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Inhibition and cognitive flexibility of children and adolescents with and without ASD and their parents.

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Inhibition and cognitive flexibility in children and adolescents with and without Autism Spectrum Disorder and their parents

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Abstract

The purpose of the present study was to examine the inhibition and cognitive flexibility (parts of executive functioning) of children and adolescents with ASD, their parents, and controls (children and adolescents). Therefore, a sample of 43 children/adolescents with ASD, 33 children/adolescents without ASD (controls) and 46 parents of children/adolescents with ASD was used. To measure inhibition and cognitive flexibility parts of the ANT and D-Kefs were used. The shortened WISC/WAIS was used to estimate IQ, and the SRS and AQ were used to measure autistic traits in daily life. There was no difference between children/adolescents with and without ASD on inhibition or cognitive flexibility tasks. Age, however, had a significant effect on executive functioning and autistic traits in daily life. Parents of children/adolescents with ASD performed better on inhibition and cognitive flexibility tasks than their autistic children, but there was no difference between fathers and mothers on these tasks. Children with ASD had a higher verbal and total IQ than controls and the total and nonverbal IQ were significant predictors of inhibition and cognitive flexibility. The present study showed that the variables diagnosis, age and IQ play a role in the ability to inhibit responses and to switch between various conditions. Implications of these findings are discussed.

Introduction

1.1 Goals of the study

The purpose of the present study is to examine the executive dysfunctioning of children and adolescents with Autism Spectrum Disorder (ASD). The goals of the present study can be devided into three different parts, every part in its own way related to inhibition and cognitive flexibility. In the first part of the study the goal is to gain more knowledge about the role of age in relation to inhibition and cognitive flexibility. In the second part the aim is to explore inhibition and cognitive flexibility in a broader family perspective. Growing knowledge about the executive functioning of ASD children and their parents should be the result of examining the inhibition and cognitive flexibility of ASD children and their parents. The third part of the study aligns to intelligence and executive functioning and lines up to a more clear insight in the relation between intelligence and inhibition and cognitive flexibility. To reach these different goals not only children and adolescents with ASD are participants of the current study, but also parents and controls (children and adolescents).

1.2 Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) refers to the umbrella of pervasive developmental disorders. It includes autism, Asperger syndrome, Rett's disorder, Childhood disintegrative disorder and Pervasive Developmental Disorder - not otherwise specified (PDD-NOS) (American Psychiatric Association, 2000). Although different labels, like Pervasive Developmental Disorder and Autism Spectrum Disorder, are used, Autism Spectrum Disorder (ASD) will be used in the present study. Children with ASD have impaired social interaction, deficits in communication, repetitive behavior and restricted interests and activities (Losh et al., 2009). The disorder occurs before age three (American Psychiatric Association, 2000; Hill, 2004a) and is a lifelong developmental disorder which affects at least 0.6% of the population. Males are affected three to four times more often than females (Hill, 2004b; Manning-Courtney et al., 2003; Rapin, 2002).

ASD is considered to be highly heritable compared to other psychiatric or developmental disorders (Losh et al., 2009). Social and non-social aspects of ASD involving problems of social communication, inflexible language and behavior, and repetitive sensory-motor movements (Hughes, 2008), seem to have distinct causes at the genetic, cognitive and neural levels (Happé & Ronald, 2008). For the possible etiology of autism multiple causes can be mentioned. Many different chromosomes and even larger number of genes, various parental conditions, many central nervous system conditions, also various systemic factors, growth and hormonal changes, electrolyte disorders, oxidative stress and high testosterone levels have been mentioned in relation to autism, as is under connectivity in the central nervous system (Hughes, 2008).

Other psychological research on finding a universal and specific psychological cause for ASD, suggests three important psychological theories: Theory of Mind (Baron-Cohen, 1995), weak central coherence (Happé & Frith, 2006) and executive dysfunction (Geurts, Corbett, & Solomon, 2009; Hill, 2004a; Lopez, Lincoln, Ozonoff, & Lai, 2005). In the present study the focus will be on executive dysfunction.

1.3 Executive dysfunction

The executive dysfunctioning theory of ASD is thought to be essential in explaining symptoms in the disorder. Executive functions – including planning, inhibition, working memory and cognitive flexibility – are responsible for guiding and controlling cognitive processes (Geurts et al., 2009; Russo et al., 2006; Van Zomeren & Eling, 2006). The perseverative, stereotyped behavior and difficulties in the regulation and modulation of motor acts may illustrate poor cognitive flexibility (Hill, 2004b; Shu, Lung, Tien, & Chen, 2001). Executive dysfunction may also be reflected by rigid thought processes (Anderson, Northam, Hendy, & Wrennall, 2001). The impairments in executive function in ASD may appear early in development and persist, or may represent a more transient delay.

Inhibition and cognitive flexibility will be subject of the present study, because there is no consistency in previous studies about those aspects of executive functioning. Inhibition is the ability to suppress the activation, processing, or expression of information that would otherwise interfere with the attainment of a behavioral or cognitive goal (Christ, Holt, White, & Green, 2007; Van Zomeren & Eling, 2006). Cognitive flexibility can be defined as the ability to shift to a different thought or action in response to changes in the situation (Robinson, Goddard, Dritschel, Wisley, & Howlin, 2009).

Research on inhibition is not consistent. Hill (2004b), and Sergeant, Geurts, and Oosterlaan (2002) found no difference in inhibition between children with and without ASD. Christ et al. (2007), Kleinhans, Akshoomoff, and Delis (2005), and Luna, Doll, Hegedus, Minshew, and Sweeney (2007) on the other hand, have found impaired inhibition in children with ASD; children with ASD perform worse on inhibition tasks.

Research on cognitive flexibility is also not consistent. Whereas Pascualvaca, Fantie, Papageorgiou, and Mirsky (1998), Sergeant et al. (2002), and Sinzig, Morsch, Bruning, Schmidt, and Lehmkuhl (2008) all found that children with ASD have impaired cognitive flexibility, Geurts et al. (2009) question whether failure on tasks is related to cognitive inflexibility and conclude there is no consistent evidence for cognitive flexibility deficits in Autism Spectrum Disorders. Robinson et al. (2009) also state that children with ASD do not differ from controls in cognitive flexibility.

