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Neuropsychological deficits in relation to ADHD symptoms, quality of life, and daily life functioning in young adulthood

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ABSTRACT

Attention-deficit/hyperactivity disorder (ADHD) is related to multiple neuropsychological deficits. However, most previous studies, especially studies of adult samples, have not taken the overlap between different neuropsychological deficits into account. In addition, the link between neuropsychological deficits and daily life functioning and quality of life needs to be further investigated. The aim was therefore to investigate the independent effects of executive deficits, delay-related behaviors and emotion dysregulation on ADHD symptom levels, daily life functioning, and quality of life in a non-clinical sample of younger adults. Results showed independent effects of all three neuropsychological deficits on the two ADHD symptom domains. With regard to daily life functioning and quality of life, bivariate relations were found to all three neuropsychological deficits. However, it was primarily the associations to executive deficits that remained significant when studying independent effects. Executive deficits were related to daily life functioning and quality of life also when controlling for ADHD symptom levels. Conclusively, this study shows that ADHD is related to multiple neuropsychological deficits, even in adulthood. Previous studies may have overestimated the importance of delay-related behaviors and emotion dysregulation for daily life functioning, as they have failed to control for the effects of executive deficits.

KEYWORDS

ADHD symptoms; executive deficits; emotion regulation; delay aversion; quality of life

Introduction

Previous research has emphasized the need to view attention-deficit/hyperactivity disorder (ADHD) as a heterogeneous disorder related to multiple neuropsychological deficits such as executive deficits, delay-related behaviors (i.e., the tendency to prefer smaller sooner rewards to longer delayed rewards), and emotion dysregulation (Castellanos, Sonuga-Barke, Milham, & Tannock, 2006; Coghill, Seth, & Matthews, 2014; Nigg, Willcutt, Doyle, & Sonuga-Barke, 2005; Sjöwall, Roth, Lindqvist, & Thorell, 2013). This research has largely been based on studies of children and adolescents, although there are also studies showing links between ADHD symptoms in adulthood and executive deficits (Alderson, Kasper, Hudec, & Patros, 2013; Boonstra, Oosterlaan, Sergeant, & Buitelaar, 2005), delay-related behaviors (Mowinckel, Pedersen, Eilertsen, & Biele, 2015), and emotion dysregulation (Christiansen, Hirsch, Albrecht, & Chavanon, 2019; Shaw, Stringaris, Nigg, & Leibenluft, 2014). One limitation of previous studies on adult ADHD is that few have included multiple neuropsychological deficits within the same study, the result being that we know little about the extent to which these deficits overlap in relation to ADHD. In addition, the link between neuropsychological deficits, daily life functioning, and quality of life needs to be explored in more detail. The aim of this study was therefore

to investigate independent effects of executive deficits, delay-related behaviors and emotion dysregulation on ADHD symptom levels, daily life functioning, and quality of life in a non-clinical sample of younger adults (age 25 years). As argued by the Lancet Psychiatry Commission (Holmes et al., 2018), understanding the underlying mechanisms should be considered essential for developing direct, precise, and effective treatments.

Overlap between different neuropsychological deficits in ADHD

Previous ADHD research on children has shown that there are independent effects of, but also an overlap between, different neuropsychological deficits in both clinical (Nigg et al., 2005; Sjöwall et al., 2013; Sonuga-Barke, Bitsakou, & Thompson, 2010) and non-clinical samples (Wählstedt, Thorell, & Bohlin, 2009). In the few previous studies of adults that have investigated the overlap between different neuropsychological deficits, it has been shown that delay-related behaviors and executive deficits have independent effects on ADHD in both clinical (Holst & Thorell, 2017; Mostert et al., 2015) and non-clinical samples (Thorell, Sjöwall, Mies, & Scheres, 2017). This finding is in line with the dual pathway hypothesis (Sonuga-Barke, 2003). In

addition, it has been shown that the overlap between working memory, inhibition, and speed of processing is larger in younger (18–45 years) than in older adults (60–75 years), with 11% of older adults and 30% of younger adults showing deficits in all three domains (Thorell, Holst, et al., 2017). There are very few studies examining the extent to which emotion dysregulation overlaps with other neuropsychological deficits in relation to adult ADHD. However, one previous study found that there were no differences in executive functioning in adults with the combination of ADHD and emotion dysregulation compared to those with ADHD only. Together with previous ADHD research on children showing that emotion dysregulation explains additional variance beyond that explained by both executive deficits and delay-related behaviors (Sjöwall et al., 2013), these findings indicate that emotion regulation could be a core feature of ADHD that is not explained by other neuropsychological deficits.

