Universiteit Utrecht

On diminished time-based prospective memory and its underlying mechanisms in high-functioning autistic adolescents.

S.R. Bolt, 3907848

In association with M. van Gemert and M.L.M.C. Deen,

Radboud University Nijmegen

Supervised by Dhr. D.P. Sheppard and Dhr. M.J. Schut

Word count

6644

On diminished time-based prospective memory and its underlying mechanisms in high-functioning autistic adolescents.

Keywords: High-Functioning Autism, Adolescents, Prospective Memory, Theory of Mind, Executive Functioning

Abstract

The current study aimed to investigate what underlying mechanisms contribute to prospective memory (PM) dysfunction in adolescents with high-functioning autism (HFA). Mechanisms that are claimed to be generally impaired in individuals with HFA, such as executive functioning (EF) might help to explain difficulties with PM as well. Social skill deficits claimed to be evident in autism, such as diminished Theory of Mind (ToM), might have a part in PM tasks when these are socially motivated. To investigate this, a group of adolescents with HFA was compared to a control group on measures of EF, ToM and PM. The motivation to perform well on the prospective memory task was manipulated to be either neutral, social of personal. It was hypothesized that healthy controls would outperform adolescents with HFA on all three measures. Moreover, it was expected that ToM would moderate the relation between motivation and PM performance. In line with the expectations, it was found that the HFA group performed less on the prospective memory task. However, the origin of these differences remains unclear as the HFA group did not differ from the control group on EF, nor ToM. No relationship was found between PM and EF, social motivation and ToM. It seemed that the presence of comorbid ADHD symptomatology in part of the HFA group did influence PM performance. Current findings underline the importance of maintaining a dimensional approach toward psychopathological diagnoses such as HFA and ADHD. More research is needed to investigate the network of dimensional traits underlying PM.

Contents

Introduction

Autism spectrum disorder (ASD) is mainly characterized by deficits in social reciprocity, communication or language skills as well as repetitive or stereotyped interests and behaviors (Steyn & Le Couteur, 2003). In 1980, the APA adopted 'Pervasive Developmental Disorder' in both the ICD and DSM, describing a broader range of autistic-like deficits as well as core autism (Haq & Le Couteur, 2004). Recently, the DSM-V replaced the previously used categorical approach with a dimensional representation of ASD in order to encourage understanding of the heterogeneity of the condition (Frazier et al., 2012; Ozonoff, Pennington & Rogers, 1991). The expression of deficits in ASD appears at all levels of cognitive functioning in varying severity (Altgassen, Williams, Bölte & Kliegel, 2009; Stichter et al., 2010). Consequently, even autistic individuals with above average intellectual abilities face difficulties in everyday tasks and social situations (Altgassen et al., 2009; Stichter et al., 2010). This condition is often referred to as High-Functioning Autism (HFA).

An important mental function claimed to be critical in everyday life that is argued to be impaired in HFA, is prospective memory (PM) (Altgassen et al., 2009; Altgassen et al., 2014; Loft, 2014; Williams, Boucher, Lind & Jarrold, 2013; Williams, Jarrold, Grainger & Lind, 2014). Individuals with HFA self-reported significant difficulties related to PM in everyday life (Williams et al., 2014). PM entails the remembrance of an intended future action to be carried out either at a certain time (time-based) or when a particular event occurs (event-based), fixed in ongoing activity (Altgassen et al., 2009; Altgassen, Vetter, Phillips, Akgün & Kliegel, 2014; Brandimonte, Einstein & McDaniel, 2014). Williams and colleagues (2013, 2014) claim that it is mainly time-based PM that is impaired in HFA. PM is often analyzed from a cognitive psychological point of view which has contributed to an understanding of underlying cognitive skills, such as executive functioning (EF) (Altgassen et al., 2014; Ford, Driscoll, Shum & Macaulay, 2012; Kliegel, McDaniel & Einstein, 2008; Kvavilashvili, Kyle & Messer, 2007; Mahy & Moses, 2011; Martin, Kliegel & McDaniel, 2003; Williams, Boucher, Lind & Jarrold, 2012). EF is usually described as the ability to exert endogenous self-control, in order to achieve future goals through the use of appropriate problem solving strategies (Geurts et al., 2004). EF deficits such as planning and cognitive flexibility are evident in autistic individuals (Geurts, Verté, Oosterlaan, Roeyers & Sergeant, 2004; Liss et al., 2001; Ozonoff et al., 1991).

However, Penningroth, Scott and Freuen (2011) argue that another important factor might influence PM; motivation. Several studies have pointed out different types of motivation might lead to either remembering or forgetting to perform future tasks (Kliegel, Martin, McDaniel & Einstein, 2001; Kliegel, Martin, McDaniel & Einstein 2004; Jeong & Cranney, 2009). PM tasks that are deemed important are less easily forgotten, as has been found in various studies (Einstein et al., 2005; Jeong & Cranney, 2009; Penningroth & Scott, 2011). Penningroth and colleagues (2011) found that socially relevant PM tasks were viewed as more important and were therefore more likely to be remembered and executed. Considering that social skill deficits are evident in individuals with HFA (Stichter et al., 2010), a social motivation might not be a good predictor of PM performance in this population. One main underlying construct that has been theorized to explain social difficulties evident in HFA is Theory of Mind (ToM) (Baron-Cohen, Leslie & Frith, 1985; Lacava, Golan, Baron-Cohen & Myles, 2007; Stichter et al., 2010). ToM refers to the capability to understand mental states and attribute mental states to others (Vetter, Altgassen, Phillips, Mahy & Kliegel, 2013). Individuals with HFA are often found to be impaired in comprehending other people's mental states, such as thoughts, beliefs and intentions (Frith & Frith, 2003).

Even though PM seems to be an important factor in further understanding behavioral links in autism with core deficits such as ToM, relatively little research has been conducted to investigate this (Williams et al., 2014). Therefore, the aim of the current research was to investigate the contribution of ToM to socially relevant time-based PM performance in adolescents with HFA. This group is prone to face difficulties in school, not only as a result of poor social skills, but presumably due to deficits in PM as well. Thus, a better understanding of how these factors are entangled, might lead to valuable implications and recommendations on providing appropriate guidance to autistic individuals within school settings.

To measure ToM, the 'Animated Shapes' task was administered. Concurrently with an ongoing '2-back Working Memory' task, PM was measured by participants pressing a key at one minute intervals. Therein, motivation was manipulated by giving different instructions about the PM task; a neutral, personal or social instruction.

Based on the current literature, it was hypothesized that controls would outperform the HFA group on EF, ToM and PM. Moreover, the HFA group was expected to particularly perform poorer on the PM task when a social motivation was assigned.

Thus, the relationship between motivation and PM performance was expected to be moderated by ToM.

Methods

Participants

In the current study, a sample of 61 autistic adolescents was gathered with an average age of 16.23 (*SD* = 1.43, range 14.11-19.41). This group consisted of 58 boys. Autistic individuals were included on the criteria of having an IQ of above 80 and the absence of major co-morbidity. Participants were not included if they had any other co-morbid condition, with the exception of ADHD. Nearly half of all autistic participants had ADHD as well. Healthy controls were recruited to match the clinical group based on age, IQ and gender. The control group consisted of 61 boys with an average age of 15.89 (*SD* = 1.06, range 14.14-18.92). Intellectual verbal and non-verbal ability of both the clinical and control group was measured. The vocabulary subtests of the Wechsler Intelligence Scale for Children (WISC-III, Wechsler, 2005) was used for children aged 13 through 16 years, whereas the vocabulary subtest of the Wechsler Adult Intelligence Scale (WAIS-IV, Wechsler, 2012) was used to assess participants above the age of 16 years. Non-verbal ability was assessed using the 'Matrices' subtest as a part of the Wechsler Nonverbal Scale of Ability (WNV, Wechsler & Naglieri, 2008).

In both the clinical- and control group, parents as well as participants signed informed consent. Preceding this, they were asked to read respectively the parental information sheet or an easier-to-read information flyer. The study was approved by the Ethics Committee Faculty of Social Sciences (ECSS), Radboud University Nijmegen, under the ethical approval number C 2014-1003-207a.

Tasks and Stimuli

Prospective memory task

The prospective memory task was combined with an ongoing 2-back working memory task. Participants were presented with pictures on a computer screen and asked to indicate whether the on-screen picture was the same as was the picture shown two slides back. The presentation time of stimuli was 1500 ms, with a 500 ms fixation cross between the stimuli. Participants were asked to press the "Z" key (colored in green) for addressing a hit (i.e. the picture is the same) or the "B" key (colored in orange) if there was no hit according to them. After a short practice consisting of 10 trials, participants

continued with the working memory task, which consisted of 150 trials and had a total duration of approximately 6 minutes. As for the prospective memory task, throughout performing the ongoing task, participants were asked to press the "P" key (colored in pink) at 1 minute time intervals. They were instructed to check time by bringing up a digital clock via pressing space bar, at any time throughout the ongoing task. The prospective memory task instructions were given 10 minutes before the actual task was to be performed; a verbal intelligence task served to fill out this pause. Participants were told they had to memorize the instructions, since they would not be repeated in the meantime. Moreover, the prospective memory task instructions varied; there were three different conditions. In a 'neutral' condition, participants received plain instructions (to press the pink key at 1 minute intervals). In a 'social' condition, participants were told that they would really help the experimenter if they could press the pink key. Finally there was a 'personal' condition, in which participants were told they would receive 5 euros if they had a certain amount of hits, pressing the pink key.