1.4 Age and executive functioning

Executive functions are relatively immature in childhood and develop during life (Hill, 2004b; Russo et al., 2006; Verté, Geurts, Roeyers, Oosterlaan, & Sergeant, 2005). The executive functions are mediated by the frontal lobe and especially by the prefrontal cortex

(Hill, 2004a). These parts of the brain are last to develop and depend on efficient functioning of other brain regions, which is realized by elimination of synapses during the first years of life (Anderson et al., 2001). In children with ASD, abnormal brain overgrowth occurs until age 4, which is followed by arrested growth (Belmonte et al., 2004; Courchesne, 2004). This prolonged period of brain development affects the regions essential for complex cognitive functions (Baron-Cohen & Belmonte, 2005; Belmonte et al., 2004). The theory of executive dysfunction assumes a form of frontal lobe pathology which leads to deficits in abilities such as cognitive inflexibility (Gokcen, Bora, Erermis, Kesikci, & Aydin, 2007).

Since the brain regions that mediate executive functions develop during life, it is important to take age into account in research on inhibition and cognitive flexibility. Performance on executive function tasks improves with age and becomes more pronounced during adolescence (Happé, Booth, Charlton, & Hughes, 2006; Verté et al., 2005). Improvement with age is found for inhibition, but not for cognitive flexibility (Luna et al., 2007; Robinson et al., 2009; Russo et al., 2006). The following questions will be answered in the present study;

1. Is there a difference in mean inhibition and cognitive flexibility between children/adolescents with and without ASD?
2. Is there a difference in inhibition between individuals with and without ASD, when controlling for differences in age?
3. Is there a difference in cognitive flexibility between individuals with and without ASD, when controlling for differences in age?

Hypothesized is that individuals with ASD do not differ from 'controls' on inhibition. The one part of inhibition that is generally impaired in individuals is the inhibition of a prepotent response (Hill, 2004b). Christ et al. (2007), and Kleinhans et al. (2005) have found impaired inhibition in children with ASD, but not on the Stroop task or Color Word Interference Test. The Color Word Interference Test was also used in the present study. It is hypothesized that children/adolescents with ASD differ from 'controls' on cognitive flexibility, since individuals with ASD perform worse on tasks that measure cognitive flexibility (Russo et al., 2007; Teunisse, Cools, Van Spaendonck, Aerts, & Berger, 2001). It is also hypothesized that adolescents perform better on inhibition and cognitive flexibility than children since performance on executive functioning tasks improves with age (Happé et al., 2006).

Children with ASD have impaired social interaction, deficits in communication, repetitive behavior and restricted interests and activities. These traits are visible in daily life situations. The executive dysfunction theory is used in explaining symptoms in children with

ASD, for example the perseverative, stereotyped behavior and difficulties in the regulation and modulation of motor acts may illustrate poor cognitive flexibility (Hill, 2004b). Therefore the amount of autistic traits will also be subject of research;

4. Is there a correlation between executive functions and autistic traits in daily life?

A correlation between executive functioning and autistic traits in daily life situations is expected (Filipek et al., 1999; Hill, 2004b). It is hypothesized that problems in inhibition and cognitive flexibility correlate with more autistic traits in daily life.

1.5 Executive functioning: parents and children

Asperger (1944) and Kanner (1943) both note that parents of children with ASD appear to share some of their children's characteristics. Kanner (1943) even suggests the syndrome is inherited from the fathers. Later findings suggest a broader cognitive phenotype for ASD; relatives of people with ASD may not have the condition itself, but have a 'lesser variant' of it (Baron-Cohen & Hammer, 1997). The findings of Best, Moffat, Power, Owens, and Johnstone (2008) provide support for the continuum hypothesis of autism. This hypothesis is based on the idea that mild autistic traits are distributed through the population. These traits may have the same underlying cognitive determinants as ASD.

Aspects of local processing style and executive dysfunctions are considered to be part of the broader cognitive phenotype of autism (Bölte & Poustka, 2006). Deficits in some aspects of executive functions, including cognitive flexibility, are found in relatives of individuals with ASD (Gokcen et al., 2007). There are reports of significant differences between parents of autistic children and control parents on tests measuring aspects of central coherence and executive function (Bailey, Palferman, Heavey, & Le Couteur, 1998). A limited number of studies have reported deficits in some aspects of executive functions, including cognitive flexibility, in relatives of persons with ASD (Ozonoff, Rogers, Farnham, & Pennington, 1993; Hughes, Leboyer, & Bouvard, 1997; Piven & Palmer, 1997).

Parents of children with ASD demonstrate a specific profile of performance on a range of components of executive function: planning, set-shifting (cognitive flexibility), inhibition and generativity. ASD parents show poorer performance on a fluency test and fathers also demonstrate a weakness in cognitive flexibility. Parents of children with ASD, however, seem to display no difficulties with planning or inhibition (Wong, Maybery, Bishop, Maley, & Hallmayer, 2006). Research in this part of the study is guided by the following questions:

1. Is there a difference between children with ASD and their parents on inhibition, controlling for an effect of age, gender and diagnosis of ASD of the child and the parents?
2. Is there a difference in inhibition between fathers and mothers of children with ASD?
3. Is there a difference between children with ASD and their parents on cognitive flexibility, controlling for an effect of age, gender and diagnosis of ASD of the child and the parents?
4. Is there a difference in cognitive flexibility between fathers and mothers of children with ASD?

It is hypothesized that there will be a difference between the cognitive flexibility of ASD children and their parents, ASD diagnosis will not play a role, but age and gender will (Bölte, Poustka, & Constantino, 2008; Wong et al., 2006). Age-related differences in cognitive flexibility will be found: older adults will show less cognitive flexibility than younger adults (Kramer, Hahn, & Gopher, 1999). Gender related differences will also be seen, as ASD children and their fathers mainly demonstrate a strong relation in cognitive flexibility, whereas the relation between the cognitive flexibility of ASD children and their mothers is found to be less strong. Fathers of children with ASD will score worse than mothers on cognitive flexibility, for inhibition this difference will not be found. For inhibition it is hypothesized that a difference between children and parents will not be found, neither will gender, age or ASD diagnosis play a role (Hill, 2004a; Wong et al., 2006).

1.6 Intelligence and executive functioning

The WISC-III and WAIS-III are commonly used to measure intelligence. The total intelligence quotient, measured by the WISC-III or the WAIS-III, contains a verbal and a non-verbal component (Wechsler, 1997). A high percentage of children with ASD have a significantly stronger verbal IQ than nonverbal IQ (Coolican, Bryson, & Zwaigenbaum, 2008; Mayes & Calhoun, 2003). Therefore, children and adolescents with ASD may differ from controls on IQ.

