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An endophenotype for attention deficit/hyperactivity disorder (AD/HD) is executive functioning. In the autism and developmental literature executive dysfunctions has also been linked to theory of mind (ToM) and pragmatic language use. The central question of this review is whether deficits in ToM and pragmatic language use are common in AD/HD. AD/HD seems to be associated with pragmatic deficits, but not with ToM deficits. In this review we address how this pattern of findings might facilitate the understanding of the commonalities and differences between executive functioning, ToM, and pragmatic abilities. Based on the reviewed studies we conclude that ToM is not likely to be a potential endophenotype for AD/HD, while it is too early to draw such a conclusion for pragmatic language use.

Keywords: Autism; AD/HD; Executive functioning; Pragmatic abilities; Theory of Mind.

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Research regarding distinctive but related neurodevelopmental disorders such as attention deficit hyperactivity disorder (AD/HD) and autism,[1] is increasingly moving towards determining cognitive endophenotypes that can characterize the heterogenic nature of these disorders, instead of trying to pinpoint which single cognitive construct underlies all AD/HD or autism characteristics (e.g., Anderson, 2008; Castellanos & Tannock, 2002; Happé, Ronald & Plomin, 2006; Viding & Blakemore, 2007). These endophenotypes can be conceptualized on a neurophysiological, neuroanatomical and/or cognitive level, and they are the intermediate between the behavioural classification (i.e., AD/HD as phenotype) and the biological variables (i.e., genotypes and environment) that cause the disorder (Gottesman & Gould, 2003). One potential cognitive endophenotype for both AD/HD and autism is executive functioning (Durston, De Zeeuw, & Staal, 2009; Hill, 2004; Pennington & Ozonoff, 1996).

Executive functions (EFs) are cognitive control processes that enable us to monitor ongoing performance in a dynamically changing environment (Eslinger, 1996; Ridderinkhof, Van den Wildenberg, Segalowitz, & Carter, 2004). In recent reviews it has been discussed that executive functioning (or cognitive control) is a valid and reliable endophenotype for AD/HD (e.g., Doyle et al., 2005; Durston et al., 2009). However, these executive dysfunctions in AD/HD do not exist in isolation. Other potential endophenotypes have also been put forward to understand the aetiology of AD/HD (Castellanos & Tannock, 2002; Nigg, Willcutt, Doyle, & Sonuga-Barke, 2005; Rommelse et al., 2008; Sonuga-Barke, 2005). For example, evidence accumulates that deficient reward processing may be another likely endophenotype for AD/HD (Castellanos & Tannock, 2002; Luman, Oosterlaan, & Sergeant, 2005; Sonuga-Barke, 2005). Moreover, EFs do relate to other notions that are important in the cognitive developmental literature, such as theory of mind (ToM) and pragmatic language use. These two domains will be the focus of the current review.

Some researchers argue that the development of executive functioning is closely linked to the development of ToM (e.g., Hughes, 1998; Perner & Lang, 1999; Russell, 1997) and pragmatic language use (Martin & McDonald, 2003). Deficits in EFs (e.g., Hill, 2004), ToM (e.g., Baron-Cohen, Tager-Flusberg, & Cohen, 2000) and pragmatic language use (e.g., Bishop, 1998) are known to coexist in, for example, individuals with autism, but are there deficits in ToM and pragmatic language use in AD/HD?

In the theoretical debate on the relationship between EF and ToM (see, e.g., Fisher & Happé, 2005; Hughes & Ensor, 2007; Ozonoff, Pennington, & Rogers, 1991; Pellicano, 2007) there are three different viewpoints. It has

[1]We use the term autism to refer to autism spectrum disorders including autism, Asperger syndrome, and pervasive developmental disorders not otherwise specified (PPD-NOS).