Executive function tests

To measure EF, two computer-based tasks were used. They covered inhibition and task-switching and had a total duration of approximately 3,5 minutes.

The inhibition task comprised of a computerized version of a Go/NoGo task. Participants watched arrows on-screen that were either pink or yellow. They were asked to press keyboard arrow keys that correspond to the direction of the on-screen arrows, unless the arrow was a yellow one. Stimuli were presented on screen for 500 ms, with 500 ms of blank screen between the trials. A short practice round was presented before continuing to the Go/NoGo task, in which there were 80 trials in total.

To measure task-switching, a computerized task was used in which participants were shown either a red or a blue, square or a diamond on-screen. They were asked to practice first, by pressing the left arrow for a red figure and the right arrow for a blue figure. Thereafter, they were asked to press the left arrow for a square shape and the right arrow for a diamond shape. In the last practice round, above every shape, there was either the word 'Shape' or 'Color'. Directed by these words, participants had to switch between a shape-based rule (press the left arrow for a square, right arrow for a diamond) and a color-based rule (press the left arrow for red, right arrow for blue). After these practice trials, participants were to continue in the same way. Stimuli were

presented for 1000 ms. Between trials, participants would receive feedback on their response by means of a 500 ms screen displaying a smiley face indicating they had either answered correctly, incorrectly or too slow. There were 80 trials in total.

Theory of mind test

Theory of mind was measured through the 'Animated Shapes' task. Participants were asked to watch animated triangles moving across the computer screen for approximately 30 seconds per sequence. There were 10 animated sequences in total. The triangles either moved randomly, in a goal-directed fashion (i.e. chasing, hiding) or interactively with the other triangle, where an implied intention could be perceived (i.e. coaxing, tricking). Participants were asked to describe what they thought the triangles were 'doing'. Responses were audio-recorded and transcribed and scored later on.

Verbal descriptions given during each interactive (ToM), goal-directed and random animated sequence were granted a 'mentalisation' score varying from 0 to 2. This score reflects the extent to which mental state terms and ToM are used. In order to control for subjectivity of the method, language analysis was conducted on the type of verb that participants used to describe the triangles' actions. A score of 0 was obtained where no mental state words were used, and where there was no appreciation of the other agent nor recognition of actions, intentions or interaction. A score of 1 was granted for the use of simple, first order mental state words (e.g. he is angry, he is being sneaky), or words that imply psychological states in a social context (e.g. she is scared that he is going to leave her). A score of 2 was awarded where descriptions involved meta-cognitive states (beliefs about beliefs) or when agents were described to be affecting or manipulating the other agents' mental states, as well as descriptions of complex mental states (e.g. she felt both sad and angry at the same time).

Besides a mentalisation score participants were granted a 'accuracy' score between 0 to 2 as well, indicating how accurately their narratives reflected the sequences as they were intended by the task designers (Abell, Happé & Frith, 2000). Accuracy scores were granted only for interactive and goal-directed sequences, not for random sequences. A score of 0 was awarded for plainly wrong or bizarre descriptions, or when they only focused on a minor, unimportant element of the sequence. A score of 1 could be obtained for descriptions that related to the sequence, but were either

imprecise or incomplete. Finally, a score of 2 was granted for spot-on descriptions, appropriately portraying multiple aspects or both characters' actions.

Procedure

The participants in the clinical group were gathered and tested at 'De Berkenschutse school' in Heeze, a Dutch special education school. Control participants were recruited from two different Dutch schools for higher general secondary education (HAVO/VWO), namely the 'GsG Leo Vroman' in Gouda and the 'Andreas College' in Katwijk. This way, participants were aimed to match the experimental group on IQ. Moreover, verbal and non-verbal intelligence was measured in both groups. All participants were received in a classroom one by one and tested for approximately an hour per individual. They were all comfortable participating with just the experimenter present. Since there were sometimes two or three participants tested in parallel, testing could not always take place in the same room. However, all rooms were prepared in exactly the same way, ensuring they were clear of distraction, tidy and comfortable. Chairs, tables and laptops were organized in the same position. All experimenters received a basic 'autism awareness' training in advance, to ensure a consistent and reassuring approach with the clinical group. Participants were informed they could take a break, or stop, at any moment during the sessions. However, this was not necessary for any of the participants. After finishing testing, every participant received 5 Euros as a reward. The participating schools received 5 Euros as well, for each child that participated in this study.

Analyses

To analyze the data, Statistical Package for the Social Sciences (SPSS), the 20th edition, was used. Exploratory analyses were used to check if various assumptions were met. A correlational analysis was used to explore the dataset and discover the presence of intercorrelations. Comparative research was done using independent samples t-tests and an analysis of variance (ANOVA). To predict influences and investigate moderation, a regression analysis was conducted. Finally, for exploratory purposes, more independent samples t-tests were conducted, as well as a repeated measures ANOVA.

Results

Initial analyses

The data was imported into SPSS. Firstly, data was explored in order to examine if various assumptions were met. No disturbing or seemingly odd outliers were displayed in stem-and-leaf plots. Normality was explored using Q-Q-plots and histograms, demonstrating that verbal and nonverbal ability, EF, PM data was sufficiently normally distributed, but ToM mentalisation scores were not. It should be noted however, that the central limit theorem states that when a sample is large enough, it can be assumed to have been obtained from a normal distribution (Field, 2013). Due to large enough sample sizes, regression analyses as well as ANOVAs should be robust against minor violations of normality. The assumption of homogeneity of variance was met, as well as the assumption of independence, and there were no incidences of multicollinearity.

Correlations

A Spearman correlational analysis was conducted, merely to explore relationships between variables of interest. Table 1 demonstrates the presence of intercorrelations. These correlations might be interesting to look into, but currently they do not have major implications for further analyses.

Table 1.

Spearman intercorrelations among variables of interest

	1	2	3	4	5	6	7	8
1. Age	-	-.02	.03	.29**	.23**	.12	.23*	.07
2. Nonverbal	-.02	-	.10	-.17	-.04	.26**	.21*	.15
3. Verbal	.03	.10	-	-.20*	.02	.14	.21*	-.02
4. Inhibition	.29**	-.17	-.20*	-	.05	.03	.03	.17
5. Task switching	.23**	-.04	.02	.05	-	.11	.21*	.10
6. Mentalisation	.12	.26**	.14	.03	.11	-	.59**	.15
7. Accuracy	.23*	.21*	.21*	.03	.21*	.59**	-	.18
8. PM hits	.07	.15	-.02	.17	.10	.15	.18	-

*$p < .05$, **$p < .01$

Comparative analyses

Both groups were compared using an independent samples t-test on measures of age, verbal ability, nonverbal ability and executive functioning to identify if any significant differences were present at baseline. It was expected that age, verbal and nonverbal ability would be roughly equal, as groups were aimed to match on these measures. Based on previous findings, the control group would be expected to perform better on EF tasks. As can be observed from table 2, this test confirmed that there were no significant differences evident on measures of non-verbal ability and age. However, significant differences were found on measures of verbal ability; controls scored significantly lower on verbal ability. Moreover, in contrast to what would be expected, there were no differences in task switching scores and inhibition scores between the autistic and control group. It should be noted that, taken from these measures, the HFA group appears to be more able than our control group. This might have implications for further interpreting research findings.

Another independent samples t-test was conducted to determine if groups differed on main variables of interest: mentalisation, accuracy and PM performance. Based on the current literature, it was expected that controls would outperform the HFA group on all three measures. Interestingly though, as table 2 demonstrates, mentalisation scores of the HFA group were slightly (though not significantly) higher than those of the control group. Accuracy scores were significantly higher in the HFA group compared to the control group. Contrastingly, in line with the expectation, the average number of PM hits in the HFA group was significantly lower in comparison with the control group. However, the HFA group outperformed the control group on our measure of ToM, which might compromise our expectations regarding relations between ToM, motivation and PM performance.

Table 2.

Summary of descriptive statistics and t-test for group differences on various measures

	Controls		HFA			
	M	*SD*	*M*	*SD*	*t*	*df*
Age	15.89	1.06	16.23	1.43	1.49	120
Verbal	11.07	2.16	13.03	2.41	4.75***	120
Nonverbal	58.56	8.60	59.00	7.89	.29	120
Task switching	30.48	10.49	27.69	11.21	-1.42	120
Inhibition	19.38	1.40	19.02	1.65	-1.30	120
Mentalisation	2.78	1.95	3.24	2.37	1.13	112
Accuracy	8.05	2.90	9.48	3.02	2.58*	112
PM hits	4.7	1.71	3.85	1.97	-2.53*	119

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

Besides group differences (HFA versus control), it was expected that the type of motivation (neutral, social and personal) would lead to different outcomes as well. A one way ANOVA was conducted to explore differences in PM performance, considering motivation. Based on previous studies, it was expected that controls would perform better on a PM task in case of a social motivation. Contrastingly, the HFA group was expected to be relatively unaffected by a social motivator. It was revealed that, when analyzing the whole sample, the condition participants were in during the PM task did indeed significantly affect the number of PM hits, $F(2,118) = 4.03$, $p = .02$. Using a post hoc Tukey HSD comparison, significant differences were found only between the neutral ($M = 3.79$, $SD = 1.96$) and personal condition ($M = 4.90$, $SD = 1.56$).

