypical men (F(3, 76) = 16, $P = .000$, partial $\eta^2 = .387$). Also, women with ASD had more difficulty with digit spans than neurotypical women (F(3, 46) = 4.37, $P = .009$, partial $\eta^2 = .222$). Women with ASD however were able to produce longer digit spans than men with ASD (F(3, 68) = 9.324, $P = .000$, partial $\eta^2 = .291$). Men with ASD also had more difficulty with letter-number sequencing than neurotypical subjects (F(3, 76) = 7.467, $P = .000$, partial $\eta^2 = .228$). The same group difference was found in women, where neurotypical women had longer letter-number sequences than women with ASD (F(3, 46) = 4.784, $P = .006$, partial $\eta^2 = .238$). Men with ASD were able to produce longer sequences than women with ASD (F(3, 68) = 9.324, $P = .000$, partial $\eta^2 = .291$).

Generativity and Self-Monitoring

Mean scores, deviations and levels of significance are represented in Table 5. A main effect was found on the overall fluency tasks for diagnosis (F(4, 188) = 5.635, $P = .000$, partial $\eta^2 = .107$), but not for gender (F(4, 188) = 1.739, $P = .143$, partial $\eta^2 = .036$). No interaction effect was found for gender and diagnosis on the performance on fluency tasks (F(4, 188) = .188, $P = .944$, partial $\eta^2 = .004$). Total intelligence had a main effect on the fluency tasks (F(4, 188) = 7.934, $P = .000$, partial $\eta^2 = .144$) and men and women with ASD had slightly lower intelligence scores.

Table 5. Mean Scores, Standard Deviations and Levels of Significance on Generativity and Self-Monitoring Tasks

Semantic fluency	Males ASD	Neurotypical males	Females ASD	Neurotypical females
Animals	24.80 (6.13)	26.62 (5.81)	25.62 (5.92)	26.46 (6.62)
Professions	18.74 (5.3)	22.15 (4.58)	20.31 (5.08)	22.37 (5.67)
Phonemic fluency				
Letter 'K'	14.85 (4.52)	16.06 (3.81)	14.15 (4.31)	16.21 (4.81)
Letter 'M'	12.96 (4.48)	14.56 (4.31)	14.19 (4.72)	16.88 (5.51)
Level of significance	Men ASD versus neurotypical men	Women ASD versus neurotypical women	Men ASD versus women ASD	
Semantic fluency				
Animals	.001***	.636	.007**	
Professions	.002***	.461	.083	
Phonemic fluency				
Letter 'K'	.003***	.196	.023*	
Letter 'M'	.133	.065	.304	

*$P \leq 0.05$; **$P \leq 0.01$; ***$P \leq 0.005$.

Men with ASD had impaired performance in the semantic fluency tasks in comparison to neurotypical subjects (animals: $F(3, 76) = 5.956$, $P = .001$, partial $\eta^2 = .190$; professions: ($F(3, 76) = 5.296$, $P = .002$, partial $\eta^2 = .173$). However, women did not differ from each other on semantic fluency tasks (animals: ($F(3, 46) = .572$, $P = .636$, partial $\eta^2 = .036$; professions: ($F(3, 46) = .874$, $P = .461$, partial $\eta^2 = .054$). Women with ASD were able to produce more names of animals than men with ASD ($F(3, 68) = 4.392$, $P = .007$, partial $\eta^2 = .162$), but no difference was found in number of professions ($F(3, 68) = 2.318$, $P = .083$, partial $\eta^2 = .093$).

Regarding phonemic fluency, men with ASD named less words with 'K' ($F(3, 76) = 7.972$, $P = .003$, partial $\eta^2 = .164$), but no significant difficulty naming words with 'M' compared with neurotypical subjects ($F(3, 76) = 1.922$, $P = .133$, partial $\eta^2 = .071$). Women in both groups did not differ in performance on both tasks ('K': ($F(3, 46) = 1.629$, $P = .196$, partial $\eta^2 = .096$); 'M': ($F(3, 46) = 2.579$, $P = .065$, partial $\eta^2 = .411$). Men with ASD were able to produce significantly more words with 'K' than women ($F(3, 68) = 3.402$, $P = .023$, partial $\eta^2 = .131$), but this difference was not found in the second task regarding words with 'M' ($F(3, 68) = 1.233$, $P = .304$, partial $\eta^2 = .052$).