been argued that EF deficits lead to ToM deficits (so EFs are a prerequisite to develop ToM; e.g., Hughes, 1998; Russell, 1997). However, the reverse argument that ToM deficits lead to EF deficits has also been made (e.g., Perner & Lang, 1999, 2000). Alternatively, it could even be the case that both EF and ToM deficits stem from some other cognitive deficit. If indeed EF deficits lead to ToM deficits or when both deficits stem from the same cognitive deficit, one would expect ToM deficits in individuals that are characterized by EF deficits. As executive dysfunction has been thought to underlie the key characteristics of AD/HD (Barkley, 1997; Nigg & Casey, 2005), AD/HD will be an interesting testing case as one would expect at least mild ToM difficulties in people with AD/HD due to their EF deficits (Sergeant, Geurts, & Oosterlaan, 2002; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005; Willcutt, Sonuga-Barke, Nigg, & Sergeant, 2008). This same line of reasoning can be followed for pragmatic language use as both EF and ToM are related to pragmatic language use (Martin & McDonald, 2003). Hence, even when no ToM deficits are present in individuals with AD/HD one could expect at least mild pragmatic deficits due to the presence of EF deficits.

In this paper we will argue that as EF deficits are a key characteristic of AD/HD it could be productive to study (1) ToM abilities in AD/HD, and (2) pragmatic language use in AD/HD. Studying these abilities in AD/HD will not just gain insight into what type of difficulties individuals with AD/HD encounter besides their well-described EF deficits (e.g., Willcutt et al., 2008), but might also shed some light on the relationship between three related constructs, EF, ToM, and pragmatic abilities. Moreover, if ToM and pragmatic language use deficits are indeed associated with AD/HD it might be fruitful to study in more detail whether these are also potential endophenotypes for AD/HD. First, we will define EF and ToM and explain why it is thought that these two cognitive domains are highly interlinked. Second, we will discuss AD/HD studies focusing on ToM. Third, the relationship between EF, ToM, and pragmatic language use will be introduced. Fourth, studies focusing on pragmatic language use in AD/HD will be discussed.

1. EXECUTIVE FUNCTIONS, THEORY OF MIND, AND THEIR POTENTIAL RELATIONSHIP

Various abilities are shared under the wings of EF (Eslinger, 1996) as EFs encompass the ability to change strategies (cognitive flexibility), to keep and manipulate information online (working memory), to plan ahead (planning), and to suppress responses (inhibition). Hence, EFs are especially important when people need to exert effortful control to deal with novel, complex or ambiguous situations in everyday life. EFs have been studied with a broad range of tasks (see Table 1).

TABLE 1
Conceptual descriptions and commonly used tasks to study different domains of EF and ToM

EF/ToM	*Concept*	*Description*	*Commonly used tasks/ paradigms*[1]
EF	Inhibition	To slow down or stop a particular activity or response because it is no longer appropriate	Stop Signal Task; Go–NoGo Task; Negative Priming Task; Stroop CWT; Eriksen Flanker Task
EF	Working memory	Maintaining and manipulating information across a given time interval	Memory span such as Reading span & Digit span backwards (WAIS); Numbers and Letters (WAIS); n-Back; SoP
EF	Planning	The ability to think ahead to reach future goals for which intermediate steps are needed. These steps need to be executed in a proper order and at the proper moment in time	ToL; ToH; Stockings of Cambridge; Rey CFT
EF	Cognitive flexibility	The ability to adjust ideas and responses in a dynamically changing environment	WCST; ID/ED; Task switching; TMT A/B
ToM[2]	1st order belief	Knowledge that other people's have other mental states and beliefs than yourself	False belief (ability to recognize that others can have beliefs about the world that are wrong) tasks; picture sequencing measure; transfer test; deceptive box test; appearance-reality task; "false-photograph" task, Smarties test
ToM[2]	2nd order belief	Knowledge of what people think of other ones thoughts and beliefs	Ice cream van test, 2nd order variants of the 1st order test mentioned above, SST, Irony test