The level of intelligence seems to be related to the performance on executive function tasks (Graham et al., 2009; Liss et al., 2001). Participants with a higher IQ use more effective cognitive strategies which results in faster responses on executive function tasks (Graham et al., 2009). According to Bitsakou, Psychogiou, Thompson, and Sonuga-Barke (2007) no relation exists between intelligence and inhibitory control, while Orekhova et al. (2008) have found that intelligence and inhibition are positively related. Orekhova et al. (2008) have compared a retarded ASD group with an ASD group with a normal intelligence and have found that the retarded group has performed less on inhibitory control tasks. Polderman et al. (2009) have also found a significant positive correlation between inhibitory control and IQ. In summary, most previous studies report a positive relation between inhibition and intelligence.

This positive relation between inhibition and intelligence is comparable to the relation between cognitive flexibility and intelligence. Intelligence has an influential role: higher IQ is associated with a better performance on cognitive flexibility tasks (Graham et al., 2009; Harris et al., 2008). Colzato, Van Wouwe, Lavender, and Hommel (2006) also suggest that high intelligence is accompanied by a higher degree of cognitive flexibility.

According to Liss et al. (2001), and Joseph, McGrath, and Tager-Flusberg (2005) the verbal IQ component is positively correlated to executive functioning. Turner (1999) says that cognitive flexibility is equally impaired in the ASD group with a low verbal IQ as in the ASD group with a high verbal IQ. There is no consistency regarding the relation between the verbal IQ and cognitive flexibility and inhibition. A few studies on executive functions control their findings not only for the total intelligence quotient (Harris et al., 2008), but also for the verbal and nonverbal IQ components (Joseph et al., 2005; Liss et al., 2001). When interpreting the fact that a few studies control their findings for both the nonverbal and the verbal IQ, it could be that the nonverbal IQ component is, just like the verbal component, positively correlated to cognitive flexibility and inhibitory control.

The first aim of the third part of the present study is to see if there is a difference in the total, nonverbal or verbal intelligence between children and adolescents with and without ASD. The second aim is to see if it is possible to predict the scores on inhibition and cognitive flexibility with the total IQ, and with the nonverbal and verbal IQ. The questions to be answered are:

1. Is there a difference in the total, nonverbal or verbal intelligence between individuals with and without ASD?
2. Can scores on inhibition and cognitive flexibility be related to total, verbal and nonverbal IQ?

It is expected that children and adolescents with ASD have a higher verbal IQ compared to controls and because of that also a higher total IQ. The nonverbal IQ of people with ASD will be comparable to that of controls. The level of intelligence seems to be related to the performance on executive function tasks (Graham et al., 2009; Liss et al., 2001), therefore it is expected that the total IQ can predict scores on inhibition and cognitive flexibility. Beside of the inconsistency of studies about the relation between the verbal and nonverbal IQ and inhibition and cognitive flexibility, it is expected that the verbal and nonverbal IQ can be related to inhibition and cognitive flexibility.

Method

2.1 Sample and procedure

A total amount of 122 persons participated in the present study. This group contained 43 children/adolescents with ASD, 33 children/adolescents without ASD (controls) and 46 parents of children/adolescents with ASD (22 fathers and 24 mothers) who also participated in the present study. Not all parents of ASD children participated and some participating parents had more than one child with ASD. One subject was left out of the analyses on basis of age (55 years in a control group with M = 20.28). The children/adolescents were divided further into groups based on diagnosis (with or without ASD) and age (children < 16 or adolescents ≥ 16 years). Table 1 contains descriptive statistics of the sample. The children and adolescents with ASD - and their parents - were all known by University Medical Centre (UMC) Utrecht, department Child Psychiatry; Autism and Psychosis, and participated in a voluntary way. Controls also participated on a voluntary basis and were approached via a newsletter to different elementary schools and regional education centers. Most adolescent controls were recruited on technical education schools.

Table 1. *Descriptive Statistics of the Sample*

Group[a]	*N*			Age		IQ	
	Total	Male	Female	*M*	*SD*	*M*	*SD*
Children with ASD	27	22	5	11.99	1.68	108.85	16.70
Adolescents with ASD	16	11	5	20.88	3.11	110.37	19.74
Children, controls	12	7	5	11.58	1.49	108.25	8.17
Adolescents, controls	21	17	4	20.28	2.43	105.60	14.08
Parents of children/ adolescents with ASD	46	22	24	45.84	6.75	118.89	20.66

Note.[a] Children are younger than age 16, adolescents are 16 years or older.

When using two-tailed tests and $\gamma = .40$, suggesting there's a big difference between the used test variables, analysis including the total group had a power of .99. Analysis including only the parents gave a power of .77. A power of .74 was found when only the children and adolescents with ASD were included and .63 when only the controls were included. These amounts of power could be qualified as satisfactory.

To confirm the diagnosis of ASD, parents of participants with ASD were questioned with the Autism Diagnostic Interview - Revised (ADI-R; Lord, Rutter, & LeCouteur, 1994), the children and adolescents with ASD were observed using the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 2002). A requirement to participate as a control was a neutral result on a screening, followed by a non-clinical score on the Child Behavior Checklist (CBCL; Achenbach, 1991) and mastery of the Dutch language. A contra indication for participation as a control in the present study was a psychiatric disorder within the family. All participants needed to have an IQ above 70. Because of the select way of sampling, the participants were not a representative sample of the children and adolescents with ASD in the Netherlands, neither were the parents and controls.

Participants of the present study were asked to fill out two questionnaires and to do eight neuropsychological tasks. Completion of the tasks and questionnaires took about 2.5 hours, including a break of 15 minutes. Participants received a gift coupon of 25 Euros as a reward for participating. The study was approved by the Medical Ethics Committee of the UMC-Utrecht. Two of the neuropsychological tasks were presented on a DELL laptop, type Latitude D250. The screen (1280 x 800) was placed at approximately 50 cm from the participant.

