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Quick Delay Questionnaire: Reliability, Validity, and Relations to Functional Impairments in Adults With Attention-Deficit/Hyperactivity Disorder (ADHD)

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The Quick Delay Questionnaire (QDQ) is a self-report measure of delay-related behaviors in adults, and the present study aimed at investigating the psychometric properties of QDQ scores, how well they can discriminate between ADHD adults and both clinical and nonclinical controls, as well as their relations to measures of functional impairments. In the present study, QDQ ratings, a laboratory measure of delay discounting, and ratings of functional impairments were collected from adults diagnosed with attention-deficit/hyperactivity disorder (ADHD; $n = 51$), a clinical control group with other psychiatric disorders ($n = 46$), and a nonclinical control group ($n = 105$). Results showed that the QDQ scores showed adequate reliability. Adults with ADHD had higher scores compared with normal controls on both QDQ subscales, and they also reported higher levels of delay aversion than the clinical controls. Logistic regression analyses showed high specificity but low sensitivity when trying to discriminate between adults with ADHD and nonclinical controls. QDQ scores were not associated with a laboratory measure of delay discounting, but with functional impairments such as substance use, criminality, and money management. Our findings indicate that QDQ scores are reliable, but this instrument should be regarded as a complement rather than as a replacement for laboratory measures. The relatively low sensitivity of QDQ scores is in line with current models of heterogeneity stating that only a subgroup of individuals with ADHD has high levels of delay-related behaviors. Our findings further indicate that this subgroup may be at particularly high risk for problems in everyday life.

Public Significance Statement
This study shows that the QDQ is a rating instrument that can be used to identify a subgroup of adults with ADHD who show high levels of delay-rated behaviors (i.e., negative feelings/attitudes toward waiting and delaying rewards). These behaviors are more common in adults with ADHD compared with controls. Delay-related behaviors are also related to important functional impairments, especially criminality, substance use, and problems with money management.

Keywords: attention-deficit/hyperactivity disorder, delay discounting, self-report, neuropsychology, reliability and validity

During recent decades, it has repeatedly been argued that attention-deficit hyperactivity disorder (ADHD) is a heterogeneous disorder with multiple neuropsychological underpinnings (Castellanos, Sonuga-Barke, Milham, & Tannock, 2006; Nigg, Willcutt, Doyle, & Sonuga-Barke, 2005; Sonuga-Barke & Fairchild, 2012). For example, according to the dual-pathway model, executive deficits constitute one pathway to ADHD, and a unique motivational style constitutes another (Sonuga-Barke, 2002). With regard to empirical support for this model, a fairly large number of studies investigating deficits in executive functioning have found that individuals with ADHD differ from controls with regard to executive functions such as inhibitory control, working memory, and shifting during both childhood (e.g., Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005) and adulthood (e.g., Boonstra, Oosterlaan, Sergeant, & Buitelaar, 2005). However, results are more inconsistent with regard to motivational deficits, and a better understanding of the psychometric properties of the measures used in different studies is needed.

A number of laboratory measures are available that tap into delay-related behaviors, such as delay of gratification (e.g., Mischel, Shoda, & Rodriguez, 1989), delay aversion (e.g., Sonuga-Barke, Taylor, Sembi, & Smith, 1992), and delay discounting (e.g., Critchfield & Kollins, 2001). Meta-analyses have shown that children with ADHD are more delay averse compared with controls (Willcutt, Sonuga-Barke, Nigg, & Sergeant, 2008) and that individuals with ADHD

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show relatively steeper delay discounting (e.g., Jackson & MacKillop, 2016; Patros et al., 2016). However, it should be noted that there are individual studies that have failed to find significant group differences between children with ADHD and controls on delay aversion and delay-discounting tasks (Bidwell, Willcutt, Defries, & Pennington, 2007; Karalunas & Huang-Pollack, 2011; Scheres et al., 2006; Sjöwall, Roth, Lindqvist, & Thorell, 2013; Solanto et al., 2007). With regard to studies on adults, a link between delay-related behaviors and dimensional measures of ADHD symptoms was found in two studies using nonclinical samples of university students (e.g., Clare, Helps, & Sonuga-Barke, 2010; Scheres, Lee, & Sumiya, 2008). However, a recent meta-analysis of clinical studies concluded that adults with ADHD do not differ significantly from controls on delay discounting, the effect size being only .14 (Mowinckel, Pedersen, Eilertsen, & Biele, 2015).