Notes: [1]We selected some examples of tasks that are commonly used to measure each of the domains, but there are many variants of each of these tasks and different types of names are given. The list here gives a general idea of the tasks used in most of the papers we described in the current selective review. [2] Please note that there are also many ToM tasks that cannot be categorized as 1st or 2nd order belief. We refer to the comprehensive review of Baron-Cohen (2001) for a more detailed overview of the various ToM tasks. For example, the SST and the Irony test are not just 2nd order tests but also involve pragmatic language abilities (see text). EF = Executive Functions; ID/ED = Intra-Dimensional/Extra-Dimensional shift task; Rey CFT = Rey Complex Figure Test; SoP = Self ordered pointing task; SST = Strange Stories Test; Stroop CWT = Stroop Colour Word Task; TMT = Trailmaking A and B; ToH = Tower of Hanoi; ToL: Tower of London; ToM = Theory of Mind; WAIS = Wechsler Adult Intelligence Scale (similar tasks in children's version of this task); WCST = Wisconsin Card Sorting Test.

ToM involves the ability to attribute mental states to one's self and to others, and understanding how mental states influence human behaviour (e.g., Baron Cohen, 2001). A well-developed ToM is crucial for making social inferences and guiding social behaviour in everyday-life communicative interactions. In ToM research, distinctions are often made between tasks that require an understanding of false belief, 1st order belief, 2nd order belief, or of complex humour such as jokes and irony (see Table 1 for an overview of these different types of tasks). These ToM abilities are thought to be made up of the ability to decode mental states based on observable information (i.e., if a person is smiling, we assume he/she is happy), and on the ability to reason about others' mental states and to predict and explain human behaviour based on these mental states (Sabbagh, Xu, Carlson, Moses, & Lee, 2006).

The relationship between EF and ToM has received a great deal of attention (Fisher & Happé, 2005; Hughes & Ensor, 2007; Ozonoff et al., 1991; Pellicano, 2007) as these constructs seem to be highly interlinked (Frye, Zelazo, Brooks, & Samuels, 1996; Hala, Hug, & Henderson, 2003; Hughes, 1998; Perner & Lang, 2000; Sabbagh et al., 2006). For example, cognitive flexibility involves the ability to rapidly switch between multiple tasks, and may be crucial to changing strategies or perspective in ToM tasks or during everyday conversation. Moreover, ToM tasks require working memory (McKinnon & Moscovitch, 2007) as intermediate steps are needed to perform well on, for example 2nd order tasks. The intermediate steps need to be kept in mind, evaluated and perhaps adjusted, so more intermediate steps may require a larger involvement of working memory. In EF tasks such as classical cognitive flexibility tasks, ToM may play a role as the participants have to adjust their behaviour based on feedback given by the assessor of the task (Ozonoff, 1995). In most EF tasks the participants need to conceptualize (i.e., infer) what the experimenter wants them to do (see also Pellicano, 2007, for details), which is an important aspect of ToM. To put it differently, to perform adequately on these EF tasks one needs to have a representational understanding of mind (Perner & Lang, 2000). Hence, it is no surprise that EF and ToM deficits often go hand in hand.

2. THEORY OF MIND IN AD/HD

The cardinal features of AD/HD are inattentiveness, hyperactivity, and impulsivity (American Psychiatric Association, 2000). Although communication impairments and social impairments are not crucial for the diagnosis of AD/HD (American Psychiatric Association, 2000), people with AD/HD often show difficulties in these domains (Nijmeijer et al., 2007).

In the last decade, a plethora of studies focused on EF in AD/HD. This neurodevelopmental disorder is mainly associated with EF deficits in the

domain of inhibition and working memory (see Willcutt et al., 2005, 2008, for overviews). However, to our knowledge, only five studies have examined ToM abilities in AD/HD. Three of these studies concluded that ToM abilities are intact in individuals with AD/HD (Charman, Carroll, & Sturge, 2001; Dyck, Ferguson, & Shochet, 2001; Perner, Kain, & Barchfeld, 2002), while the findings of two studies suggest that individuals with AD/HD might be challenged on ToM tasks (Buitelaar, Van der Wees, Schwaab-Barneveld, & Van der Gaag, 1999; Fahie & Symons, 2003).