When investigating the overlap between different neuropsychological samples, it should be considered important to investigate both clinically referred samples of individuals diagnosed with ADHD and ADHD symptom levels within the general population. One reason for this is the finding showing that ADHD is best characterized as a dimension rather than as a discrete category (Sonuga-Barke & Halperin, 2010). In addition, clinical samples suffer from referral biases (Goodman et al., 1997), which could mean that the overlap between different neuropsychological deficits is larger in clinical samples.

Neuropsychological deficits, daily life functioning, and quality of life

Adult ADHD has a profound negative impact on daily life functioning (Kooij et al., 2019), and adults diagnosed with ADHD also report lower quality of life (Agarwal, Goldenberg, Perry, & IsHak, 2012; Stern, Pollak, Bonne, Malik, & Maeir, 2017). However, if we are to understand these relations more in detail, it is important to examine the underlying factors related to daily life functioning and quality of life. It has also been emphasized that neuropsychological functioning might affect daily life functioning and quality of life even when they are not the source of the symptoms (Coghill et al., 2014).

Previous studies investigating the link between neuropsychological deficits and daily functioning in clinical samples of adults with ADHD have found that the subgroup with ADHD and executive deficits have significantly higher problem levels, primarily with regard to academic achievement, unemployment, criminality, and traffic accidents (Biederman et al., 2006; Halleland, Sorensen, Posserud, Haavik, & Lundervold, 2019; Holst, & Thorell, in press). Similar associations between executive deficits and daily functioning have been found when studying neuropsychological deficits as a dimension (i.e., from low to high deficits) rather than as a category (Barkley & Fischer, 2011; Barkley & Murphy, 2010, 2011). Some previous studies have found that the relation to daily functioning is stronger when

executive deficits are measured using self-ratings rather than tests (Barkley & Fischer, 2011; Barkley & Murphy, 2010, 2011).

With regard to delay-related behaviors, a number of non-clinical studies on adults have found associations with criminality and substance use (MacKillop et al., 2011). At least one previous study has also found relations to daily life functioning (e.g., money and time management), but no significant associations were found with academic achievement (Thorell, Sjöwall, et al., 2017). With regard to emotion dysregulation, it is clear that poor ability to control one's emotions has a severe negative impact on daily life, with strong associations not only with ADHD but also with many other mental disorders (Sheppes, Suri, & Gross, 2015). In clinical studies of adults with ADHD, emotion dysregulation has been linked to, for example, higher comorbid symptom levels, poorer social relations, higher unemployment, lower educational level, more traffic accidents, and poorer quality of life (Barkley & Fischer, 2010; Bodalski, Knouse, & Kovalev, 2019; Bruner, Kuryluk, & Whitton, 2015; Surman et al., 2013). The overlap between different neuropsychological deficits has not been examined in these studies, which means we do not know, for example, whether emotion dysregulation is still related to poor academic achievement after controlling for executive deficits.

Another important limitation of previous research is that few studies have examined the extent to which neuropsychological deficits are related to daily life functioning when controlling for ADHD symptom levels. If neuropsychological deficits are found to be related to daily life functioning beyond the influence of ADHD symptom levels, this may help us better determine which specific mechanisms are related to various outcomes in daily life. When controlling for ADHD symptom levels, self-ratings of inhibition and self-organization/planning have been shown to be related to overall impairment (Barkley & Fischer, 2011), and self-rated executive deficits have been shown to be related to quality of life (Stern et al., 2017; Thorell, Holst, & Sjöwall, 2019). In addition, a few studies have shown that ADHD patients with executive deficits have more problems in daily life functioning with regard to unemployment, academic achievement, and criminality compared to ADHD patients without these deficits (Holst & Thorell, in press). Further, self-ratings of delay-related behaviors have been shown to be associated with criminality and poor money management when controlling for ADHD symptom levels (Thorell, Sjöwall, et al., 2017). Finally, with regard to emotion dysregulation, one previous study (Barkley & Fischer, 2010) showed that emotional impulsivity was related to multiple outcomes (e.g., occupational, educational, social, criminal, driving, and financial), beyond ADHD symptom levels.