Moreover, when analyzing both groups separately, it appeared that motivation did not have a significant effect at all on PM hits in the HFA group, $F(2, 58) = .92$, $p = .40$. In contrast, controls' PM scores did vary significantly over conditions. The assumption of

equality of error variances was violated in measures of PM hits in the control group, as demonstrated by Levene's Test, $F(2, 57) = 8.46$, $p = .00$ Therefore, a robust Welch test was used, demonstrating a significant effect of motivation on PM hits, $F(2,28.13) = 11.17$, $p = .00$. A Games-Howell test was used for post hoc comparisons. Controls' PM hits were significantly more plentiful in the personal condition ($M = 5.71$, $SD = .56$), compared to both the neutral ($M = 4.28$, $SD = .1.74$) and social condition ($M = 4.05$, $SD = 2.01$). Consider the main hypothesis this study was concerned with; individuals with HFA perform poorer on socially relevant PM tasks due to deficits in ToM. Since the current HFA group was not outperformed by controls on ToM, and they seem to perform equally well on both a socially- and personally relevant PM task, we might want to adjust this hypothesis somewhat before heading on to further analyses. Since the control groups' ToM scores were slightly lower, and they tended to perform significantly better on personally relevant PM tasks as opposed to socially relevant tasks, it might still be expected that ToM moderates the relationship between motivation and PM performance.

Regression analysis

A multiple regression analysis was administered to predict the influence of motivation on PM performance in both groups. As aforementioned, it was expected that motivation would predict PM performance, moderated by ToM. Vocabulary- and matrices test scores, were entered at first, to control for differences due to verbal and non-verbal ability. In the next step, inhibition- and task-switching scores were entered to control for differences due to executive functioning. In the final step, mentalisation scores and an interaction term between motivation and mentalisation scores were entered. Using the enter method, results indicate that mentalisation by itself and the interaction between mentalisation scores and motivation did not explain a significant amount of variance in overall PM performance, $F(6, 106) = 1.01$, $p = .42$, $R^2 = .05$, $R^2Adjusted = .00$. The autistic and control group were analyzed separately as well. No significant amount of variance in PM performance was found to be explained by mentalisation scores, nor the interaction between mentalisation and motivation either, respectively $F(6, 47) = .32$, $p = .92$, $R^2 = .04$, $R^2Adjusted = -.08$ and $F(6, 52) = 1.47$, $p = .20$, $R^2 = .15$, $R^2Adjusted = .05$.

Explorative analyses

To further investigate how scores on the Animated Shapes task were established, the type of sequence was taken into account. Groups were compared using an independent samples t-test on accuracy and mentalisation scores separately on ToM, Goal-Directed and Random sequences. As can be seen from table 3, the HFA groups' accuracy scores in ToM sequences were significantly higher compared to the control group. Moreover, in Goal-Directed sequences, the HFA groups' mentalisation scores were significantly higher than scores of the control group.

Table 3.

Mean ratings of participants' descriptions in the Animated Shapes task

Score type and group	Animation type		
	Theory of Mind	Goal Directed	Random
Mentalisation			
HFA	2.54	.57*	.20
Control	2.37	.33*	.15
Accuracy			
HFA	4.52**	4.96	-
Control	3.37**	4.35	-

**Significant difference between scores at p < .05 ** Significant difference between scores at p < .01*

Furthermore, within the clinical group, an independent samples t-test was used to determine whether a comorbid ADHD diagnosis contributed to differences on PM hits. It appeared that children with comorbid ADHD, had significantly less PM hits (M = 3.17, SD = 1.91) than autistic children without ADHD (M = 4.47, SD = 1.83), $t(59) = 2.7$, $p = .01$. For exploratory purposes, an ANCOVA was conducted to see what would happen if ADHD were considered a covariate. It appeared that, when adjusted for the presence of comorbid ADHD, the HFA group and control group did not differ on PM performance any longer, $F(1, 118) = .35$, $p = .56$. However, since ADHD and autism are closely linked, they share variance. As explained by Field (2013), in such cases, one cannot simply rule out differences by putting covariates into the analysis. Nevertheless, it is valuable to

consider why comorbid ADHD would lead to poorer performances on the current PM task.

Ultimately, clock checks were analyzed, representing participants' time monitoring behavior during the ongoing WM task and PM task. Both the clinical and control groups' average amount of clock checks across four separate 15 second-intervals during each minute was analyzed as a within-subjects factor using a repeated measures ANOVA (Altgassen et al., 2009; Kliegel, Martin, McDaniel & Einstein 2001). When comparing groups, Mauchly's test indicated that the assumption of sphericity had been violated in both cases, $\chi^2(5) = .23$, $p = .00$, $\chi^2(5) = .04$, $p = .00$. Therefore a Greenhouse-Geisser correction was applied ($\varepsilon = .52$, $\varepsilon = .41$). Results demonstrated that both autistic individuals' and controls' time checking behavior increased during intervals approaching one minute targets, respectively $F(1.57, 91.20) = 75.20$, $p = .00$ and $F(1.22, 69.27) = 49.21$, $p = .00$.

Thereafter, group (clinical versus control) and motivation (neutral, social and personal) were added as between-subjects factors. Mauchly's test indicated that the assumption of sphericity had been violated once more, $\chi^2(5) = .090$, $p = .00$, therefore another Greenhouse-Geisser correction was applied ($\varepsilon = .44$). A significant interaction between groups and time checking behavior was found, $F(1.32, 151.90) = 5.27$, $p = .02$. No significant interaction was found between time monitoring behavior and condition, $F(2.64, 151.90) = 2.45$, $p = .07$. Figure 1 demonstrates time monitoring behavior for both groups separately, illustrating how they differed.

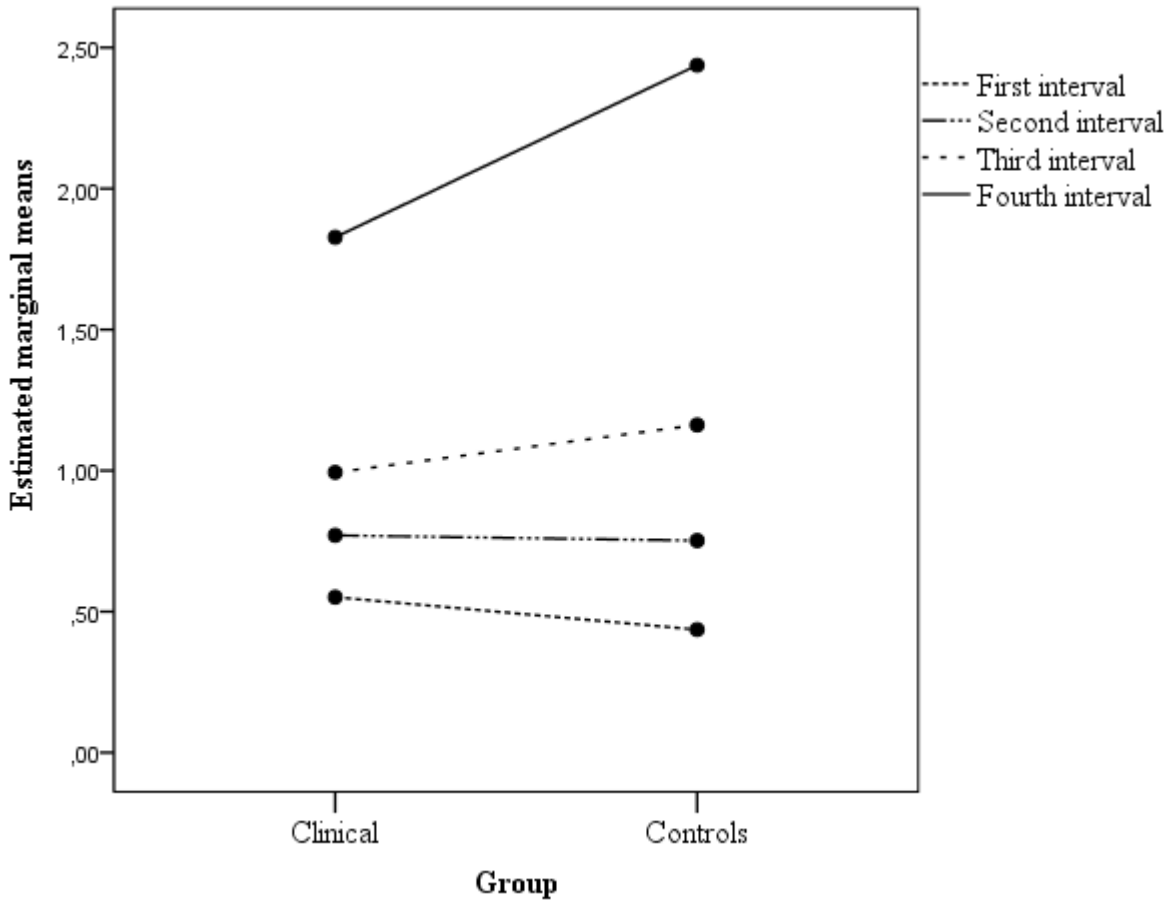

Figure 1. Time monitoring behavior of the clinical HFA group compared to the control group.