In the previously mentioned meta-analysis on delay discounting in adults with ADHD (Mowinckel et al., 2015), it was concluded that there are few studies available ($n = 6$ in the meta-analysis), and that the tests used to study delay-related behaviors might not have been adequately adapted to an adult population. Among children, relations between delay-related behaviors and ADHD have been shown to be stronger in younger compared with older children (cf. Karalunas & Huang-Pollock, 2011; Pauli-Pott & Becker, 2011). This finding could be related to measurement issues, or to the fact that relations between delay-related behavior and ADHD are not as strong after the preschool years. It is interesting that it has also been suggested that delay-related behaviors are expected to be more strongly associated with symptoms of hyperactivity/impulsivity than with symptoms of inattention (Castellanos et al., 2006). In line with this notion, one nonclinical study of children (Thorell, 2007) found that delay aversion was only related to hyperactivity/impulsivity when controlling for the overlap between the two ADHD symptom domains. However, some support for the opposite (i.e., that delay aversion is more strongly related to symptoms of inattention) has also been found (e.g., Paloyelis, Asherson, & Kuntsi, 2009; Sjöwall, Backman, & Thorell, 2015). To our knowledge, the issue to what extent delay-related behavior is specifically related to either one of the two ADHD symptom domains has not been addressed in previous studies of adults.

One final issue that should be taken into consideration when examining the link between delay-related behavior and ADHD is that the tests used to measure delay-related behaviors may not fully capture this construct. According to Sonuga-Barke (2002), delay aversion is a motivational style characterized by the desire to escape delays when possible, because of the negative emotions experienced during waiting periods. Thus, delay aversion refers not only to choices that result in minimal waiting periods, but also to negative subjective experiences during such periods. Therefore, there is a need for subjective delay aversion measures that can be used as a complement to neuropsychological tests.

Based on the limitations of the laboratory measures described previously, the need for an easily administered questionnaire-based measure of response to delay in adulthood has been pointed out. To address this need, Clare and colleagues (2010) introduced the "Quick Delay Questionnaire" (QDQ), a 10-item self-rating instrument for adults that measures delay-related behaviors. The QDQ includes items related to responses and attitudes to delay-related activities and situations that are relevant to everyday adult life such as queuing/waiting and choosing long-term over short-term outcomes (e.g., "Even if I have to wait a long time for something I won't give up if it is important to me" and "I am usually calm when I have to wait in queues"). In the first study introducing this instrument (Clare et al., 2010), the psychometric properties of the QDQ scores were examined in a convenience sample of university students. A factor analysis showed that the questionnaire has two subscales (i.e., delay aversion and delay discounting) and that the scores had both adequate internal consistency ($\alpha = .68/.77$) and good test–retest reliability ($r = .80/.81$). In addition, this study showed that the scores for both subscales were significantly related to symptoms of inattention and hyperactivity in this nonclinical sample. Significant, although somewhat weaker, relations were also found between QDQ scores and symptoms of both anxiety and depression. Significant relations between the QDQ scores and both ratings of ADHD symptoms and depression have also been confirmed in a more recent study (Mies, de Water, & Scheres, 2016). The study by Mies and colleagues also found evidence for convergent validity of the QDQ because high scores on the two QDQ subscales were associated with a higher number of choices for smaller sooner rewards compared with larger later rewards in a delay-discounting task using hypothetical rewards. Except for this study, no previous studies have examined the convergent validity of QDQ scores, and there is only one study available (Holst & Thorell, 2013) that has included individuals with ADHD. This study did not include a nonclinical control group. Thus, it is still unknown to what extent QDQ scores can be used to discriminate between adults with ADHD and adults without psychiatric disorders. The QDQ has, on the other hand, been used in studies investigating gambling (Addicott, Pearson, Kaiser, Platt, & McClernon, 2015), Parkinson's disease (Torta et al., 2012), and Type 2 diabetes (Williams, Lynch, Knapp, & Egede, 2014). Several adapted parent-rated versions of the QDQ for assessing delay-related behavior in children with ADHD have also recently been presented (Hsu, Benikos, & Sonuga-Barke, 2015; Van Lieferinge et al., in press). Thus, the QDQ has been used in several different areas of research, despite the fact that the psychometric properties of the QDQ scores have not been thoroughly examined.

According to Clare and colleagues (2010), the items included in the QDQ are intended to provide descriptions of responses to and attitudes toward delay-related situations of relevance in everyday adult life. However, the link between QDQ ratings and daily life functioning has not been examined. This means that it is not known to what extent the questionnaire can be used to provide a better understanding of the functional impairments known to affect individuals with ADHD, such as academic underachievement (Frazier, Youngstrom, Glutting, & Watkins, 2007), high unemployment (e.g., Shaw et al., 2012), problematic social relations (e.g., Nijmeijer et al., 2008), problems in daily situations such as handling money (e.g., Graziano et al., 2015), substance abuse (e.g., Lee, Humphreys, Flory, Liu, & Glass, 2011), and criminality (e.g., von Polier, Vloet, & Herpertz-Dahlmann, 2012).