In summary, executive deficits, delay-related behaviors, and emotion dysregulation are associated with daily life functioning and quality of life, and the few studies available indicate that at least some of these associations remain significant even after controlling for ADHD symptom levels. Importantly, however, no previous study has simultaneously investigated multiple neuropsychological deficits in relation

to daily functioning and quality of life in adults. Thus, we have a limited understanding of the relation between specific mechanisms and outcomes in adult ADHD.

Aim of the study

The aim of this study was to investigate self-ratings of neuropsychological functioning (i.e., executive deficits, delay-related behaviors, and emotion dysregulation) in relation to ADHD symptom levels, daily life functioning, and quality of life in a population-based sample of young adults (25 years of age). In contrast to most previous studies, we investigated the overlap between different neuropsychological deficits in relation to ADHD symptom levels and we controlled for ADHD symptom levels when studying associations with daily functioning and quality of life. In line with previous studies as well as current models of heterogeneity described above, we hypothesized that executive deficits, delay-related behaviors, and emotion regulation would be related to ADHD symptom levels, daily life functioning, and quality of life when studying bivariate correlations. Due to the scarcity of previous studies examining all three neuropsychological deficits within the same study, no *a priori* hypotheses were made with regard to independent effects.

Method

Participants and procedure

The participants in this study consisted of 121 young adults (56% male) age 26 years ($M = 25.9$ years, $SD = 0.26$) recruited from a larger longitudinal study investigating the development of ADHD symptoms and neuropsychological deficits from early childhood to adulthood. The sample included in this study constituted 82% of the 148 participants who could be reached at the 26-year follow-up. For more detailed information on the recruitment procedure, please see Berlin and Bohlin (2002). Although the study originally included a non-clinical sample, 22% of the sample reported having received a psychiatric diagnosis at the 26-year follow-up, of which ADHD, depression, and anxiety were the most common diagnoses. Information about the study was distributed either by regular mail or by e-mail, and the questionnaires were completed using a secure online system. The participants received 500 SEK (approximately 50 Euros) for completing the questionnaire. The study was approved by the local ethics committee in Stockholm.

Measures

Executive functioning

Executive deficits were measured using the Adult Executive Functioning Inventory (Holst & Thorell, 2018), which is a 14-item questionnaire measuring working memory and inhibition. It is an adult version of the Childhood Executive Functioning Inventory (CHEXI; Thorell & Nyberg, 2008), and both the child and adult version are freely available in several languages (see www.chexi.se). The ADEXI has been

shown to be a reliable instrument that can distinguish well between adults with ADHD and non-clinical controls in both younger (Holst & Thorell, 2018) and older adulthood (Thorell, Sjöwall, et al., 2017). As described in more detail in previous publications (Holst & Thorell, 2018; Thorell & Nyberg, 2008), the CHEXI and the ADEXI were created to specifically investigate deficits in working memory and inhibition and thereby address the limitations of other rating instrument of executive functioning that often also include items addressing ADHD symptom levels.

Delay-related behaviors

Delay-related behaviors were measured using the Quick Delay Questionnaire (QDQ; Clare, Helps, & Sonuga-Barke, 2010). Ratings were made on a five-point Likert scale ranging from 1 (“not like me at all”) to 5 (“very like me”), and the score used in this study was the mean value of the 10 items included in this scale.