Discussion

Findings

Prospective memory, Theory of Mind and executive functioning

The aim of the current study was to investigate how prospective memory performance and motivation relate to core deficits of high-functioning autism, specifically Theory of Mind. Results indicate that adolescents with HFA compared to adolescents without HFA perform poorer on a PM task. This is in line with what would be expected based on previous literature regarding PM deficits linked to autism (Altgassen et al., 2009; Altgassen et al., 2014; Loft, 2014; Williams et al., 2013; Williams et al., 2014). In contrast with what would be expected based on previous research, the control group did not outperform the HFA group on measures of ToM, or on measures of Executive Functioning. More than that, our HFA group was more accurate in describing the 'Animated Shapes' videos, especially the ToM sequences. Lastly, the HFA group used

more mental state terms than did the control group in describing Goal-Directed sequences.

Verbal ability

In the current study, the HFA group was verbally more able than the control group. It has been argued that verbal ability in individuals with HFA or Asperger Syndrome might compensate for ToM deficits, through which these individuals would still pass verbal PM tasks in experimental settings (Eisenmajer & Prior, 1991; Happé, 1994; Fombonne, Siddons, Archard, Frith & Happe, 1994; Klin, 2000). Most classical ToM tasks do require verbal skills; many studies found ToM performance on these tasks to be related to verbal ability (Bowler, 1992; Eisenmajer & Prior, 1991; Prior, Dahlstrom & Squires, 1990; Yirmiya, Erel, Shaked & Solomonica-Levi, 1998; Yirmiya & Shulman, 1996). Nevertheless, the Animated Shapes task is argued to overcome verbal compensation through the non-verbal nature of animated sequences (Abell et al., 2005). As could be seen from the current results, it was found that nonverbal ability is indeed correlated with mentalisation, whereas verbal ability is not. However, verbal ability did correlate with how accurate participants were in describing (ToM) sequences. Thus, in the current study the HFA groups' verbal ability might have assisted them to outperform the control group on accuracy in ToM sequences.

Motivation and social skills

Moreover, it was expected that the control group would perform better than the HFA group on a PM task when the motivation to properly engage in such a task, was a social one (Penningroth et al., 2011). As individuals with HFA are known to generally have social skill deficits, due to a lack of ToM (Baron-Cohen, Leslie & Frith, 1985; Lacava, Golan, Baron-Cohen & Myles, 2007; Stichter et al., 2010), this groups' PM performance was expected to be unaffected by a social motivator. Overall the HFA group did not appear to have poorer ToM than the control group, though. Moreover, the current results suggest that, compared to the neutral condition, the control group did not have better PM performance in case of a social motivator either. The control group did show better PM performance in case of a personal motivator, compared to a neutral or social condition. PM performance of adolescents with HFA was indeed untouched by social motivation as well, and in this group a personal motivator did not lead to better PM

performance either. Considering previous findings it would have been expected that at least the control group would benefit from a social motivator in terms of PM performance (Altgassen et al., 2010; Brandimonte, Ferrante, Bianco & Villani, 2010; Penningroth et al., 2009). Contrastingly, a social motivation did not improve PM performance, regardless of whether or not participants had HFA. Considering that (monetary) rewards are often argued to induce importance and thereby improve PM performance, it is not odd that the control groups' performance did improve in the personal reward condition (Jeong & Cranney, 2009; Meacham & Singer, 1977; Shapiro & Krishnan, 1999). It is argued that personal rewards merely enhance extrinsic motivation, whereas they decrease altruistic or pro-social behavior by undermining intrinsic motivation (Brandimonte et al., 2010; Walter & Meier, 2014). Prosocial behavior is argued to be naturally rewarding and therefore intrinsically motivated (Chevallier, Kohls, Troiani, Brodkin & Schultz, 2012). It seems that in the current study the social condition did not facilitate intrinsic motivation, whereas the personal reward did elicit extrinsic motivation in the control group. It remains unclear why the HFA groups' PM performance did not improve in either of these conditions. It could be that the social motivation condition did not sufficiently reflect a social motivation as it would appear in real-world, thereby undermining ecological validity. Future studies that want to look into motivation might want to consider how genuine pro-social behavior and intrinsic motivation can be elicited in an experimental setting.

Considering these findings so far, it can be concluded that in the current study poorer PM performance in the HFA group was not due to (social) motivation. Their PM performance, nor the relationship between motivation and PM performance was influenced by ToM. Considering that the control group did perform better in case of a personal motivator as opposed to a social motivator, one could still argue that this relationship might have been influenced by ToM. As the results reveal though, no such relationship was evident in the control group either.

Comorbid ADHD, attention and time monitoring

The current study succeeded to verify previous findings of PM deficits in individuals with HFA. However, it did not precisely manage to explain what underlying aspects might cause these deficits. Besides ToM, many previous studies have pointed out that EF deficits might play an important part in causing PM deficits as well (Altgassen et al.,

2014; Ford, Driscoll, Shum & Macaulay, 2012; Kliegel, McDaniel & Einstein, 2088; Kvavilashvili, Kyle & Messer, 2007; Mahy & Moses, 2011; Martin, Kliegel & McDaniel, 2003; Williams, Boucher, Lind & Jarrold, 2012). Indeed, PM is argued to rely mainly on EF and retrospective memory (Zinke, Altgassen, Mackinlay, Rizzo, Drechsler & Kliegel, 2010). However, the current study did not prove EF to be related to PM performance, neither did the HFA group perform poorer on EF compared to the control group. Moreover, group differences in PM performance appeared to vanish when a comorbid ADHD diagnosis was taken into account. Considering that the sample size of individuals with HFA without ADHD was quite small (approximately 30), the disappearance of significant group differences might have been due to a lack of statistical power. Still, it is worth noting that the presence of ADHD seemed to make up for at least part of the current findings regarding PM performance. The question remains what distinguishes HFA with comorbid ADHD from HFA without comorbid ADHD, and how this could explain differences in PM performance that have been found.

The current study focused on ToM and EF, considering that HFA is accompanied by deficits in these areas. A typical aspect of ADHD that has often been demonstrated, but that was not examined in the current research, is a lack of sustained attention (Bellgrove, Hawi, Gill & Robertson, 2006; O'Connell, Bellgrove, Dockree & Robertson, 2004; Tucha et al., 2006). Sustained attention entails the ability to focus on one or multiple non-arousing information targets over a certain, unbroken period of time without getting distracted or habituated (Johnson et al., 2007). Sustained attention is facilitated by vigilance, which is the ability to maintain focus in the presence of infrequently occurring, respons-demanding events (Tucha et al., 2008). Although there is a lack of consensus in literature regarding sustained attention deficits in ADHD and ASD, Johnson and colleagues (2007) found that children with HFA appeared to have intact sustained attention but impaired inhibition, whereas children with ADHD clearly had sustained attention deficits, and impaired inhibition as well. Although traditional vigilance tasks might take up to 15, 30 or even 60 minutes (Johnson et al., 2007; Paus et al., 1997), the relatively short PM task used in the current study might still have elucidated a time-on-task effect. Children with ADHD compared to normal children might exhibit time-induced variation in performance (Heinrich, Moll, Dickhaus, Kolev, Yordanova & Rothenberger, 2001). Although the current study did not look into this, considering participants with HFA and comorbid ADHD performed poorly on the PM

task, one could argue the duration of this task might have had a negative effect on their performance. If sustained attention deficits are indeed merely a symptom of ADHD or combined HFA + ADHD, the duration and demand of vigilance of the task might have caused differences in performance between the HFA with ADHD and without ADHD.

In addition to differences in concrete PM performance, current results also emphasize that the HFA groups' time monitoring behavior during the PM task differed from that of the control group. In line with previous studies on time monitoring, all participants demonstrated increased clock checks with the target time (one minute intervals) approaching (Ceci & Bronfenfenner, 1985; Kerns, 2000; Mäntylä, Carelli & Forman, 2007). However, in line with what was previously found by Altgassen and colleagues (2009), the control groups' clock checks increased more steeply towards one minute targets. A more efficient way of monitoring the passing of time in the control group has most likely contributed to their more superior PM performance. Regarding the HFA and partially HFA + ADHD group, we might consider sustained attention once again. Attention as a contributor in PM tasks might vary as a function of contextual reminders of the predetermined action. Especially in the case of time-based prospective memory, self-initiated time monitoring is needed at some point to ensure the action is carried out at the appropriate time (Carlesimo, Casadio & Caltagirone, 2004). If time checking does indeed merely reflect attention (Carlesimo, 2004), then the HFA + ADHD group might have underperformed on this measure as well, resulting in less efficient time monitoring behavior in the HFA group and consequently, less PM hits.