Buitelaar and colleagues (1999) were the first to study ToM abilities in AD/HD. They reported that children with AD/HD and autism could not be differentiated on a composite score of 2nd order false-belief tasks while the clinical groups performed worse than the typically developing group. Based on these findings they concluded that children with AD/HD indeed have ToM difficulties. Although this study measured ToM abilities quite exhaustively (six 1st order and four 2nd order ToM tasks), it suffered from a very small sample size as it included only nine children with AD/HD. Moreover, no mention was made of whether participants belonged to a specific subtype of AD/HD. The EF account predicts executive dysfunctions in the predominantly combined subtype and the hyperactive/impulsive subtype, but not in the inattentive subtype (Barkley, 1997). Moreover, it is not clear whether these AD/HD children do have comorbid disorders or characteristics of comorbid disorders such as autism or specific language disorders that might also be associated with ToM deficits.

In contrast, ToM difficulties were not observed in two larger AD/HD studies (Charman et al., 2001; Dyck et al., 2001). In both these studies a well-known and broadly used ToM task, the Strange Stories Test (SST; Happé, 1994) was applied to measure ToM. The SST, which was not included in the Buitelaar study (1999), was developed as some people with autism are able to pass 1st order and 2nd order ToM tasks while showing difficulties in appreciating non-literal speech, such as indirect requests, sarcasm, irony, and metaphorical expressions (Happé, 1993, 1994). In the SST, participants read stories and are tested on whether they give mental-state explanations for the story characters' non-literal utterances (jokes, lies, or figures of speech). The SST is constructed in such a way that the motivation behind an utterance is interpreted in one specific way by most people. Studies using this task indeed showed that participants with autism that passed standard 2nd order ToM tasks had difficulties with the SST (e.g., Happé, 1994; Joliffe & Baron-Cohen, 1999). In both AD/HD studies the children with AD/HD passed the SST.

The Dyck et al. (2001) study only involved children with AD/HD of the inattentive subtype who are not expected to encounter EF deficits in the first place (Barkley, 1997). One would expect to observe ToM difficulties in children with AD/HD from the combined subtype as these children are

known to encounter EF difficulties. Children with AD/HD of this specific subtype were included in the Charman study (2001) yet no ToM deficits were observed, even though these children failed on inhibition and planning tasks. It seems that when ToM is measured with the SST, children with AD/HD do not encounter ToM deficits (Charman et al., 2001; Dyck et al., 2001). The absence of difficulties on one specific ToM task does not imply that children with AD/HD will perform normally on other ToM tasks as ToM is a multi-faceted construct. Hence, children with AD/HD do not encounter difficulties on the SST, but might encounter deficits on other ToM tasks, which would be in line with the findings of Buitelaar et al. (1999) who found AD/HD-related ToM deficit on a composite score that included scores on various ToM tasks.

Also, Perner and colleagues (2002) included various ToM tasks (three 2nd order false-belief tasks) in their study. Participants in this community study were children at risk for developing AD/HD. None of these children showed any difficulties on a composite score of the ToM tasks whereas they showed difficulties in EF domains such as planning. Even when ToM performance was taken into account, the EF deficits were still present in the "at risk for AD/HD" group. A follow-up on these results is needed to determine whether these children indeed developed full-blown AD/HD later, but these findings suggest that AD/HD is not necessarily associated with ToM difficulties.

Interestingly, Fahie and Symons (2003) also included both ToM tasks (four false-belief tasks) and EF tasks (focusing on working memory). The participants in this study did not have clinical diagnoses of AD/HD, but showed attention and behavioural problems. These problems were similar to difficulties experienced by children with AD/HD and were so severe that referral to a clinic was needed. In these children, ToM ability (here, an aggregated score of the four false-belief tasks) was negatively related to both attention problems and impulsivity. Across all children working memory abilities were related to overall ToM performance. Working memory is an EF that is known to be dysfunctional in AD/HD and has been shown to be important for performances on various ToM tasks (e.g., Bull, Phillips, & Conway, 2008; McKinnon & Moscovitch, 2007). Please note that in this study it is also not clear whether other disorders next to AD/HD might explain the pattern of findings. Working memory is thought to be deficient in many other disorders besides AD/HD (Willcutt et al., 2008).