Emotion dysregulation

Emotion dysregulation was measured using the Comprehensive Emotion Regulation Inventory (CERI; Thorell, Tilling, & Sjöwall, 2019). It includes subscales related to emotional reactivity, how often an individual uses different strategies for regulating emotions, problems with using regulatory strategies, and negative impact on daily life. The strategies included in the inventory are based on Gross’s (2001) process model of emotion regulation and include situation selection, situation modification, attentional deployment, cognitive reappraisal, and suppression. In this study, only the items related to having problems using regulatory strategies (i.e., the implementation subscale) were included (e.g., “I find it difficult to avoid a situation even if I think it will upset me” and “I find it difficult to hide my negative emotions even when I want to”). Thus, in contrast to many previous ratings of instruments of emotion regulation, the instrument used in this study addresses problems with regard to the specific regulatory strategies included in Gross’s (2001) process model instead of including more general items that address both emotion dysregulation and emotional reactivity (i.e., how often and how intensely an individual displays different emotions). Ratings on the CERI are made on a scale from 1 (“very seldom/never”) to 5 (“very often/always”), and the mean score for the six items included in the implementation subscale was used to measure emotion dysregulation.

Daily life functioning

The ADHD Daily Problem Questionnaire (ADPQ; Thorell, Sjöwall, et al., 2017) was used to investigate daily life functioning. The ADPQ contains a list of daily activities, and participants (or a close relative/friend of the patient) are asked to rate their level of functioning on a scale from 0 (“no problem”) to 9 (“very severe problem”) with regard to four problem areas known to be associated with ADHD:

Table 1. Intercorrelations between the neuropsychological variables, means, and standard deviations for all included variables, as well as associations between neuropsychological deficits and ADHD symptom levels.

	Executive functioning	Delay-related behaviors	Emotion Regulation	Mean (SD)
Intercorrelations				
Executive functioning	1.00			2.10 (0.65)
Delay-related behaviors	.54***	1.00		2.40 (0.64)
Emotion regulation	.44***	.41***	1.00	2.47 (0.65)
Relations to ADHD symptoms				
Inattention	.78***	.53***	.49***	2.52 (0.73)
Hyperactivity/impulsivity	.53***	.55***	.49***	2.46 (0.73)
Relations to quality of life				
Life productivity	-.60***	-.37***	-.32***	73.97 (19.25)
Psychological health	-.46***	-.51***	-.32***	58.61 (19.66)
Life outlook	-.45***	-.33***	-.25**	62.58 (18.71)
Relationships	-.45***	-.31***	-.31***	68.32 (18.93)
Relations to daily problems				
Chores	.53***	.35***	.24**	1.46 (1.57)
Social life	.33***	.19*	.22*	2.14 (2.15)
Money management	.54***	.47***	.34***	1.20 (1.67)
Time management	.59***	.37***	.19*	1.56 (1.41)

* $p < .05$; ** $p < .01$; *** $p < .001$.

economic problems (e.g., “handling money in a responsible way”), daily chores/responsibilities (e.g., “cleaning” and “doing laundry”), time management (e.g., “keeping appointments”), and social relations (e.g., “going to a party when I do not know the other guests well”).

Quality of life

Quality of life was assessed using the Adult ADHD Quality of Life measure (AAQoL; Brod, Johnston, Able, & Swindle, 2006) which includes four subscales: (1) Life Productivity, (2) Psychological Health, (3) Relationships, and (4) Life Outlook. Items are scored on a five-point scale ranging from 1 (Not at all/Never) to 5 (Extremely/Very Often). Scores are then converted into four subscale scores ranging from 0 to 100, with high value always indicating high quality of life. Previous studies have found this scale to have adequate psychometric properties (Brod et al., 2006).

Statistical analyses

Outliers were handled using the outlier labeling rule (Hoaglin & Iglewicz, 1987), adjusting outliers to the upper or lower value using the formula (1st/3rd Quartile \pm (2.2 \times Interquartile range)). To check whether the predictors and outcome variables conformed to a normal distribution, kurtosis and skewness were checked. Nonparametric tests were used if variables were outside the recommended range (± 2.0).

To obtain an overview, inter-correlations between all variables were first calculated. Next, regression analyses were used to investigate independent effects of the three neuropsychological deficits on ADHD symptom levels (with separate analysis for inattention and hyperactivity/impulsivity), daily functioning, and quality of life. Next, we wanted to investigate whether neuropsychological deficits could explain additional variance in daily functioning and quality of life, over and above ADHD symptom levels. Hierarchical regressions were therefore conducted, where ADHD symptoms were entered in the first step and neuropsychological deficits

Table 2. Regression analyses examining independent effects and overall explained variance on ADHD symptoms at 25 years for neuropsychological deficits.