Considering the current findings, it could be argued that an underlying factor other than EF and ToM influenced PM performance. Many studies, including this study, do not initially differentiate between autistic (or HFA) individuals in low versus high comorbid ADHD symptomatology. Nevertheless, between these groups it is argued there is an obvious inequality in the clinical presentation of psychopathological symptoms (Holtmann, Bölte & Poustka, 2007). On the other hand, ASD and ADHD are often argued to be closely related in terms of clinical deficits, wherefore it is hard to make a clear-cut differentiation between both diagnoses (Raymaekers, Antrop, Van der Meere, Wiersema & Roeyers, 2007). Consequently, some have argued that three independent disorders can be distinguished, namely ASD, ADHD and a combined ASD + ADHD diagnosis (Taurines, Schwenck, Westerwald, Sachse, Siniatchkin & Freitag, 2012). If it is true that ASD + ADHD, or in this case HFA + ADHD can be considered a separate diagnosis, than it

might be important to distinguish individuals with 'pure' HFA in order to learn something about underlying mechanisms and their link to common deficits such as decreased PM.

Nevertheless, it remains debatable whether psychiatric diagnosis should be considered as being categorical altogether. Psychiatric diagnoses are merely a clinicians' or policy-makers' communication tool to describe certain standardized combinations of clinical observations, and they are rarely as informative as somatic diagnoses (London, 2014; Rutter, 2011). Categorical (DSM) diagnoses offer little insight in etiology, biomarkers or prognoses, whereby they fail to represent the complex nature of disorders (Rutters, 2011). Moreover, clear boundaries between health and disease or between different disorders are often lacking (Clark, Watson & Reynolds, 1995). To overcome some of the limitations of categorical diagnoses, the upcoming DSM-V offers an additional dimensional approach towards psychiatric disorders. Although ADHD and ASD as (separate) categorical diagnoses are well established, a dimensional viewpoint of latent traits might be a valuable contribution in accurately describing and examining aforementioned disorders (Biederman, 2005; Elton, Alcauter & Gao, 2014; Frazier et al., 2012; Larsson, Anckarsater, Råstam, Chang, & Lichtenstein, 2012).

Limitations and recommendations

Considering the current study, few limitations should be taken into account. Firstly, the HFA groups' superior verbal ability might have assisted them to perform equally well or even better than their healthy controls on certain measures. All HFA students were in VWO (pre-university education) classes, while a certain amount of controls' was recruited from HAVO (general secondary education) classes as well. For future studies to gain insight into HFA deficits, it is important to bear in mind that verbal intelligence might influence performance on certain tasks. It is recommended to match groups on (verbal) intelligence in order to detect actual shortfalls in areas such as ToM and EF, or to select tests that are insensitive to verbal intelligence.

Considering the measure of PM in this study, it should be noted that PM performance was based solely on the number of hits. A 2-back working memory task was administered to serve as an ongoing activity and to measure baseline working memory functioning. Participants' working memory baseline might have influenced PM performance as well; if an individual has a hard time performing the 2-back task, they

might more easily get distracted from their PM task. Unfortunately, in the current study something went wrong with recording working memory responses. Therefore, we were unable to analyze or control for possible contributions of working memory to PM performance. To attain a more adequate and complete impression of PM mechanisms, future studies might want to take working memory baseline into account.

Considering the measure of ToM in the current study, it should be mentioned that the recordings were transcribed and scored by seven different researchers, each assessing different participants. Even though all of the researchers used the same scoring sheets, describing what type of words deserve what score, inter-rater reliability of this measure might still have been compromised. In order to ensure a reliable ToM measure, future studies might want to check for inter-rater concordance or use a more standardized measure of ToM.

Conclusions and future directions

The current study supported previous findings of differences in PM functioning comparing adolescents with HFA and adolescents without HFA. The origin of these differences in PM performance is currently unknown. The motivation to perform a PM task, whether this was social or personal motivation, did not seem to make a difference for individuals with HFA. Neither ToM nor EF appeared to be impaired in the HFA group, and these mechanisms did not seem to contribute to PM performance. One factor that did seem to influence PM performance, was the presence of comorbid ADHD symptomatology in part of the HFA group. The current study supports the idea that HFA and ADHD share various dimensional traits that could lead to deficits in areas such as PM. For future studies, it would be interesting to specifically look into both HFA individuals with and without comorbid ADHD and analyze how they are the same and how they are different. When examining psychopathological conditions and their accompanying deficits, it is important to take into account that these conditions are not merely categorical but might share latent traits that vary in severity. This way, we might be able to gain better insight in deficits accompanying HFA and the network of underlying functions.

References

Abell, F., Happe, F., & Frith, U. (2000). Do triangles play tricks? Attribution of mental states to animated shapes in normal and abnormal development. *Cognitive Development*, *15*(1), 1-16.

Altgassen, M., Vetter, N. C., Phillips, L. H., Akgün, C., & Kliegel, M. (2014). Theory of mind and switching predict prospective memory performance in adolescents. *Journal of experimental child psychology*, *127*, 163-175

Altgassen, M., Williams, T. I., Bölte, S., & Kliegel, M. (2009). Time-based prospective memory in children with autism spectrum disorder. *Brain Impairment*, *10*(01), 52-58.

Bellgrove, M. A., Hawi, Z., Gill, M., & Robertson, I. H. (2006). The cognitive genetics of attention deficit hyperactivity disorder (ADHD): sustained attention as a candidate phenotype. *Cortex*, *42*(6), 838-845.

Biederman, J. (2005). Attention-deficit/hyperactivity disorder: a selective overview. *Biological psychiatry*, *57*(11), 1215-1220.

Bowler, D. M. (1992). "Theory of Mind" in Asperger's Syndrome Dermot M. Bowler. *Journal of Child Psychology and Psychiatry*, *33*(5), 877-893.

Brandimonte, M. A., Einstein, G. O., & McDaniel, M. A. (2014). *Prospective memory: Theory and applications*. Psychology Press.

Brandimonte, M. A., Ferrante, D., Bianco, C., & Villani, M. G. (2010). Memory for pro-social intentions: When competing motives collide. *Cognition*, *114*(3), 436-441.

Carlesimo, G. A., Casadio, P., & Caltagirone, C. (2004). Prospective and retrospective components in the memory for actions to be performed in patients with severe closed-head injury. *Journal of the International Neuropsychological Society*, *10*(05), 679-688.

Ceci, S. J., & Bronfenbrenner, U. (1985). " Don't Forget to Take the Cupcakes out of the Oven": Prospective Memory, Strategic Time-Monitoring, and Context. *Child development*, 152-164.

Chevallier, C., Kohls, G., Troiani, V., Brodkin, E. S., & Schultz, R. T. (2012). The social motivation theory of autism. *Trends in cognitive sciences*, *16*(4), 231-239.

Clark, L. A., Watson, D., & Reynolds, S. (1995). Diagnosis and classification of psychopathology: Challenges to the current system and future directions. *Annual review of psychology*, *46*, 121.

Einstein, G. O., McDaniel, M. A., Thomas, R., Mayfield, S., Shank, H., Morrisette, N., & Breneiser, J. (2005). Multiple processes in prospective memory retrieval: factors determining monitoring versus spontaneous retrieval. *Journal of Experimental Psychology: General*, *134*(3), 327.

Eisenmajer, R., & Prior, M. (1991). Cognitive linguistic correlates of 'theory of mind' ability in autistic children. *British Journal of Developmental Psychology*,*9*(2), 351-364.

Elton, A., Alcauter, S., & Gao, W. (2014). Network connectivity abnormality profile supports a categorical-dimensional hybrid model of ADHD. *Human brain mapping*, *35*(9), 4531-4543.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics.* London: SAGE publications Ltd.

Fombonne, E., Siddons, F., Achard, S., Frith, U., & Happé, F. (1994). Adaptive behaviour and theory of mind in autism. *European Child & Adolescent Psychiatry*, *3*(3), 176-186.

Ford, R. M., Driscoll, T., Shum, D., & Macaulay, C. E. (2012). Executive and theory-of-mind contributions to event-based prospective memory in children: Exploring the self-projection hypothesis. *Journal of experimental child psychology*, *111*(3), 468-489.

Frazier, T. W., Youngstrom, E. A., Speer, L., Embacher, R., Law, P., Constantino, J., ... & Eng, C. (2012). Validation of proposed DSM-5 criteria for autism spectrum disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, *51*(1), 28-40.

Frith, U., & Frith, C. D. (2003). Development and neurophysiology of mentalizing. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *358*(1431), 459-473.

Geurts, H. M., Verté, S., Oosterlaan, J., Roeyers, H., & Sergeant, J. A. (2004). How specific are executive functioning deficits in attention deficit hyperactivity disorder and autism?. *Journal of child psychology and psychiatry*, *45*(4), 836-854.