Based on the five aforementioned studies, it still seems premature to conclude whether or not children with AD/HD necessarily encounter ToM difficulties, but the evidence so far favours the idea that ToM deficits are not strongly present in these children. Hence, this would suggest that EF deficits do not automatically lead to ToM deficits.

3. EXECUTIVE FUNCTIONS, THEORY OF MIND, AND PRAGMATIC ABILITIES

Both EF and ToM are cognitive notions that are thought to be related to language deficits, especially pragmatic abilities (e.g., Martin & McDonald, 2003). Pragmatic ability refers to the appropriate use of language within a social communicative context (e.g., Rapin, 1996; Tannock & Schachar, 1996). It involves a broad array of social linguistic skills, such as using contextual information to interpret incoming utterances, the ability to comprehend non-literal/figurative expressions (such as jokes and irony), and inferring implicit messages. Pragmatic difficulties including, among others, overly literal language interpretation, impairments in production and comprehension of prosody, difficulties with understanding narrative-humour, making socially inappropriate comments, disorganization in the speech content, lie at the core of a neurodevelopmental disorder such as autism (American Psychiatric Association, 2000; Volkmar, Lord, Bailey, Schultz, & Klin, 2004). However, pragmatic deficits have also been observed in AD/HD, which will be discussed in more detail later on.

Under the EF account, pragmatic deficits are caused by executive dysfunction (McDonald, 1993). For instance, in order to interpret jokes, one must hold information in memory and, at the same time, flexibly evaluate and interpret this information, potentially in subsequent stages. It thus stands to reason that EFs such as cognitive flexibility and working memory are necessary for pragmatic language use (Ozonoff & Miller, 1996). Moreover, the ability to plan ahead during real-time conversation is important to retain a coherent story line, so failures in planning will negatively affect the discourse. So EF and pragmatic abilities seem to be interlinked. As AD/HD is associated with EF deficits one would expect pragmatic deficits in individuals with AD/HD.

According to the ToM account, pragmatic deficits in people with autism occur due to their inability to take someone else's perspective during communicative exchanges. Inferring the appropriate meaning of what your conversational partner is saying, requires taking into account his/her intentions, beliefs, and knowledge. Hence, pragmatic interpretation is considered by some as inherently metapsychological and involving the construction and evaluation of a hypothesis about the communicator's meaning, thus drawing upon processes that are also involved in ToM (i.e., social or communicative inference; see also Martin & McDonald, 2003; Sperber & Wilson, 2002). It is not clear how ToM and pragmatic abilities precisely relate to one another (see Sperber & Wilson, 2002, for a discussion) as a deficit in pragmatic abilities can occur for several reasons. For example, it might be due to some degree of mind blindness and/or a failure in use of context (see also Baron-Cohen, 2001). The general idea is that ToM is not

needed for all pragmatic aspects of language (e.g., Sperber & Wilson, 2002). So, even absence of ToM deficits in AD/HD does not exclude the possibility of pragmatic language deficits in AD/HD.

4. PRAGMATIC ABILITIES IN AD/HD

Bishop and Baird (2001) showed that children with AD/HD had pragmatic difficulties: children with AD/HD showed more stereotyped conversations, had more problems with conversational rapport, and demonstrated more problems with social relationships compared to typically developing children, who show no deviances in their language development. A striking finding was that children with AD/HD hardly differed from children with autism. These observed pragmatic difficulties in AD/HD children have been replicated in various other studies (Bignell & Cain, 2007; Bruce, Thernlund, & Nettelbladt, 2006; Geurts & Embrechts, 2008; Geurts et al., 2004b; Norbury, Nash, Baird, & Bishop, 2004). The pragmatic difficulties in children with ADHD were, in general, less profound compared to those observed in children with autism for whom pragmatic language deficits are a key characteristic (American Psychiatric Association, 2000). Although each of these studies differed in the AD/HD subtypes that were included, the findings were consistent. To our knowledge, all studies to date have reported pragmatic language deficits in children with AD/HD.