	β	R^2
Inattention		.64***
Executive functioning	.65***	
Delay-related behaviors	.13 ⁺	
Emotion regulation	.15*	
Hyperactivity/Impulsivity		.43***
Executive functioning	.25**	
Delay-related behaviors	.31***	
Emotion regulation	.26**	

⁺ $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$.

in the second step. In order to correct for multiple comparison, the p value was adjusted based on the number of regressions carried out for each hypothesis.

Results

Mean values and standard deviations for all variables are presented in Table 1 (see rightmost column). In addition, Table 1 reports intercorrelations between the three neuropsychological domains as well as associations between the three neuropsychological deficits, ADHD symptom levels, daily functioning, and quality of life. The results showed that there were significant inter-correlations between all three neuropsychological deficits. In addition, each neuropsychological function accounted for between 24% and 61% of the variance in inattention and between 24% and 30% of the variance in hyperactivity/impulsivity.

To explore our main research question, we thereafter used regression analysis to investigate independent effects and the overall explained variance in ADHD symptom levels that could be explained by neuropsychological functioning. The results (see Table 2) showed that for symptoms of inattention, executive deficits were the most important predictor. However, the effect of emotion regulation was also significant and the effect of delay-related behaviors was marginally significant. Overall, the three neuropsychological deficits explained 64% of the variance in inattention. For hyperactivity/impulsivity, the three neuropsychological

Table 3. Regression analyses examining independent effects, and overall explained variance on functional outcomes for neuropsychological deficits.

	β	R^2
Daily chores		.28***
Executive functioning	.48***	
Delay-related behaviors	.09	
Emotion regulation	-.01	
Social life		.11**
Executive functioning	.28**	
Delay-related behaviors	.00	
Emotion regulation	.09	
Money management		.34***
Executive functioning	.27*	
Delay-related behaviors	.24*	
Emotion regulation	.07	
Time management		.36***
Executive functioning	.58**	
Delay-related behaviors	.10	
Emotion regulation	-.10	

* $p < .05$; ** $p < .01$; *** $p < .001$.

Table 4. Regression analyses examining independent effects and overall explained variance on quality of life for neuropsychological deficits.

	β	R^2
Life productivity		.37***
Executive functioning	-.55***	
Delay-related behaviors	-.05	
Emotion regulation	-.06	
Psychological health		.36***
Executive functioning	-.18	
Delay-related behaviors	-.36***	
Emotion regulation	-.21**	
Life outlook		.22***
Executive functioning	-.37***	
Delay-related behaviors	-.11	
Emotion regulation	-.04	
Relationships		.22***
Executive functioning	-.36**	
Delay-related behaviors	-.06	
Emotion regulation	-.12	

* $p < .05$; ** $p < .01$; *** $p < .001$.

deficits explained 43% of the total variance, with each variable contributing independently.

Next, we investigated independent effects and the overall variance in daily life functioning that could be explained by the three types of neuropsychological deficits (see Table 3). Neuropsychological functioning explained between 11% and 36% of the variance in daily life functioning. Executive deficits were shown to have an independent effect with regard to all investigated aspects of daily life (i.e., daily chores, social life, money management, and time management). In addition, an independent effect of delay-related behaviors was also seen in relation to money management. All independent effects remained significant after controlling for ADHD symptom levels.

Finally, we investigated independent effects and the overall variance in quality of life that could be explained by neuropsychological functioning (see Table 4). Neuropsychological functioning explained between 22% and 36% of the variance in quality of life. Executive deficits had an independent effect on all aspects of quality of life, except for psychological health. For psychological health, independent effects were instead found for both delay-related

behaviors and emotion dysregulation. All independent effects remained significant after controlling for ADHD symptom levels, except for the effect of executive deficits on the subscale “relationships,” which was reduced to being marginally significant, $\beta = -.23$, $p < .10$.