Happé, F. G. (1994). Annotation: current psychological theories of autism: the "theory of mind" account and rival theories. *Journal of Child Psychology and Psychiatry*, *35*(2), 215-229.

Haq, I., & Le Couteur, A. (2004). Autism spectrum disorder. *Medicine*, *32*(8), 61-63.

Heinrich, H., Moll, G. H., Dickhaus, H., Kolev, V., Yordanova, J., & Rothenberger, A. (2001). Time-on-task analysis using wavelet networks in an event-related potential study on attention-deficit hyperactivity disorder. *Clinical Neurophysiology*, *112*(7), 1280-1287.

Holtmann, M., Bölte, S., & Poustka, F. (2007). Attention deficit hyperactivity disorder symptoms in pervasive developmental disorders: association with autistic behavior domains and coexisting psychopathology. *Psychopathology*, *40*(3), 172-177.

Jeong, J. M., & Cranney, J. (2009). Motivation, depression, and naturalistic time-based prospective remembering. *Memory*, *17*(7), 732-741.

Johnson, K. A., Robertson, I. H., Kelly, S. P., Silk, T. J., Barry, E., Dáibhis, A., ... & Gill, M. (2007). Dissociation in performance of children with ADHD and high-functioning autism on a task of sustained attention. *Neuropsychologia*,*45*(10), 2234-2245.

Kerns, K. A. (2000). The CyberCruiser: An investigation of development of prospective memory in children. *Journal of the International Neuropsychological Society*, *6*(01), 62-70.

Kliegel, M., & McDaniel, M. A. (2008). *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives*. Taylor & Francis.

Kliegel, M., Martin, M., McDaniel, M., & Einstein, G. (2004). Importance effects on performance in event-based prospective memory tasks. *Memory*,*12*(5), 553-561.

Kliegel, M., Martin, M., McDaniel, M. A., & Einstein, G. O. (2001). Varying the importance of a prospective memory task: Differential effects across time- and event-based prospective memory. *Memory*, *9*(1), 1-11.

Klin, A. (2000). Attributing social meaning to ambiguous visual stimuli in higher-functioning autism and Asperger syndrome: the Social Attribution Task. *Journal of Child psychology and Psychiatry*, *41*(7), 831-846.

Kvavilashvili, L., KyLe, F., & Messer, D. J. (2008). The development of prospective memory in children: Methodological issues, empirical findings, and future directions. *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives*, 115-140.

Lacava, P. G., Golan, O., Baron-Cohen, S., & Myles, B. S. (2007). Using assistive technology to teach emotion recognition to students with asperger syndrome a pilot study. *Remedial and Special Education*, *28*(3), 174-181.

Larsson, H., Anckarsater, H., Råstam, M., Chang, Z., & Lichtenstein, P. (2012). Childhood attention-deficit hyperactivity disorder as an extreme of a continuous trait: a quantitative genetic study of 8,500 twin pairs. *Journal of Child Psychology and Psychiatry*, *53*(1), 73-80.

Liss, M., Fein, D., Allen, D., Dunn, M., Feinstein, C., Morris, R., ... & Rapin, I. (2001). Executive functioning in high-functioning children with autism. *Journal of Child Psychology and Psychiatry*, *42*(02), 261-270.

Loft, S. (2014). Applying Psychological Science to Examine Prospective Memory in Simulated Air Traffic Control. *Current Directions in Psychological Science*, *23*(5), 326-331.

London, E. B. (2014). Categorical diagnosis: a fatal flaw for autism research? *Trends in neurosciences*, *37*(12), 683-686.

Mahy, C. E., & Moses, L. J. (2011). Executive functioning and prospective memory in young children. *Cognitive Development*, *26*(3), 269-281.

Mäntylä, T., Carelli, M. G., & Forman, H. (2007). Time monitoring and executive functioning in children and adults. *Journal of experimental child psychology*, *96*(1), 1-19.

Martin, M., Kliegel, M., & McDaniel, M. A. (2003). The involvement of executive functions in prospective memory performance of adults. *International Journal of Psychology*, *38*(4), 195-206.

Meacham, J. A., & Singer, J. (1977). Incentive effects in prospective remembering. *The Journal of Psychology*, *97*(2), 191-197.

O'Connell, R. G., Bellgrove, M. A., Dockree, P. M., & Robertson, I. H. (2004). Reduced electrodermal response to errors predicts poor sustained attention performance in attention deficit hyperactivity disorder. *Neuroreport*, *15*(16), 2535-2538.

Ozonoff, S., Pennington, B. F., & Rogers, S. J. (1991). Executive function deficits in high-functioning autistic individuals: Relationship to theory of mind. *Journal of child Psychology and Psychiatry*, *32*(7), 1081-1105.

Penningroth, S. L., Scott, W. D., & Freuen, M. (2011). Social motivation in prospective memory: Higher importance ratings and reported performance rates for social tasks. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale*, *65*(1), 3.

Prior, M., Dahlstrom, B., & Squires, T. L. (1990). Autistic children's knowledge of thinking and feeling states in other people. *Journal of Child Psychology and Psychiatry*, *31*(4), 587-601.

Raymaekers, R., Antrop, I., Van der Meere, J. J., Wiersema, J. R., & Roeyers, H. (2007). HFA and ADHD: A direct comparison on state regulation and response inhibition. *Journal of Clinical and Experimental Neuropsychology*,*29*(4), 418-427.

Rutter, M. (2011). Child psychiatric diagnosis and classification: concepts, findings, challenges and potential. Journal of Child Psychology and Psychiatry, 52, 647–660.

Shapiro, S., & Krishnan, H. S. (1999). Consumer memory for intentions: A prospective memory perspective. *Journal of Experimental Psychology: Applied*, *5*(2), 169.

Steyn, B., & Le Couteur, A. (2003). Understanding autism spectrum disorders. *Current Paediatrics*, *13*(4), 274-278.

Stichter, J. P., Herzog, M. J., Visovsky, K., Schmidt, C., Randolph, J., Schultz, T., & Gage, N. (2010). Social competence intervention for youth with Asperger syndrome and high-functioning autism: An initial investigation. *Journal of autism and developmental disorders*, *40*(9), 1067-1079.

Taurines, R., Schwenck, C., Westerwald, E., Sachse, M., Siniatchkin, M., & Freitag, C. (2012). ADHD and autism: differential diagnosis or overlapping traits? A selective review. *ADHD Attention Deficit and Hyperactivity Disorders*,*4*(3), 115-139.

Tucha, L., Tucha, O., Walitza, S., Sontag, T. A., Laufkötter, R., Linder, M., & Lange, K. W. (2008). Vigilance and sustained attention in children and adults with ADHD. *Journal of Attention Disorders*.

Tucha, O., Walitza, S., Mecklinger, L., Sontag, T. A., Kübber, S., Linder, M., & Lange, K. W. (2006). Attentional functioning in children with ADHD–predominantly hyperactive-impulsive type and children with ADHD–combined type. *Journal of neural transmission*, *113*(12), 1943-1953.

Vetter, N. C., Altgassen, M., Phillips, L., Mahy, C. E., & Kliegel, M. (2013). Development of affective theory of mind across adolescence: disentangling the role of executive functions. *Developmental neuropsychology*, *38*(2), 114-125.

Walter, S., & Meier, B. (2014). How important is importance for prospective memory? A review. *Frontiers in psychology*, *5*, 657.

Wechsler, D. (2005). Wechsler intelligence scale for children – third edition. Nederlandstalige bewerking. Amsterdam: Pearson Assessment and Information B.V.

Wechsler, D. (2012). Wechsler adult intelligence scale – fourth edition. Nederlandstalige bewerking. Technische handleiding. Amsterdam: Pearson Assessment and information B.V.

Wechsler, D., & Naglieri, J. A. (2008). Wechsler nonverbal scale of ability – Nederlandstalige bewerking. Amsterdam: Pearson Assessment and Information B.V.

Williams, D., Boucher, J., Lind, S., & Jarrold, C. (2013). Time-based and event- based prospective memory in autism spectrum disorder: the roles of executive function and theory of mind, and time-estimation. *Journal of autism and developmental disorders*, *43*(7), 1555-1567.

Williams, D. M., Jarrold, C., Grainger, C., & Lind, S. E. (2014). Diminished time- based, but undiminished event-based, prospective memory among intellectually high-functioning adults with autism spectrum disorder: relation to working memory ability. *Neuropsychology*, *28*(1), 30.

Yirmiya, N., Erel, O., Shaked, M., & Solomonica-Levi, D. (1998). Meta-analyses comparing theory of mind abilities of individuals with autism, individuals with mental retardation, and normally developing individuals.*Psychological Bulletin*, *124*(3), 283.

Yirmiya, N., Solomonica-Levi, D., Shulman, C., & Pilowsky, T. (1996). Theory of mind abilities in individuals with autism, Down syndrome, and mental retardation of unknown etiology: The role of age and intelligence. *Journal of Child Psychology and Psychiatry*, *37*(8), 1003-1014.