2.2 Instruments: neuropsychological tasks and questionnaires

Inhibition: To measure inhibition, tasks of the Amsterdamse Neuropsychologische Taken (ANT; De Sonneville, 1996) and the Delis-Kaplan Executive Function System (D-Kefs; Delis, Kaplan, & Kramer, 2001) were used. The ANT, a computerized task, was developed for a standardized and systematic evaluation of the basal processes that underlie the execution of complex cognitive processes. The ANT is an often used test for scientific and clinical research, the validity and reliability of the ANT are sufficient to good (De Sonneville, 2005). The Shifting Attentional Set – Visual (SSV) and the Shifting Attentional Set – Auditory (SSA) of the ANT were used in the present study. The SSV is a visual task in which the participant has to react to blocks on a computer screen, it contains a baseline condition, an inhibition condition and a switching condition. The inhibition condition will be discussed here, the switching condition will be discussed under *cognitive flexibility*. In the inhibition tasks the participant was shown a red block. When the block moves to the right, the participant has to press the left mouse button and vice versa. The task was designed to inhibit the response to press the button which corresponded to the movement of the block. Registered were the reaction time in msec. and the amount of mistakes made. Scores were automatically converted into *z*-scores by the ANT-program. Norms were available for age 5-64. The SSA is an auditory task in which the participant hears different sounds; again the task contains a baseline, inhibition, and switching condition. The switching condition will be discussed under *cognitive flexibility*. In the inhibition task the participant has to press the mouse button of their preference hand once if he/she hears a high tone twice and press twice if the high tone is presented one time. Scores were also automatically converted into *z*-scores. Norms for the SSA were available for age 8-12.

Of the D-Kefs, the subtests Color Word Interference Test (CWI) and Design Fluency Test (DFT) were used. The CWI and DFT were reliable for most ages (Delis, Kaplan, & Kramer, 2007; Delis, Kaplan, & Kramer, 2008). The CWI was designed to evaluate the ability to inhibit an automatic response. It contains four conditions; color naming, word reading, inhibition and inhibition/switching. The inhibition condition will be discussed here, the inhibition/switching condition will be discussed under *cognitive flexibility*. In the inhibition condition the participant was presented a laminated card with 50 color names printed in an incongruent ink color. The participant was asked to name the color of the ink and ignore the written word, for example when the word RED was printed in blue ink the participant had to say blue, which requires inhibiting the more automatic reading response. Registered was the time needed to complete the test, the amount of mistakes corrected by the participant, and the amount of uncorrected mistakes. A lot of uncorrected mistakes correspond to a lower score on inhibition. The scores for each condition are based on the number of seconds to complete the task. Scores were converted into a scaled score: range 1-19 (M = 10, SD = 3). The DFT is a nonverbal test in which the participant was presented a paper with 35 boxes with dots. The participant needed to connect dots and draw as many different figures for 60 seconds. Registered were the total amount of attempts, the amount of repetitive attempts and the amount of mistakes. A lot of repetitive attempts and mistakes correspond to a lower score on inhibition. Only four straight lines could be used to connect dots. The DFT contained three conditions; filled dots, empty dots (inhibition) and switching between filled and empty dots. To measure inhibition only the inhibition condition was used, the switching condition will be discussed under *cognitive flexibility*. The inhibition condition contained of five filled and five empty dots, the participant was instructed to ignore the filled dots. The scores were based on the total amount of correct figures. For the DFT scores were also converted into scaled scores with M = 10, SD = 3 and range 1-19.

Cognitive flexibility: To measure cognitive flexibility the ANT and D-Kefs were also used. The switching condition of the SSV and SSA were used to measure cognitive flexibility. The switching condition of the SSV contains green and red blocks which move from left to right. The color of the block told the participant which mouse button to press. When the block was green the participant had to press the congruent mouse button, when the block was red the mouse button incongruent to the movement had to be pressed. In the switching task of the SSA the participant listened to high and low tones. When a low tone was presented one time, the participant had to press the mouse button of their preference hand once. This was also the case if a high tone was presented twice. The participant had to press twice if a low tone was presented twice or when one high tone was presented. Registered were the reaction time and the amount of mistakes made. A lower reaction time and a higher amount of mistakes correspond to a lower score on cognitive flexibility. Scores were automatically converted into z-scores.

In the inhibition/switching condition of the CWI the participant needed to switch between reading a word that indicates a color if this word was written in a box, or naming the color of the ink in which the word was printed. The participant was presented with 50 items on a laminated card. Registered was the time needed to complete the test, the amount of mistakes corrected by the participant, and the amount of uncorrected mistakes. A higher completion time and a higher amount of mistakes correspond to a lower score on cognitive flexibility. In the DFT the switching condition contained five filled and five empty dots, the participant was instructed to alternate between filled and empty dots. The participant was presented with a paper with 35 boxes. In 60 seconds of time the participant had to complete as many patterns as possible. Registered were the total amount of attempts, the amount of repetitive attempts and the amount of mistakes. A lower total amount of attempts and a higher amount of repetitive attempts and mistakes correspond to a lower score on cognitive flexibility.

IQ: The intelligence of the participants was estimated with the shortened WISC-III and WAIS-III. Short versions of the WISC-III and the WAIS-III are often used (Donders, 1997; Wechsler, 1997). In the present study, the short version of the WISC-III and the WAIS-III contained the following subtests: Vocabulary and Similarities to measure the verbal IQ, Block Design and Object Assembly to measure the nonverbal IQ. The subtest Vocabulary measured the vocabulary level, for example *Can you tell me what a bike is?* and the subtest Similarities measured the level of abstract thinking, for example *Can you tell me the similarity between red and blue?*. The nonverbal subtest Block Design measured nonverbal reasoning, the respondent needed to copy patterns with blocks and the subtest Object Assembly measured the analysis of part-whole relationships. The respondent needed to complete five jigsaws. Counting up the scores on the items of each subtest gave a total raw score for each subtest. The scores on the verbal subtests will be determined by counting up the score on each item, which is determined only by the correctness of each item. The scores on the nonverbal subtest will be determined by counting up the score on each item, which is determined by the completion time and correctness of each item. The found raw score needed to be converted to a norm score (M = 10, SD = 3). Counting up the norm scores on each subtest and comparing it with a table, gave the total IQ. The verbal and nonverbal IQ were determined by counting up the scores for the verbal or nonverbal subtests only and comparing it with the table for the verbal or the nonverbal IQ. The reliability of the WISC-III and the WAIS-III is described in Table 2. These Cronbach's Alphas are based on the whole intelligence tests and can be qualified as satisfactory (Kort et al., 2005; Wechsler, 1997).