Discussion

In this study, adults with ASD an healthy controls were examined on a variety of tasks assessing executive functioning. The executive functioning areas under investigation were planning, mental flexibility, working memory, generativity, and self-monitoring. The findings on each area will be discussed.

Planning

Planning is described by Hill [2004a] as a complex, dynamic operation in which a sequence of planned actions must be constantly monitored, re-evaluated, and updated. Planning requires the conceptualization of changes from the current situation, looking ahead by taking an objective and abstracted approach to identify alternatives, making choices, and then implementing the plan and revising it accordingly [Hill, 2004a]. In this study, men and women with ASD did not differ in planning abilities on the tower of Hanoi task. Furthermore, no differences between neurotypical adults and adults with ASD were found. As described by Hill [2004a], individuals with ASD exhibit overall impairments in planning on tower tasks. However, this is not in line with our findings. General ability is ought to have some influence on successful planning [e.g., Hill, 2004a]. This might explain that no difference was found, as the IQ level of participants in this study fell in the higher end of the normal range whereas the studies review by Hill [2004a] fell in the lower end of the normal range. The average to above average general abilities of the subjects in the current study might have compensated for planning difficulties that could be linked to ASD.

Mental Flexibility

For tasks of mental flexibility, most studies in the review conducted by Hill [2004a] found impairments in participants with ASD in this ability when using the WCST. The neurotypical men and women in this study performed better on the WCST than the individuals with ASD. Our findings are in line with the literature, as individuals with ASD find it more difficult than neurotypical individuals and individuals with other psychiatric conditions to switch between categories and prefer to continue the use of the first category they found [Hill, 2004a]. The women with ASD in this study had more perseverative errors than man with ASD, but less nonperseverative errors. Furthermore, the women with ASD completed more strategies then the men. IQ (especially verbal IQ) is ought to play a mediating role in this performance [Rajendran & Mitchell, 2007], which can be confirmed in the current study.

Working Memory

Kercood, Grskovic, Banda, and Begekse [2014] found that impaired working memory is associated with greater problems in adaptive behavior and a higher incidence of restrictive and repetitive behavior. The neurotypical individuals in this study had better working memory performance compared to individuals with ASD, which is in line with other studies [e.g. Barendse et al., 2013]. Gender differences were also found. The results indicate that men with ASD had better working memory performance than the women with ASD. The mean scores indicated that neurotypical men performed better than women, wherefore this might be an overall gender difference. Studies in the field of working memory also indicate gender-specific working memory networks [Hill, Laird, & Robinson, 2014] wherefore performance on working memory tasks might be influenced by gender.

Generativity and Self-Monitoring

To be successful in the fluency tasks, the ability to generate novel ideas spontaneously is required. Furthermore, the individual needs to be able to monitor his or her own thoughts and actions and be able to correct these if necessary. Impairments in this area are linked to repetitive behavior and having difficulties with change [Hill, 2004a]. In the Lai et al. [2011] study it was found that generativity was not impaired in ASD, this study however suggests that the ASD diagnosis was related to an impaired performance on generativity tasks. Furthermore, women with ASD had better performance on naming animals than men with ASD, but men with ASD on naming professions. Women with ASD often have more "common" special interests than men with ASD, for example, a special interest in animals or certain animals (for example horses) [Holtmann, Bölte, & Poustka, 2007]. This might have influenced the performance on the semantic fluency tasks that were used in this study. On the phonemic fluency tasks, however, men with ASD could name more words that started with "K" than women, but this difference was not found naming words that started with "M." In Dutch, there are a lot of profane words that start with "K." It is known that men tend to use more profanity than do women [Selnow, 1985], which might explain the gender difference only occurred for words starting with "K" and not with "M." However, further research is necessary to determine gender differences in performance on this area of functioning.