In our most recent study, we even showed that parental reports of pragmatic difficulties in children with autism can partly be explained by the hyperactivity characteristics in these children (Geurts & Embrechts, 2008). The extent of pragmatic language difficulties was related to the hyperactivity characteristics, but not to the attention difficulties the parents reported. These findings were in line with the findings of Bignell and Cain (2007). These authors reported pragmatic language deficits in each of the three AD/HD subtypes, but the deficits were more profound in those children that were hyperactive and impulsive (irrespective of whether they also had attention deficits as for both groups large effect sizes were obtained) than in the children that had attention deficits only (as only small effect sizes were obtained). Interestingly, although only hyperactivity is related to pragmatic language abilities (Geurts & Embrechts, 2008), both attention problems and impulsivity are related to ToM abilities (Fahie & Symons, 2003).

One disadvantage of all studies that have focused specifically on pragmatic abilities in AD/HD is that they all relied on a parent questionnaire. The question is whether participants with AD/HD also encounter pragmatic deficits when pragmatic abilities are directly measured in the children themselves. As we mentioned before, children with AD/HD do not seem to have difficulties with the SST (Charman et al., 2001; Happé, 1994 in Dyck et al., 2001). Some might argue that the SST is a direct

measure of pragmatic abilities instead of a broad ToM measure. As noted earlier, the SST was developed to detect ToM deficits in those participants with autism that pass other ToM tasks. This suggests that more advanced or subtle ToM abilities are needed for this task as compared to most other ToM tasks. If the earlier SST findings are interpreted as such we must conclude that children with AD/HD are not challenged on this advanced type of ToM. If we interpret the SST as a direct measure of pragmatic abilities, this would suggest that the findings are in contrast with the findings based on parent reports (Bignell & Cain, 2007; Bruce et al., 2006; Geurts & Embrechts, 2008; Geurts et al., 2004b; Norbury et al., 2004). A common finding in clinical language research is that the informant agreement between parents and other informants, even when very similar measures are used, is notoriously low (e.g., Bishop, 1998; Embrechts, Mugge, & Van Bon, 2005; Massa, Gomes, Tartter, Wolfson, & Halperin, 2008). We are not aware of any study that has directly tested pragmatic language use in participants with AD/HD. Hence, the inclusion of direct measures of pragmatic language use is needed in future studies to be able to draw strong conclusions regarding the pragmatic language abilities of children with AD/HD.

We focused on pragmatic language use as both EF and ToM are assumed to be related to pragmatic abilities. It seems that children with AD/HD do not encounter strong ToM deficits, even though they do encounter EF deficits (Sergeant et al., 2002; Willcutt et al., 2005, 2008). If we, for now, assume that they also encounter pragmatic deficits this would have some implications for the interpretation of findings on ToM tasks. The findings so far suggest that for every ToM task, it remains to be determined whether and to what extent task performance relies on EF and/or pragmatic abilities.[2]

5. CONCLUSIONS AND FUTURE DIRECTIONS

To serve as an endophenotype various criteria need to be met by the construct (such as EF, ToM, or pragmatic language use) under study (see De Geus & Boomsma, 2001; Durston et al., 2009; Viding & Blakemore, 2007, for details). For example, endophenotypes (such as EFs) need to be

[2]We calculated the pooled effect size by incorporating the number of participants for each of the effect sizes following the method described in the review paper of Willcutt and colleagues (2005). For the ToM studies this pooled effect size could not be calculated as most studies did not report all the necessary details (mean and standard deviation and number of participants per group). However, for the pragmatic language use studies, even though the studies sometimes differed in the reported dependent measures, the pooled effect size could be calculated. The pooled effect size (Cohen's *d*) for the pragmatic language measures is 0.14, which is small ($N_{AD/HD} = 266$ and $N_{controls} = 281$).