Table 2. *Cronbach's Alphas for the WISC-III and the WAIS-III*

	Total IQ	Verbal IQ	Nonverbal IQ	Vocabulary	Similarities	Block Design	Object Assembly
WISC-III	.94	.92	.87	.82	.74	.78	.53
WAIS-III	.98	.97	.93	.93	.86	.87	.74

Autistic traits: The questionnaires used in the present study were the Autism Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) and the Social Responsiveness Scale (SRS; Constantino et al., 2003). Both questionnaires were valid quantitative measures of autistic traits, feasible for use in clinical settings and for large-scale research studies of autism spectrum conditions (Auyeung, Baron-Cohen, Wheelwright, & Allison, 2008; Bölte et al., 2008; Constantino et al., 2003; Hoekstra, Bartels, Cath, & Boomsma, 2008; Woodbury-Smith, Robinson, Wheelwright, & Baron-Cohen, 2005). The reliability for both questionnaires was .82. The AQ measures autistic traits in daily life. The questionnaire was filled out by one of the parents (children < 16 years) or by participants themselves (≥ 16 years). It consisted of fifty statements in which the participant (or parent) indicated whether he "Definitely agrees", "Slightly agrees", "Slightly disagrees" or "Definitely disagrees", for example *I prefer to do things with others rather than on my own*. Half the questions were stated to induce an agree response, the other half of the questions to induce a disagree response. The total score ranged from 50 – 200, a higher score on the AQ indicated more autistic traits in daily life. Next to a total score, there were five domains, each domain contained 10 questions of the AQ: social skills e.g. *I find social situations easy*; communication skills e.g. *I enjoy social chit-chat*; imagination e.g. *I find it very easy to play games with children that involve pretending*; attention to detail e.g. *I tend to notice details that others do not*; and attention switching/tolerance of change e.g. *It does not upset me if my daily routine is disturbed*. Cronbach's alpha for the total questionnaire was 0.97. The internal consistencies of the five subscales were; social skills: 0.93, communication skills: 0.92, imagination: 0.88, attentional to detail: 0.83, attention switching: 0.89.

The SRS contained 65 questions about the child, filled out by one of the parents (children < 18 years) or by the participant themselves (≥ 18 years). The SRS measures the ability to engage in emotionally appropriate reciprocal social interaction, measured on five subscales: social awareness e.g. *Knows when he/she is too close to someone or invading someone's space*; social cognition e.g. *Does not recognize when others are trying to take advantage of him or her*; social communication e.g. *Is able to understand the meaning of other people's tone of voice and facial expressions*; social motivation e.g. *Seems much more fidgety in social situations than when alone*; and autistic mannerisms e.g. *Touches others in an unusual way*. The participant (or parent) indicated whether he "Definitely agrees", "Slightly agrees", "Slightly disagrees" or "Definitely disagrees". The total score ranged from 65 – 260, with a higher score indicating more autistic traits in daily life situations. Cronbach's alpha for the total questionnaire was 0.97. The internal consistencies of the five domains were; social awareness: 0.77, social cognition: 0.87, social communication: 0.92, social motivation: 0.82, autistic mannerisms: 0.90.

Results

The used fixed design in the current study was a non-experiment with a control group. In every part of the current study, inhibition and cognitive flexibility were the dependent variables, the independent variables differ per part. Table 3 shows the Pearson correlation coefficients of all used variables of the present study. Inhibition and cognitive flexibility were positively correlated when they were measured by the same test. There were significant negative correlations for the total group and the parents on inhibition measured with the ANT and the D-Kefs. Also a negative significant correlation was found for the total group on cognitive flexibility when measured with the ANT and the D-Kefs. The scores on the questionnaires were negatively correlated to the scores on cognitive flexibility of the D-Kefs, a high score on the questionnaires (autistic traits in daily life) corresponded to a lower score on cognitive flexibility. Both the total and nonverbal IQ were correlated with inhibition and cognitive flexibility. The total and nonverbal IQ were positively correlated with inhibition and cognitive flexibility measured with the D-Kefs, meaning that a higher intelligence corresponded to a higher score on inhibition and cognitive flexibility. The total and nonverbal IQ are negatively correlated to inhibition and cognitive flexibility measured with the ANT, meaning that a lower intelligence score corresponds to a higher score on inhibition and cognitive flexibility.

Table 3. *Pearson Correlation Coefficients of All Used Variables of the Present Study*

	SRS	AQ	Total IQ	Verbal IQ	Nonverbal IQ	Inhibition D-Kefs	Inhibition ANT	Cognitive flexibility D-Kefs	Cognitive flexibility ANT
SRS	-	.81**	-.20*	-.13	-.27**	-.29**	.23*	-.49**	.20*
		.63**	-.17	-.10	-.28	-.26	.18	-.31*	.11
AQ	.88**	-	-.12	-.02	-.22*	-.29**	.18	-.38**	.21*
	.76**		-.10	-.01	-.23	-.35*	-.07	-.22	.09
Total IQ	-.03	.06	-	.74**	.80**	.32**	-.24**	.29**	-.21*
	-.24	-.14		.83**	.85**	.15	-.15	.18	-.27
Verbal IQ	-.14	-.01	.68**	-	.25**	.20*	-.02	.16	.01
	-.24	-.25	.76**		.48**	.13	-.02	.15	-.20
Nonverbal IQ	.01	.05	.74**	.02	-	.32**	-.34**	.29**	-.37**
	-.21	-.06	.83**	.30		.24	-.21	.17	-.28
Inhibition	-.25	-.12	.31	.21	.26	-	-.29**	.66**	-.16
D-Kefs	-.11	-.20	.37*	.21	.27		-.33*	.61**	-.17
Inhibition ANT	.25	.21	-.30	-.13	-.32	-.30	-	-.21*	.55**
	.26	.17	-.34*	-.15	-.41	-.31		-.21	.29
Cognitive	-.41*	-.33	.14	-.04	.24	.73**	-.33*	-	-.09
flexibility D-Kefs	-.41**	-.40*	.32	.26	.22	.47**	-.10		.01
Cognitive	.04	-.07	-.12	-.08	-.15	-.09	.64**	-.05	-
flexibility ANT	.13	.16	-.11	.05	-.24	-.19	.76**	-.13	

Note. * $p < .05$. ** $p < .01$.

Underlined interface = correlations for total group, Plain interface = correlations for the parents, **Bold** interface = correlations for children (< 16), *Italic* interface = correlations for adolescents (≥ 16).

N ranges from 30 – 122.