Discussion

This study found support for the notion that ADHD is a neuropsychologically heterogeneous disorder in young adults, with independent effects of executive deficits, delay-related behaviors, and emotion regulation in relation to the two ADHD symptom domains. Furthermore, the study found that all three neuropsychological deficits were significantly related to all aspects of daily life functioning and quality of life when studying bivariate correlations. However, when controlling for the overlap between different neuropsychological deficits, executive deficits had an independent effect on all outcomes, except for one aspect of quality of life. In contrast, delay-related behaviors were only independently related to money management, and both delay-related behaviors and emotion regulation were independently related to one aspect of quality of life (i.e., psychological health). All relations between neuropsychological deficits, daily life functioning, and quality of life remained significant or marginally significant after controlling for ADHD symptom levels.

Neuropsychological deficits in relation to ADHD

Executive deficits have long been regarded as a major deficit in ADHD (Barkley, 1997), and the present results confirm the view of ADHD as an “executive” disorder, in that very strong associations were found between executive deficits and both inattention and hyperactivity/impulsivity. When controlling for the overlap between the three neuropsychological functions, the effect of executive deficits remained significant for the two symptom domains. In line with previous research (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), the present results showed an especially strong link to symptoms of inattention.

With regard to the finding of independent effects on executive deficits and delay-related behaviors in relation to symptoms of hyperactivity/impulsivity, this is in line with the dual pathway model (Sonuga-Barke, 2003) as well as previous empirical findings (Thorell, Sjöwall, et al., 2017). It has been suggested (Castellanos et al., 2006) that delay-related behaviors would be most strongly related to hyperactivity/impulsivity, whereas executive deficits would be most strongly related to inattention. Data from a previous non-clinical study of adults (Thorell, Sjöwall, et al., 2017) support this notion. However, the present results were more mixed, as delay-related behaviors showed similar correlations with the two symptom domains in the bivariate correlations, but stronger relations with hyperactivity/impulsivity when controlling for the overlap between the three neuropsychological deficits. Results from previous studies of children have also been mixed with regard to this issue

(Paloyelis, Asherson, & Kuntsi, 2009; Sjöwall, Backman, & Thorell, 2015; Thorell, 2007). In conclusion, delay-related behaviors were related to ADHD symptoms, but it is unclear whether they are more strongly related to hyperactivity/impulsivity than to inattention.

Emotion dysregulation has been acknowledged as a major deficit in ADHD (Shaw et al., 2014), but it has been argued that previous studies have not taken the potential overlap with motivational aspects and cognition into account (Christiansen et al., 2019). The present results therefore contribute new important knowledge by showing that emotion dysregulation has an independent effect on adult ADHD beyond the influence of both executive deficits and delay-related behaviors. This is in line with a study indicating independent effects on emotion regulation in adults when controlling for executive deficits (Surman et al., 2013). However, it should also be noted that several studies have shown a relatively strong link between emotion regulation and executive deficits (Zelazo & Cunningham, 2007). In sum, emotion regulation and executive functioning appear to be related processes, but they only partially overlap in relation to ADHD symptom levels.

From a clinical standpoint, previous studies have shown that ADHD medication can reduce both core ADHD symptoms and emotional dysregulation (Moukhtarian, Cooper, Vassos, Moran, & Asherson, 2017) as well as delay-related behaviors in children (Shiels et al., 2009). In addition, working memory training has been shown to lead to improvements in emotional functioning as well (Xiu, Wu, Chang, & Zhou, 2018). However, effect sizes have been small. The fact that this study showed that both delay-related behaviors and emotion dysregulation have independent effects on ADHD symptom levels suggests that the great focus many treatments have on improving executive functioning might not be enough for individuals with deficits primarily in delay-related behaviors or emotion regulation.

Neuropsychological deficits, daily life functioning, and quality of life

With regard to daily life functioning and quality of life, the most important finding of this study was probably that all three neuropsychological deficits were significantly related to all outcomes when studying bivariate correlations, whereas a much more differentiated pattern of results was found when controlling for the overlap between different neuropsychological deficits. Studying independent effects, executive deficits were clearly a much more important predictor of both daily life functioning and quality of life compared to either delay-related behaviors or emotion regulation, and this could be taken as an indication that the subgroup with ADHD and executive deficits may need more support in managing their daily life.

Another important finding was that results remained after controlling for ADHD symptom levels. Thus, adults with neuropsychological deficits do not have more problems in daily life functioning simply because they also have higher ADHD symptom levels. This finding could also be

seen as support for the alternative causal model (Coghill et al., 2014), in which cognitive deficits and ADHD symptoms are independently related to daily life functioning, rather than for the traditional causal model, which proposes that cognitive deficits lead to ADHD symptoms, which in turn have effects on daily life functioning.