In conclusion, our study shows that some gender differences in EF exist in neurotypical adults and adults with ASD and that most of these findings are in line with previous studies. We did not find an unequivocal image or "specific cognitive model" of impairments in executive functioning in men and women with ASD. No specific impairments that are typical for men or women with ASD could be pinpointed. Hill [2004a], however, suggests that evidence for a unique executive functioning deficit in individuals with ASD is unlikely, which might not only be so on a diagnostic level but also on gender level. Some executive functions, for example, mental flexibility and inhibition, are strongly related with each other [Lopez et al., 2005]. Tasks assessing executive functioning have been designed to investigate only one aspect of executive functioning, but they often measure multiple abilities [Rajendran & Mitchell, 2007]. This could mean that impaired performance on a task, might be due to impairments on a different area of EF than thought to be measured with the task. This could explain the mixed results we found in some of the tasks. Some researchers, therefore, argue that executive functions should not be investigated as separate entities [e.g., Kenworthy, Yerys, Gutermuth, & Wallace, 2008]. Furthermore, findings by White, Burgess, and Hill [2009] suggest that individuals with ASD tend to create fewer spontaneous strategies and show more idiosyncratic behavior which leads to a poorer performance on more open-ended executive functioning tasks. White, Burgess, and Hill attribute this to their socio-communicative problems that lead to a poor understanding of implicit demands. This could disadvantage individuals with ASD when a task is more open-ended in comparison to a neurotypical individual. Since the tests that are used in this study differ in "open-endedness," this also could have contributed to the mixed results. ASD in women is often presented in different ways than in men, and it is possible that women with ASD are more successful in (sometimes unintentionally) masking their impairments with learned strategies compared to men with ASD [Dworzynski et al., 2012; Gould & Ashton-Smith, 2011]. Therefore, it could be thinkable that the open-endedness of some tasks could be more of a problem for the men with ASD and this might have influenced the results.

In clinical practice the individual strengths and frailties (e.g., performance on an intelligence test) should be highlighted, especially as impairments in EF are under influence of the overall cognitive abilities of the individual. This means that adults with below average intelligence might experience different impairments in cognitive functioning than do those with (above) average intelligence that were examined in the current study. Furthermore, men and women with ASD differ with regard to EF. This could explain differences in representation of ASD symptoms in both groups. These differences show how important thorough diagnostics are.

Limitations and Future Research

This study has some limitations. First, the adults in this study fell in the higher end of average or in the range of above average with their IQ levels. This means that the results of this study cannot be generalized to adults with lower or even higher IQ levels. For some tasks, we found that intelligence mediated the performance and therefore intelligence seems to be linked to the performance on executive functioning tasks. Determining the cognitive profiles across the WAIS-III subscales could be very informative to learn more about cognitive differences in men and women with ASD. This could expand the knowledge about executive functioning differences in men and women. Future research should focus on this topic.

Second, the group sizes differed and this might have influenced the findings. However, groups were matched to reduce confounding effects and reduce variation in outcomes. Third, most participants in this study were diagnosed in adult age. It has been hypothesized that when ASD is relatively late diagnosed, the symptoms are often milder [Vermeulen, 2002]. It is possible that de participants in the current study have milder symptoms and this could limit the generalizability of the results. Still little is known about the development of executive functioning and problems on the specific domains of executive functioning across the lifespan of individuals with ASD. Further research is needed on this subject. Another limitation is that men and women with ASD were not matched on ASD symptom severity. In future research this should be taken into account.

As described earlier in this article, executive functions are thought to be related [Lopez et al., 2005] and fractionation of executive functions is found to be limited [Burgess, Alderman, Evans, Emslie, & Wilson, 1998]. This means for example that by assessing mental flexibility, working memory is needed to complete the task use to measure mental flexibility and therefore is, unintentionally, assessed as well. Impaired performance on a specific domain could wrongly indicate an impairment on another domain as multiple executive abilities are often used in tasks. The tasks used in this study are designed to investigate a specific domain of executive functioning, but unfortunately often also measure other executive abilities [Rajendran & Mitchell, 2007]. Some researchers are trying to purify the tasks used to assess the domains of executive functioning so the tasks only assesses the domain for which it is designed. One could, however, wonder if this is possible. Some researchers have argued that it is better to not compartmentalize executive functioning, but to asses it as one entity [Kenworthy et al., 2008]. Another limitation with regard to the tests that are used in this study, is that the tests differ from each other in terms of reliability. As described by Chapman and Chapman [1973], when several tasks are used to assess cognitive deficits, tasks with high reliability will show a greater performance deficit for the subjects that are less able. As we did not match our tasks on their statistical characteristics, this could have influenced our results. Future research should use a set of tasks that are matched on their statistical characteristics.

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