Zinke, K., Altgassen, M., Mackinlay, R. J., Rizzo, P., Drechsler, R., & Kliegel, M. (2010). Time-based prospective memory performance and time-monitoring in children with ADHD. *Child Neuropsychology*, *16*(4), 338-349.

Appendices

1. *Information flyer, easy to read version*

EEN ONDERZOEK NAAR

ONTHOUDEN BIJ AUTISME

WAT IS HET DOEL?

We moeten dagelijks zoveel dingen onthouden, zoals om onze jas te pakken of ons huiswerk mee naar school te nemen. Als we deze dingen vergeten kan dat voor problemen zorgen in ons dagelijks leven en dat kan heel vervelend zijn. Het doel van deze studie is om te zien of onthouden anders werkt bijautisme.

WAT GA IK DOEN?

Voor het onderzoek zal je verschillende opdrachten gaan doen, sommige op de computer. Er zijn twee sessies: één sessie van één uur en één sessie van een half uur.

VOOR WIE EN WAAR?

Wij zijn op zoek naar jongeren, met en zonder autisme, tussen de 14 en met 18 jaar oud om deel te nemen aan ons onderzoek. Wij kunnen het onderzoek bij jou thuis afnemen. Jouw gegevens blijven anoniem.

HOE DOE IK MEE?

Als je mee wilt doen kun je de toestemmingsformulieren ingevuld aan je mentor geven. Als je vragen hebt kunnen je ouders contact opnemen met Daniel Sheppard, d.sheppard@donders.ru.nl

Hopelijk tot snel!

2. *Information letter, parental version*

Informatiebrief over het onderzoek 'Onthouden bij autisme'

Doel van het onderzoek

Het doel van dit onderzoek is om te kijken of kinderen en jongeren met een diagnose Autisme Spectrum Stoornis (ASS) op een andere manier alledaagse taken onthouden dan kinderen en jongeren zonder een diagnose ASS. Een voorbeeld van deze vorm van onthouden, is onthouden om uw jas te pakken voordat u naar buiten gaat. Als mensen moeite hebben met dit alledaags onthouden, kan dit ertoe leiden dat ze moeite hebben met het organiseren van taken. Ook de moeite met sociale omgang die veel mensen met ASS ervaren zou hierdoor misschien verklaard kunnen worden. Wij willen daarom graag weten of dit onthouden van alledaagse taken anders werkt bij kinderen en jongeren met een ASS dan bij kinderen en jongeren zonder een ASS.

Hoe ziet het onderzoek eruit?

Het onderzoek bestaat uit verschillende deelonderzoeken in samenwerking met het Donders Instituut in Nijmegen. Wij zijn geïnteresseerd in hoe mensen bepaalde computertaken uitvoeren. Behalve de computertaken vragen wij kinderen ook om een aantal andere taken uit te voeren, waaronder enkele intelligentiemetingen. Op deze manier kunnen wij een goed beeld krijgen van hoe processen van onthouden verlopen bij verschillende mensen.

Wie kunnen er mee doen?

Voor dit onderzoek zijn wij op zoek naar jongeren van 14 tot en met 18 jaar zonder een psychiatrische diagnose.

Wat houdt deelname in?

We vragen kinderen om deel te nemen aan onze eerste deelonderzoek. Het onderzoek kan plaatsvinden op verschillende locaties, bijvoorbeeld op school, bij u thuis of op de Radboud Universiteit in Nijmegen. Indien jullie deelnemen, zal uw zoon/dochter op

twee sessies van enkele taken/computertaken uitvoeren: de eerste sessie duurt één uur en de tweede sessie een half uur. De onderzoeker zal steeds duidelijk uitleggen wat uw zoon/dochter moet doen. We zullen ook aan de docent(en) van uw zoon/dochter vragen om vragenlijst in te vullen.
Met uw toestemming is het ook mogelijk dat wij u in de toekomst benaderen om u te vragen aan een vergelijkbaar onderzoek mee te doen.

Bij wie kan ik terecht voor vragen over het onderzoek?

De onderzoekers zijn altijd bereid uw vragen te beantwoorden. De contactgegevens staan onderaan deze informatiebrief.
Indien u liever onafhankelijk advies wilt, kunt u terecht bij de onafhankelijke deskundige. Hij of zij weet van het onderzoek af en kan uw vragen beantwoorden. Zijn of haar contactgegevens staan in de bijlage.

Krijg ik de uitslag van het onderzoek?

U krijgt geen individuele uitslag. We bekijken de resultaten per groep, dat wil zeggen dat we de resultaten van de groep van mensen met autisme vergelijken met de resultaten van de groep mensen zonder autisme.

Wat gebeurt er met de gegevens van het onderzoek?

Alle gegevens die wij tijdens het onderzoek verzamelen, worden anoniem verwerkt. Wij zijn verplicht de gegevens 15 jaar te bewaren. Als u dit niet wilt, kan uw zoon/dochter niet deelnemen aan het onderzoek.
De planning is om de onderzoeksresultaten bekend te maken in tijdschriften. Hierbij zullen alle gegevens anoniem verwerkt zijn, zodat de resultaten niet gekoppeld kunnen worden aan een persoon.

Wat gebeurt er als mijn zoon/dochter niet (meer) mee wil doen aan het onderzoek?

Deelname aan het onderzoek is vrijwillig. U beslist samen met uw zoon/dochter of u mee wilt doen. Zowel uw zoon/dochter als u kunnen op elk moment tijdens het

onderzoek besluiten om deelname te beëindigen. Wanneer uw zoon/dochter of u aangeeft niet (meer) mee te willen doen aan het onderzoek, zal de onderzoeker dit altijd respecteren. U hoeft hier niets voor te doen en u hoeft geen reden op te geven. Daarbij zal de onderzoeker de deelname stop zetten indien hij/zij merkt dat uw zoon/dochter de deelname niet prettig vindt.

Overige vragen

Indien u interesse heeft in deelname door uw zoon/dochter aan ons onderzoek, vul dan aub het bijgevoegde toestemmingsformulier in en lever dit zo snel mogelijk in bij de school. We hopen het onderzoek te starten in februari.
Als u vragen heeft, neem dan gerust contact op via onderstaand e-mailadres of telefoonnummer.

Donders Institute for Brain, Cognition and Behaviour (Nijmegen)

Contact: Daniel Sheppard, MSc. – Onderzoeker In Opleiding (OIO) – T: 024-3612631 –

E: d.sheppard@donders.ru.nl

3. Informed consent form participants

Toestemmingsverklaring voor deelname aan het onderzoek ‘Onthouden bij autisme’

Voor het meedoen aan het onderzoek gelden de volgende voorwaarden:
Ik heb de informatiebrief over het onderzoek gelezen. Ik heb de gelegenheid gehad om aanvullende vragen te stellen. Mijn vragen zijn voldoende beantwoord. Ik heb genoeg tijd gehad om te beslissen of ik meedoe.

Ik weet dat meedoen helemaal vrijwillig is. Ik weet dat ik op ieder moment kan beslissen om toch niet mee te doen. Daarvoor hoef ik geen reden te geven.

Ik weet dat sommige mensen mijn gegevens kunnen zien: de onderzoekers van het onderzoeksteam en de mensen van de toetsingscommissie.

Ik geef toestemming voor het gebruik van mijn gegevens voor ander onderzoek binnen de afdeling Neuro- en Revalidatiepsychologie van het Donders Instituut Nijmegen, op voorwaarde dat al mijn gegevens privé blijven.

Ik geef toestemming voor het publiceren van de resultaten van dit onderzoek in een goedgekeurd vaktijdschrift, op voorwaarde dat al mijn gegevens privé blijven.

Ik geef uit vrije wil toestemming om deel te nemen aan dit onderzoek.

Ik weet dat ik gevraagd kan worden om aan vervolgonderzoek mee te doen, en dat meedoen aan een vervolgonderzoek niet verplicht is.

Ik weet dat mijn gegevens 15 jaar worden bewaard.
Ik wil aan dit onderzoek mee doen.

Naam deelnemer: _____

Handtekening:

Plaats en datum: _____

__/__/____

Naam onderzoeker: _____

Handtekening:

Plaats en datum: _____ __/__/____

4. Informed consent form parents

Toestemmingsverklaring voor deelname aan het onderzoek 'Onthouden bij autisme'

Voor ouder(s)/verzorger(s) van een deelnemer

Voor het meedoen aan het onderzoek gelden de volgende voorwaarden:

Ik ben gevraagd om toestemming te geven voor de deelname van mijn zoon/dochter aan het onderzoek:

Naam proefpersoon: _____ Geboortedatum: ___ /___ /___

Ik heb de informatiebrief over het onderzoek gelezen. Ik heb de gelegenheid gehad om aanvullende vragen te stellen. Mijn vragen zijn voldoende beantwoord. Ik heb genoeg tijd gehad om te beslissen of ik meedoe.

Ik weet dat meedoen helemaal vrijwillig is. Ik weet dat ik op ieder moment kan beslissen om toch niet mee te doen. Daarvoor hoef ik geen reden te geven.

Ik weet dat sommige mensen mijn gegevens kunnen zien: de onderzoekers van het onderzoeksteam en de mensen van de toetsingscommissie.