associated with the psychopathology (AD/HD) of interest (validity) and should represent a reliable characteristic. Moreover, the association between endophenotypes and specific behaviour must be theoretically meaningful (causality; De Geus & Boomsma, 2001). We know that EFs are related to AD/HD and the association between this potential endophenotype and the specific behaviour is theoretically meaningful (see Durston et al., 2009, for an extensive discussion). Moreover, we know that in other neurodevelopmental disorders such as autism, EF deficits go hand in hand with deficits in ToM and pragmatic abilities. In the current review we show that this is not the case for AD/HD. We argue that studying neurodevelopmental disorders such as AD/HD may help us in unravelling the complex relationship between EFs, ToM, and pragmatic abilities that is observed in individuals with autism and typical development. Based on this literature review, we will draw three major conclusions and give suggestions for future research. We think this might be helpful in both understanding the link between different cognitive domains and in determining whether ToM and pragmatic abilities might be additional endophenotypes to understand the aetiology of neurodevelopmental disorders such as AD/HD.

First, EF and ToM and pragmatic abilities are all multi-faceted constructs that need further clarification and specification, in particular with regard to the separability of its components and the validity and reliability of the different tasks that are used to measure these constructs. A more clear taxonomy of each of these three constructs is needed to improve understanding of how these domains relate to each other in typical and atypical development. The work of Bull and colleagues (2008) is a good example of how fractionating EF and ToM in separate subdomains can explain some of the discrepancies across earlier studies. In that study it was shown, by using a dual-task paradigm, that whereas different aspects of EF (inhibition, updating, and switching) commonly influenced the performance on a particular ToM task (SST), only inhibition had a specific effect on another ToM task (Mind in the Eyes Test). Clearly, more experimental work is needed to fractionate EF and ToM into subconstructs that allow for more specific hypothesis testing. Moreover, it is also important to develop measures of EF, ToM, and pragmatic abilities that are more similar in order to achieve a greater focus and convergence between the ideas related to these three constructs. For example, in most studies a ToM task is correlated to an EF task to determine how these two constructs relate to each other. However, the EF tasks chosen often differ in many aspects from the ToM task beside the fact that it is measuring EF instead of ToM as, for example, ToM tasks generally require verbal responses in contrast to EF tasks that often require non-verbal motor responses.

Second, as pragmatic functioning may partly draw upon similar inference processes as ToM, studies that focus on the relationship between EF and

ToM may also inform us on the relationship between EF and pragmatic functioning. This is especially the case when ToM tasks (e.g., the SST; Happé, 1994) also tap into pragmatic language ability. However, it is important to keep in mind that ToM is not needed to explain all aspects of pragmatic language use. So, the relationship between EF and pragmatic abilities might be only partly explained by the existing relationship between EF and ToM. Aside from addressing the relationship between all these three constructs simultaneously, future research that includes ToM tasks (including the SST) and pragmatic tests (both parental questionnaires as direct tests of pragmatic functioning) in typically developing children or adults might shed some more light on how ToM and pragmatic abilities relate to each other.