3.1 Results of part 1: Age and executive functioning

A MANOVA was used to see if there was a difference in mean inhibition and cognitive flexibility between individuals with and without ASD. Group was the independent variable, whereas inhibition and cognitive flexibility were dependent variables. As expected there was no difference between children/adolescents with or without ASD on inhibition (F (3, 71) = 2.40, p = .08). When the ANT and D-Kefs were split up a significant difference was found on inhibition measured with the ANT (F (3, 70) = 5.64, p < .01), but not on inhibition measured with the D-Kefs (F (3, 71) = 0.55, p = .65). On the cognitive flexibility tasks there was a significant difference between the four groups (F (3, 71) = 7.12, p < .01) (d = 0.99). When the ANT and D-Kefs were split up a significant difference was found on cognitive flexibility measured with the ANT (F (3, 70) = 14.51, p < .01), but not on cognitive flexibility measured with the D-Kefs (F (3, 71) = 2.64, p = .06). In contrary to the expectations children performed better on cognitive flexibility tasks than adolescents, as is shown in Table 4. A positive score indicated that group I has a higher mean score on cognitive flexibility than group J, adolescents had a higher mean score on cognitive flexibility compared to children.

Table 4. *Differences between Groups on Cognitive Flexibility Tasks*

		J			
	I-J	Children with ASD	Adolescents with ASD	Children, controls	Adolescents, controls
I	Children with ASD	0			
	Adolescents with ASD	0.29*	0		
	Children, controls	-0.22	-0.51*	0	
	Adolescents, controls.	0.27*	-0.03	0.48*	0

Note. * p < .05.

An ANCOVA was used to see if there was a difference in inhibition between participants with and without ASD, when controlling for age. Diagnosis was the independent variable, inhibition was the dependent variable, and age was a control variable. As expected, diagnosis did not account for a significant difference on inhibition tasks (F (1, 72) = 0.15, p = .70), but, as hypothesized, age did account for a significant difference (F (1, 72) = 9.21, p < .01, η^2 = 0.11). Unlike the expectations children performed better on inhibition tasks than adolescents.

An ANCOVA was also used to see if there was a difference in cognitive flexibility between children/adolescents with and without ASD, when controlling for age. Cognitive flexibility was the dependent variable and diagnosis was the independent variable. Age was the control variable. Unlike the hypothesis, there was no difference in cognitive flexibility between children/adolescents with or without ASD (F (1, 72) = 1.43, p = .24), but as expected age accounted for a significant difference on cognitive flexibility (F (1, 72) = 25.59, p < .01, η^2 = 0.26). Contrary to the expectations children were significantly better on cognitive flexibility tasks than adolescents.

To see if a correlation existed between executive functions and autistic traits in daily life, a Pearson Correlation Test was used. The correlations are shown in Table 5. For inhibition there were no significant correlations. Only children/adolescents without ASD had significant correlations between cognitive flexibility and (parts of the) AQ and SRS. The higher the scores on these (sub) scales, the lower the scores on cognitive flexibility. For the total group of children/adolescents (with or without ASD) could be said that the higher the score on the subscale autistic mannerisms measured by the SRS, the lower the score on cognitive flexibility (r = -.25). For children/adolescents with ASD the scores on the (subscales) of the AQ and SRS became significantly lower with age. In other words; adolescents with ASD showed less autistic traits in daily life. For ‘controls’ the opposite is true; scores on the (subscales) of the AQ and SRS became significant higher with age. Adolescents without ASD showed more autistic traits in daily life.

Table 5. *Correlations for Inhibition, Cognitive Flexibility and Age on Total Scores and Subscores of the AQ and SRS*

	AQ total	AQ social skills	AQ communication	AQ imagination	AQ attention switching	AQ attention to detail	SRS total	SRS social awareness	SRS social cognition	SRS social communication	SRS social motivation	SRS autistic mannerisms
Inhibition	.07	.06	.03	-.07	.08	.21	.01	.05	.05	-.03	.01	.03
	.16	**.17**	**.11**	**-.12**	**.14**	**.30**	**.11**	**.21**	**.10**	**.06**	**.12**	**.06**
	-.09	*-.18*	*-.19*	*-.04*	*-.01*	*.06*	*-.26*	*-.32*	*-.08*	*-.32*	*-.27*	*-.10*
Cognitive	-.11	-.06	-.16	-.19	-.14	.10	-.21	-.13	-.21	-.22	-.13	-.25*
flexibility	**.18**	**.22**	**.07**	**-.04**	**.14**	**.31**	**.03**	**.12**	**-.03**	**-.00**	**.19**	**-.09**
	*-.39**	*-.26*	*-.44**	*-.30*	*-.37*	*-.10*	*-.49***	*-.38*	*-.40**	*-.44**	*-.45**	*-.48**
Age	-.17	-.11	-.20	-.01	-.17	-.21	-.11	-.27*	-.08	-.11	-.07	-.04
	-.46**	**-.33***	**-.41***	**-.23**	**-.49****	**-.30**	**-.42****	**-.63****	**-.33***	**-.40***	**-.34***	**-.22**
	.37	*.42**	*.20*	*.48**	*.29*	*-.00*	*.53***	*.39**	*.45**	*.45**	*.54***	*.51***

Note. * p < .05, ** p < .01.

Plain interface = correlations for total group (children/adolescents with and without ASD), **bold** interface = correlations for children/adolescents with ASD, *Italic* interface = correlations for children/adolescents without ASD. N ranges from 27 – 66.

3.2 Results of part 2: Executive functioning: parents and children

A MANCOVA was used to see if there was a difference between children with ASD and their parents on inhibition, or cognitive flexibility, controlling for an effect of age, gender and type of ASD. Results of the MANCOVA showed a significant effect of group on inhibition (F (1, 79) = 7.20, p = .01, η^2 = .08), parents of children/adolescents with ASD performed better on inhibition tasks. Parents of children/adolescents with ASD also performed better on cognitive flexibility tasks (F (1, 79) = 10.58, p < .01, η^2 = .12). For both inhibition as cognitive flexibility no significant effects were found for gender, age and type of ASD.

A MANOVA was used to see if there is a difference in inhibition or cognitive flexibility between fathers and mothers of children with ASD. No significant difference was found for inhibition (F (1, 44) = 0.23, p = .64), nor for cognitive flexibility (F (1, 44) < 0.01, p = .95). Fathers and mothers scored the same on inhibition and cognitive flexibility.

3.3 Results of part 3: Intelligence and executive functioning

A MANCOVA was used to see if there is a difference in the total, nonverbal or verbal intelligence between individuals with and without ASD. Total, verbal and nonverbal IQ were the dependent variables, diagnosis was the independent variable. In Table 6, the descriptive statistics are shown.