Ik geef toestemming voor het gebruik van mijn gegevens voor ander onderzoek binnen de afdeling Neuro- en Revalidatiepsychologie van het Donders Instituut Nijmegen, op voorwaarde dat al mijn gegevens privé blijven.

Ik geef toestemming voor het publiceren van de resultaten van dit onderzoek in een goedgekeurd vaktijdschrift, op voorwaarde dat al mijn gegevens privé blijven.

Ik geef uit vrije wil toestemming om deel te nemen aan dit onderzoek.

Ik weet dat ik gevraagd kan worden om aan vervolgonderzoek mee te doen, en dat meedoen aan een vervolgonderzoek niet verplicht is.

Ik weet dat mijn gegevens 15 jaar worden bewaard.

Ik vind het goed dat mijn zoon/dochter meedoet aan dit onderzoek.

Naam ouder/voogd1: _____

Handtekening:

Plaats en datum:_____ _/ _/_____

Naam ouder/voogd2: _____

Handtekening:

Plaats en datum:_____ _/ _/_____

Ik verklaar hierbij dat ik bovengenoemde persoon/personen volledig heb geïnformeerd over het genoemde onderzoek.

Als er tijdens het onderzoek informatie bekend wordt die de toestemming van de ouder of voogd zou kunnen beïnvloeden, dan breng ik hem/haar daarvan tijdig op de hoogte.

Naam onderzoeker: _____

Handtekening:

Plaats en datum:_____ _/ _/_____

5. Syntax SPSS

```
DATASET ACTIVATE DataSet1.

SPLIT FILE LAYERED BY Group.

DESCRIPTIVES VARIABLES=Age Sex Matrix_T_scr AllAge_verb_norm
  /STATISTICS=MEAN STDDEV MIN MAX.

FREQUENCIES VARIABLES=Age Matrix_T_scr AllAge_verb_norm
  /STATISTICS=STDDEV MEAN SKEWNESS SESKEW
  /HISTOGRAM NORMAL
  /ORDER=ANALYSIS.

SPLIT FILE OFF.

EXAMINE VARIABLES=Matrix_T_scr AllAge_verb_norm
PM_hits Inhib_Nogo_correct Task_switch_switch Tom_M_Total Tom_A_Total  BY Group
  /PLOT BOXPLOT STEMLEAF HISTOGRAM SPREADLEVEL(1)
  /COMPARE GROUPS
  /STATISTICS DESCRIPTIVES
  /CINTERVAL 95
  /MISSING PAIRWISE
  /NOTOTAL.

PPLOT
  /VARIABLES=Matrix_T_scr AllAge_verb_norm PM_hits Inhib_Nogo_correct Tom_M_Total
Tom_A_Total Task_switch_switch
  /NOLOG
  /NOSTANDARDIZE
  /TYPE=Q-Q
  /FRACTION=BLOM
```

```
  /TIES=MEAN
  /DIST=NORMAL.

CORRELATIONS
  /VARIABLES=Age Matrix_T_scr AllAge_verb_norm Inhib_Nogo_correct Task_switch_switch
Tom_M_Total Tom_A_Total
    PM_hits
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
NONPAR CORR
  /VARIABLES=Age Matrix_T_scr AllAge_verb_norm Inhib_Nogo_correct Task_switch_switch
Tom_M_Total Tom_A_Total
    PM_hits
  /PRINT=SPEARMAN TWOTAIL NOSIG
  /MISSING=PAIRWISE.

T-TEST GROUPS=Group(0 1)
  /MISSING=ANALYSIS
  /VARIABLES=Age Task_switch_switch Inhib_Nogo_correct Matrix_T_scr AllAge_verb_norm
  /CRITERIA=CI(.95).

T-TEST GROUPS=Group(0 1)
  /MISSING=ANALYSIS
  /VARIABLES=Tom_M_Total Tom_A_Total PM_hits
  /CRITERIA=CI(.95).

ONEWAY PM_hits BY Condition
  /STATISTICS DESCRIPTIVES HOMOGENEITY
  /MISSING ANALYSIS
  /POSTHOC=TUKEY ALPHA(0.05).
```

```
SPLIT FILE LAYERED BY Group.

ONEWAY PM_hits BY Condition
  /STATISTICS DESCRIPTIVES HOMOGENEITY
  /MISSING ANALYSIS
  /POSTHOC=TUKEY ALPHA(0.05).

SPLIT FILE OFF.

GET
  FILE='C:\Users\sascha\Dropbox\Sas spullen\Data analyse\Motivation_Controls and adhd ASD
completed_v3.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
DESCRIPTIVES VARIABLES=Tom_M_Total
  /STATISTICS=MEAN STDDEV MIN MAX.

COMPUTE ToMM_Centr=Tom_M_Total - 3.
EXECUTE.
COMPUTE ToMM_CentrXCondition=ToMM_Centr * Condition.
EXECUTE.
REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING PAIRWISE
  /STATISTICS COEFF OUTS R ANOVA COLLIN TOL CHANGE ZPP
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT PM_hits
  /METHOD=ENTER Matrix_T_scr AllAge_verb_norm
  /METHOD=ENTER Task_switch_switch Inhib_Nogo_correct
  /METHOD=ENTER Tom_M_Total ToMM_CentrXCondition
  /SCATTERPLOT=(*ZRESID ,*ZPRED)
  /RESIDUALS DURBIN
```

```
  /SAVE MAHAL COOK.

COMPUTE ToMsequences_total=Tom_2_M + Tom_4_M + Tom_6_M + Tom_9_M.
EXECUTE.

COMPUTE ToMaccuracy_total=Tom_2_A + Tom_4_A + Tom_6_A + Tom_9_A.
EXECUTE.

COMPUTE GDsequences_total=Tom_1_M + Tom_5_M + Tom_8_M + Tom_10_M.
EXECUTE.

COMPUTE GDaccuracy_total=Tom_1_A + Tom_5_A + Tom_8_A + Tom_10_A.
EXECUTE.

COMPUTE Randomsequence_total=Tom_3_M + Tom_7_M.
EXECUTE.

T-TEST GROUPS=Group(0 1)
  /MISSING=ANALYSIS
  /VARIABLES=ToMsequences_total ToMaccuracy_total GDsequences_total GDaccuracy_total
    Randomsequence_total
  /CRITERIA=CI(.95).

SPLIT FILE LAYERED BY Group.
T-TEST GROUPS=ADHD_Diagnosis(0 1)
  /MISSING=ANALYSIS
  /VARIABLES=PM_hits Tom_M_Total
  /CRITERIA=CI(.95).


SPLIT FILE OFF.
UNIANOVA PM_hits BY Group WITH ADHD_Diagnosis
```

```
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /CRITERIA=ALPHA(0.05)
  /DESIGN=ADHD_Diagnosis Group.

DATASET ACTIVATE DataSet1.
GLM ClockChecks_1st ClockChecks_2nd ClockChecks_3rd ClockChecks_4th BY Group
Condition
  /WSFACTOR=Clockchecking 4 Repeated
  /METHOD=SSTYPE(3)
  /SAVE=COOK
  /POSTHOC=Condition(BONFERRONI)
  /PLOT=PROFILE(Group*Clockchecking Condition*Clockchecking)
  /EMMEANS=TABLES(Clockchecking) COMPARE ADJ(BONFERRONI)
  /PRINT=DESCRIPTIVE HOMOGENEITY
  /CRITERIA=ALPHA(.05)
  /WSDESIGN=Clockchecking
  /DESIGN=Group Condition Group*Condition.

SPLIT FILE LAYERED BY Group.

GLM ClockChecks_1st ClockChecks_2nd ClockChecks_3rd ClockChecks_4th BY Condition
  /WSFACTOR=Clockchecking 4 Repeated
  /METHOD=SSTYPE(3)
  /SAVE=COOK
  /POSTHOC=Condition(BONFERRONI)
  /EMMEANS=TABLES(Clockchecking) COMPARE ADJ(BONFERRONI)
  /PRINT=DESCRIPTIVE HOMOGENEITY
  /CRITERIA=ALPHA(.05)
  /WSDESIGN=Clockchecking
  /DESIGN=Condition.
```

```
GLM ClockChecks_1st ClockChecks_2nd ClockChecks_3rd ClockChecks_4th BY Condition
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /PRINT=DESCRIPTIVE HOMOGENEITY
  /CRITERIA=ALPHA(.05)
  /DESIGN= Condition.


REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Condition
  /METHOD=ENTER ClockChecks_1st ClockChecks_2nd ClockChecks_3rd ClockChecks_4th
  /SAVE MAHAL.

GLM ClockChecks_1st ClockChecks_2nd ClockChecks_3rd ClockChecks_4th BY Condition
  /METHOD=SSTYPE(3)
  /POSTHOC=Condition(BONFERRONI)
  /INTERCEPT=INCLUDE
  /PRINT=DESCRIPTIVE HOMOGENEITY
  /CRITERIA=ALPHA(.05)
  /DESIGN= Condition.

SPLIT FILE OFF.
```