Third, the comparison of findings in related neurodevelopmental disorders can also enhance our knowledge about how different constructs might be related to each other. The discussion about the three different cognitive constructs (EF, ToM, and pragmatic abilities) stems from the autism research field. In this review we focused on a related neurodevelopmental disorder, AD/HD. We introduced AD/HD as a disorder that is associated with EF deficits, and we hypothesized, based on the suggested link between EF, ToM, and pragmatic abilities in the autism literature (e.g., Hughes & Ensor, 2007; Pellicano, 2007), that children with AD/HD would encounter deficits in ToM and pragmatic language use. However, no clear evidence for ToM deficits has been reported (e.g., Charman et al., 2001; Dyck et al., 2001; Perner et al., 2002), although children with AD/HD do show pragmatic deficits (Bignell & Cain, 2007; Bruce et al., 2006; Geurts & Embrechts, 2008; Geurts et al., 2004b; Norbury et al., 2004). From the current review we can conclude that EF deficits do not automatically lead to ToM deficits (which is in contrast with Hughes, 1998; Russell, 1997). Also, other neurodevelopmental disorders might be of interest to study the relationship between EF, ToM, and pragmatic abilities. For example, deaf children with delayed language acquisition (''late-signing'') may have substantially delayed ToM development (Peterson, 2003), but do not always show the other social and pragmatic deficits that are characteristic of autism (Peterson & Siegal, 1995). This suggests that one can experience ToM difficulties without having pragmatic difficulties. The studies with children with AD/HD already suggest that one can also experience pragmatic deficits without having ToM deficits, but another interesting group to study the relationship between ToM and pragmatic abilities are children with specific pragmatic language impairments. These children hardly have any difficulties in processing language form but show specific pragmatic impairments in language use (e.g., Bishop, 1998), whereas they show no difficulties involving the other components of the autism triad (difficulties in non-verbal communication, lack of sociability, or showing repetitive behaviours).

Although specific pragmatic language impairments children are known for their pragmatic difficulties, it is not evident whether these children have ToM and EF difficulties (Bishop, 1998; Bishop & Norbury, 2005; Botting & Conti-Ramsden, 2003; Shields, Varley, Broks, & Simpson, 1996). We believe that by focusing on distinct but overlapping disorders, a better understanding can be achieved about the relationship between EF, ToM, and also pragmatic abilities, and, therefore, future studies in this area are warranted.

One such future study might, for example, include both children with AD/HD and autism to test more specific hypotheses. It is known that these groups of children both have difficulties in working memory (Willcutt et al., 2008), whereas difficulties in cognitive flexibility seem the most prominent EF deficit in children with autism (Hill, 2004; Willcutt et al., 2008; but see Geurts, Corbett, & Solomon, 2009), and inhibition deficits lie at the core of AD/HD (Sergeant et al., 2002; Willcutt et al., 2005, 2008). As described earlier, these different EF domains seem to relate to different aspects of ToM. Hence, the two disorders might be associated with different type of both EF and ToM deficits. Although speculative, difficulties with inhibition and working memory might lead to subtle difficulties in pragmatic abilities but not in ToM as seen in children with AD/HD, while difficulties in both cognitive flexibility and working memory possibly lead to more severe ToM and pragmatic difficulties as seen in autism. So, we would predict that there might be both quantitative and qualitative differences between these two disorders in the EF, ToM, and pragmatic difficulties they encounter. For example, if inhibition measures predict conversational turn-taking abilities but cognitive flexibility measures predict perspective-taking abilities, then one would expect children with AD/HD to have more severe difficulties in turn taking while children with autism might have more severe difficulties in perspective taking. Even though some studies have focused either on EF or ToM in both AD/HD and autism (e.g., Buitelaar et al., 1999; Geurts, Verte, Oosterlaan, Roeyers, & Sergeant, 2004a; Happé et al., 2006), research has yet to be done that examines both these domains simultaneously in these two partly overlapping neurodevelopmental disorders.

In sum, there is a clear need for longitudinal studies that simultaneously focus on several developmental domains in related disorders, in order to disentangle why some children end up with severe difficulties in one domain (e.g., EF) but manage to perform well in another related domain (e.g., ToM). EF might indeed be a valid and reliable endophenotype for AD/HD and may point to those genotypes that are related to AD/HD but also to autism (see Ronald, Simonoff, Kuntsi, Asherson, & Plomin, 2008). Combining different endophenotypes such as EF, ToM, and pragmatic abilities might help us in explaining the overlap and differences between neurodevelopmental disorders in general, and more specifically in AD/HD

and autism. However, as argued in this review, it has become clear that ToM is not likely to be a potential endophenotype for AD/HD, while it is too early to draw such a conclusion for pragmatic language use.

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