With regard to delay-related behaviors, the present findings are in line with a previous study of a clinical sample of adults with psychiatric disorders (including ADHD) showing that delay-related behaviors were most strongly related to money management (Thorell, Sjöwall, et al., 2017). From a theoretical standpoint, this finding is also not surprising, considering the fact that delay aversion is defined as being unable to wait for a larger delayed reward and that an important aspect of money management is to avoid impulsive spending and save money for something that is beneficial in the long run. The finding that delay-related behaviors also had an independent effect on the aspect of quality of life referred to as psychological health is interesting. The aspect of psychological health included to investigate quality of life includes items related to emotionality, such as being anxious, overwhelmed, depressed, showing fluctuations in emotions, or overreacting in difficult situations (Brod et al., 2006). Thus, this finding could be taken as an indication that delay-related behaviors are a transdiagnostic feature that is related to several different types of mental health problems. In line with this interpretation, previous studies have found that delay-related behaviors are not only associated with ADHD symptom levels, but also with anxiety and depression (Clare et al., 2010; Mies, De Water, & Scheres, 2016).

With regard to emotion dysregulation, the only independent effect observed was in relation to psychological health. Studying the simple bivariate correlations, this study found that emotion regulation is related to multiple outcomes, as reported in previous research (Barkley & Fischer, 2010), but another picture emerged when controlling for the overlap with executive functions and delay-related behavior. These findings could be taken as a suggestion that previous studies might have overestimated the relation between emotion dysregulation and daily life functioning, as they have not controlled for executive deficits. It should also be noted that several previous studies examining emotional functioning in relation to daily life functioning in ADHD have not used measures specifically asking about difficulties in using different emotion regulation strategies, as was done in this study. Rather, they have measured emotional lability/impulsivity, which includes items such as “easily frustrated” and “lose my temper.”

Conclusions, limitations, and future directions

In conclusion, the present results are in line with findings from previous studies on both clinical and non-clinical samples showing that ADHD is related to multiple neuropsychological deficits (Castellanos et al., 2006; Coghill et al., 2014; Nigg et al., 2005; Sjöwall et al., 2013). However, this study also adds valuable new information by investigating

the overlap between different neuropsychological deficits, thereby showing which neuropsychological deficits have an independent effect on ADHD symptoms as well as functional outcomes and quality of life, beyond the influence of ADHD symptom levels. Due to the fact that this study included a non-clinical sample, it is possible that the overlap between different neuropsychological deficits has been somewhat underestimated. As mentioned above, independent effects of executive deficits and delay aversion have been found also in clinically referred sample of adults diagnosed with ADHD. However, as previous clinical studies have included all the three types of neuropsychological deficits, it should be considered important for future research to determine whether our findings can be generalized also to clinical samples.

With regard to limitations, it should be acknowledged that self-ratings were used for both independent and dependent variables, which entails the risk that we overestimated the overlap between different neuropsychological deficits as a result of halo effects. However, despite this, we found support for independent effects and specific relations between predictors and outcomes. Moreover, results were in line with previous research on children using multiple assessment approaches. This study also shows that self-ratings of neuropsychological deficits can provide a more comprehensive view of underlying deficits related to daily life functioning, as compared to solely using ratings of ADHD symptom levels. That said, the ADEXI is available also as a version for significant others and it would be valuable for future research to also include informant ratings, especially in clinical studies as patients with psychiatric disorders often have reduced symptom awareness and high levels of cognitive deficits. In addition, self-ratings are influenced by social disability bias.

Future studies should expand this line of research by collecting longitudinal data on multiple neuropsychological deficits as well as by taking daily life functioning into account. This would enable a more detailed account of how changes in ADHD symptom levels across time are related to changes in neuropsychological functioning, and how these changes affect daily life functioning. Preferably, such studies should include both clinical and non-clinical samples and focus on important life transitions, such as starting school, entering adolescence, and stepping into adulthood.

Disclosure statement

No potential conflict of interest was reported by the authors.

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