Table 6. *Descriptive Statistics of the Total, Verbal and Nonverbal IQ for Children and Adolescents with and without ASD (controls)*

	Total IQ			Verbal IQ			Nonverbal IQ		
	n	*M*	*SD*	*N*	*M*	*SD*	*n*	*M*	*SD*
ASD	42	109.43	17.70	42	105.12	16.05	41	109.83	22.34
Controls	33	107.27	12.55	33	100.06	14.99	33	116.82	19.79

In line with the expectations, there was a multivariate difference between the groups with and without ASD on total, verbal and nonverbal IQ (F (3, 70) = 3.86, p = .01). On a multivariate level, the children and adolescents with ASD outperformed the controls on total and verbal IQ and the controls outperformed the individuals with ASD on nonverbal IQ. But, in contrast to the expectations, there were no univariate differences between the groups with and without ASD on total IQ (F (1, 72) = 0.10, p = .75), verbal IQ (F (1, 72) = 1.75, p = .19), and nonverbal IQ (F (1, 72) = 1.98, p = .16).

Because of the significant correlations between the IQ coefficients and inhibition and cognitive flexibility, as shown in Table 3, the IQ coefficients might have a predicting power for inhibition and cognitive flexibility. Table 7 shows the results of multiple regression for inhibition and cognitive flexibility measured with the ANT and the D-Kefs. The table consists of two regression analysis, namely one for total IQ and one for verbal and nonverbal IQ. In line with the expectations, the total IQ was a significant predictor for both the inhibition variables and both the cognitive flexibility variables. The total IQ was a negative predictor for inhibition and cognitive flexibility measured with the ANT, meaning that a higher total IQ score corresponded to a lower score on inhibition and cognitive flexibility. However, the total IQ was a positive predictor for inhibition and cognitive flexibility measured with the D-Kefs, meaning that a higher total IQ corresponded to a higher score on inhibition and cognitive flexibility. In line with the expectations, the nonverbal IQ was a significant predictor, but contrary to the expectations, the verbal IQ was no significant predictor. The nonverbal IQ is a negative predictor to inhibition and cognitive flexibility measured with the ANT, meaning that a higher nonverbal IQ score corresponds to a lower score on inhibition and cognitive flexibility. However, the nonverbal IQ is a positive predictor to inhibition and cognitive flexibility measured with the D-Kefs, meaning that a higher nonverbal IQ score corresponds to a higher score on inhibition and cognitive flexibility. These results are in line with the correlations shown in Table 3. The proportion explained variance could be qualified as small to medium.

Table 7. *Multiple Regression for Inhibition and Cognitive Flexibility Measured with the D-Kefs and the ANT*

	Inhibition ANT		Inhibition D-Kefs		Cognitive Flexibility ANT		Cognitive Flexibility D-Kefs	
	ß	R^2	*ß*	R^2	*ß*	R^2	*ß*	R^2
Total IQ	-.24*	.06*	.32**	.10**	-.21*	.05*	.29**	.08**
Verbal IQ	.07	.12**	.13	.12**	.10	.14**	.09	.09**
Nonverbal IQ	-.36**		.29**		-.39**		.27**	

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

Discussion

In the present study the inhibition and cognitive flexibility (parts of executive functioning) of children and adolescents with ASD, their parents and children and adolescents without ASD are examined. The inhibition and cognitive flexibility variables are positively correlated when measured by the same test. On the other hand there are significant negative correlations between inhibition and cognitive flexibility measured with the ANT and inhibition and cognitive flexibility measured with the D-Kefs. An explanation for these negative correlations could be that the ANT and the D-Kefs are different measures of inhibition and cognitive flexibility. Another explanation for these negative correlations could lie in the choice of the used sub variables of both the ANT and the D-Kefs. Sub variables of both instruments were used to create one sum variable measuring inhibition and cognitive flexibility. Probably counting up other sub variables of ANT and D-Kefs to create the sum variable would have given different correlations.

First it is studied if there is a difference in inhibition and cognitive flexibility when controlling for age and if there is a correlation between executive functions and autistic traits in daily life. In line with previous research (see for a review; Hill, 2004b), the present study does not find a difference for inhibition between children/adolescents with and without ASD. Unlike the expectations also no difference is found between children/adolescents with and without ASD for cognitive flexibility. An explanation for this result is that most previous studies used the Wisconsin Card Sorting Test (WCST) to measure cognitive flexibility. Failure on this task is no evidence for cognitive flexibility, but may be due to deficits in learning from feedback, noticing that a change of strategy is necessary, inhibiting a previous response, or sustain responding over time (Geurts et al., 2009). Happé et al. (2006) state that performance on executive function tasks improve with age and become more pronounced during adolescence. In the present study a significant effect of age is found on inhibition and cognitive flexibility, but contrary to the expectations children perform better on inhibition and cognitive flexibility tasks than adolescents. An explanation for these results has not been found in the literature on inhibition and cognitive flexibility. Possibly the results can be explained by the fact that a combination of the ANT and D-Kefs has not been used before. The decision for a combination of variables of the ANT and D-Kefs might contribute to the results found in the present study. Further research on the effect of age on inhibition and cognitive flexibility, with a larger sample and different tasks, has to be done.

Three core domains of ASD are impairments in social interaction, deficits in communication, and repetitive behavior/restricted interests and activities. These ‘autistic’ traits are visible in daily life situations. Recent research suggests a correlation between deficits in executive functioning and autistic traits in daily life situations (Filipek et al., 1999; Hill, 2004b). For inhibition no significant correlations with autistic traits are found. Only children/ adolescents without ASD has significant negative correlations between cognitive flexibility and (parts of the) AQ and SRS; a higher score on cognitive flexibility correlates with a lower score on autistic traits. For children/adolescents with ASD the scores on the (subscales) of the AQ and SRS become significantly lower with age; adolescents with ASD show less autistic traits in daily life. An explanation for the decrease in autistic traits in daily life is that the questionnaires (AQ and SRS) for children (AQ < 16, SRS < 18) are filled out by one of their parents, which can lead to higher scores on visible autistic traits in daily life. Parents can see the problems in social interaction, communication, and repetitive behaviour/restricted interests and activities as their child interacts with others. For adolescents the AQ and SRS (SRS ≥ 18) depends on self-report on subjects of social life, which may be difficult for individuals with social deficits. Adolescents with ASD might overrate their social abilities (Baron-Cohen, Hoekstra, Knickmeyer, & Wheelwright, 2006).

In the second part the difference between groups (children/adolescents with ASD and parents of children/adolescents with ASD) on inhibition and cognitive flexibility, when controlling for age, gender and diagnosis is studied. Also the difference in inhibition and cognitive flexibility between fathers and mothers of children/adolescents with ASD is studied. The results concerning executive functioning in parents and children show, contrary to the expectations, that parents outperform their children/adolescents with ASD on inhibition. In line with the expectations, parents have a higher score on cognitive flexibility than their children. No differences are found on cognitive flexibility and inhibition, comparing fathers and mothers, while it is expected to find a difference on cognitive flexibility and no difference on inhibition. These results confirm the fact that research on inhibition is not consistent. An explanation for these differences in results and expectations probably lies in the number of participants and the measures used. In previous studies, executive function deficits of relatives of autistic patients were mostly measured with the Tower of Hanoi test and to a lesser extent with cognitive flexibility tasks (Gokcen et al., 2007). In the present study parents outperform their children on inhibition, and these results are entirely not in line with the broader phenotype as mentioned in Baron-Cohen, and Hammer (1997). According to the present study, it seems to be that parents of children/adolescents with ASD are not impaired in executive functioning. Future studies comparing children with ASD and their parents with a control group of children and parents, or examining a possible correlation between the executive functions of children and their parents – maybe even with a matched design – might shed another light on these results. The research questions in the present study resulted in a broader exploration of inhibition and cognitive flexibility in a broader family perspective.

Third it is studied if there is a difference in intelligence between individuals with and without ASD and if IQ-scores can predict the level of inhibition and cognitive flexibility. When looking at intelligence and executive functioning, strong significant relations between the total and nonverbal IQ, and inhibition and cognitive flexibility are found, while there is no relation between the verbal IQ and executive functioning. On a multivariate level children with ASD outperform controls on the total and verbal IQ and controls have a higher nonverbal IQ, but on a univariate level, no differences existed. According to Mayes, and Calhoun (2007) children with high-functioning autism have high scores (> 10) on the subtests Similarities, Vocabulary, and Block Design. This may be an explanation of why children with ASD outperform controls on total and verbal IQ, because all participants needed to have an IQ above 70. The fact that controls have a higher nonverbal IQ can be explained by the fact that most controls were recruited on technical education schools. For this reason they probably have another IQ profile than controls with a nontechnical background. When looking at the predictive power of IQ on executive functioning, it is found that the total IQ is a significant predictor of both inhibition and cognitive flexibility. When taking the verbal and nonverbal IQ components into account, it can be said that only the nonverbal IQ is a significant predictor for inhibition and cognitive flexibility measured with the ANT and the D-Kefs. The total and nonverbal IQ are positive predictors for inhibition and cognitive flexibility measured with the D-Kefs, but negative predictors for inhibition and cognitive flexibility measured with the ANT. As mentioned earlier, an explanation for these positive and negative predictors could be that the ANT and the D-Kefs differ in which part of inhibition and cognitive flexibility is measured. Another explanation lies in the choice of the used sub variables to create one sum variable measuring inhibition and cognitive flexibility for the ANT and the D-Kefs. Further research is necessary to confirm this explanation.

There are some limitations worth noticing. The first limitation concerns the instruments used to measure inhibition and cognitive flexibility. For the quantitative translation of inhibition and cognitive flexibility choices are made about which score to use for which variable. These choices are made on basis of the information in the test manual and factor analysis. Still other choices can also be made, legitimately resulting in other effects. The UMC-Utrecht has made a deliberate choice for the D-Kefs and ANT to measure inhibition and cognitive flexibility. The combination of these tasks is not used before. Although well-considered, these tasks may be not sufficiently sensitive to differentiate between the different groups (Kleinhans et al., 2005).

The second limitation concerns the short form IQ-test. The use of this combination of four subtests as a short WISC or WAIS version is not found to be used in previous studies (Boone, 1990; Groth-Marnat, 2003). According to Groth-Marnat (2003) correlations with the full IQ and the ‘short form IQ’ are in the low to mid-.90s when using a four subtest combination out of Vocabulary, Block Design, Arithmetic, Matrix Reasoning, Picture Arrangement, Information, Comprehension, Similarities, or Picture Completion. It needs to be noticed that Object Assembly is missing, but instead this subtest is used in the present study. It may be that the short-form-IQ is not a good estimation of the full IQ. However, the fact that according to the present study, IQ is a significant and also relevant predictor of executive function, may be a motivation for future studies to take IQ into account when looking to the executive functioning of people with ASD.

The third limitation concerns the sample. The results described in this report are obtained in a sample with sufficient power to draw valid conclusions for all groups, but it is more valid to draw conclusions with a higher power. Although certain significant results are obtained in the ASD groups and control groups, these analyses must be replicated in a bigger sample (with a higher power) with ideally more equal group sizes. In the present study individuals with and without ASD were not matched on age. Matching on age, gender, and IQ might give more valid results. The children and adolescents with ASD are all known by University Medical Centre (UMC) Utrecht. Because of the select way of sampling these results are not representative for the whole group of children and adolescents with ASD and their parents in the Netherlands. Also siblings are not included in the study. Based on Happé, Briskman, and Frith (2001), signs of the broader phenotype shall be more pronounced in siblings than in parents, since parents are of necessity a selected sample whose functioning is sufficiently good to allow partnership and children. Including a sibling group might give more significant results.

Beside these limitations, the present study confirmed earlier studies that age is an important factor in research on executive functioning and autistic traits in daily life. It also confirmed earlier studies that parents outperform their autistic children on inhibition and cognitive flexibility and that IQ is a significant predictor of inhibition and cognitive flexibility.

From a social point of view knowledge about the inhibition and cognitive flexibility of autistic children and adolescents is important for their education, employment, quality of life, and future prospect. This helps improving their self-image, gaining knowledge of their cognitive strengths and weaknesses, and the formulation of realistic cognitive expectations. As executive functions are responsible for guiding and controlling cognitive processes, profound research give leads for designing methods suited for autistic children and adolescents to learn or work with. In this way the results might help autistic people to study, work, take care of themselves, and have a better knowledge of their disorder, specifically supported with it by their families, schools and other organizations.

Future studies will be essential to further specify the influence of intelligence and age on executive functioning and to learn more about the specific role of executive functions in the broader cognitive phenotype of autism. Knowledge about the inhibition and cognitive flexibility of children and adolescents might give space for continuing research; starting from a cognitive point of view, combined with a neuropsychological and genetically component (Happé & Ronald, 2008). Only by taking these different viewpoints together, the links between functional brain abnormalities, neuropsychological and genetic deficits will become less indistinct.

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