Addressing this issue should be considered of vital importance, particularly because it has been argued that even though measures of neuropsychological deficits are often suboptimal with regard to discriminating between individuals with ADHD and controls, they might provide useful clinical information by identifying individuals with increased risk of functional impairments (Pritchard, Nigro, Jacobson, & Mahone, 2012; Sjöwall & Thorell, 2014).

A final important aspect when examining the link between motivational aspects and ADHD is to what extent these deficits are independent of executive function deficits. According to the dual-pathway model (Sonuga-Barke, 2002, 2003), delay aversion and executive function deficits are two core deficits of ADHD that should be at least partially dissociable. A relatively large number of previous studies on children support this distinction, at least with regard to inhibitory control and delay aversion (e.g., Coghill, Seth, & Matthews, 2014; Dalen, Sonuga-Barke, Hall, & Remington, 2004; Solanto et al., 2001; Sonuga-Barke, Dalen, & Remington, 2003). However, Karalunas and Huang-Pollock (2011) suggested that some executive functions might be more likely than others to be related to a delay-averse motivational style. More specifically, they argued that executive functions that rely on engagement across periods of delay (i.e., working memory) might be more strongly linked to delay aversion than other executive functions (e.g., inhibition). In support of this hypothesis, they found that delay aversion was related to working memory but not to inhibition. Also in support of a link between delay-related behaviors and working memory, it was demonstrated that rates of discounting of delayed rewards were significantly reduced among adults who received memory training but remained unchanged among those who received control training (Bickel, Yi, Landes, Hill, & Baxter, 2011).

In summary, current theoretical propositions as well as the empirical findings referred to previously, suggest that scores on a measure of delay-related behavior such as the QDQ will most likely have high specificity (i.e., few controls will be impaired), but relatively low sensitivity, because only a subgroup of individuals with ADHD will have high levels of delay-related behaviors. This subgroup might be at a particularly high risk of certain functional impairments, and it is therefore important to examine the link between delay-rated behaviors and daily functioning. Finally, it is of importance to further investigate to what extent executive function deficits and delay aversion are truly two dissociable components in relation to ADHD, and such studies should include measures of several different executive functions and not only inhibition.

Aims of the Study

The overall aim of the present study was to examine the psychometric properties and the clinical utility of QDQ scores for examining delay-related behaviors in adults with ADHD. More specifically, we aimed to:

(1) Investigate the psychometric properties (i.e., internal consistency and test–retest reliability, as well as both convergent and discriminative validity) of QDQ scores.

(2) Examine the association between scores on the QDQ and symptoms of ADHD in nonclinical samples and to what extent QDQ scores can be used to discriminate between individuals with ADHD and nonclinical or clinical controls (i.e., patients with primarily depression and anxiety disorders).

(3) Examine whether scores on the QDQ can increase the prediction rate, above and beyond the influence of executive function deficits (i.e., including measures of inhibition, working memory and set shifting), when trying to discriminate between adults with ADHD and controls.

(4) Examine the association between QDQ scores and measures of daily functioning (i.e., social relations, daily problem areas, academic achievement, unemployment, substance abuse and criminality) in a clinical sample.

Method

Participants

Because we were interested in comparing an ADHD group with normal controls as well as with a clinical sample of individuals with psychiatric disorders other than ADHD, the study included two clinical samples and one nonclinical sample of adults in the age range 18–45 years. More detailed information on recruitment is presented under the heading "Procedure" below and demographic information is presented in Table 1.

Nonclinical sample. The nonclinical sample was a convenience sample recruited from two different sources. A total of 44 individuals (18 men, 26 women) were part of another ongoing

Table 1
Results of the Analyses of Covariance (ANCOVAs; Dimensional Variables) or Chi-Square Test/Fisher's Exact Test (Categorical Variables) Comparing the Attention-Deficit/Hyperactivity Disorder (ADHD) Group (1), The Clinical Control Group (2), and the Nonclinical Control Group With Regard to Background Variables and the Two Quick Delay Questionnaire (QDQ) Subscales

Variable	*M* (*SD*)			F/χ^2	η_p^2	Post hoc
	ADHD group	Clinical controls	Nonclinical controls			
Background variables						
Age (years)	27.03 (6.20)	25.53 (5.02)	26.50 (5.57)	1.03	.01	*ns*
Gender (% men)	41.4%	30.2%	41.9%	2.24		*ns*
Educational level (%)				77.14***		1 < 2 < 3
Min requirement (≤ 9 years)	37.3%	4.4%	0%			
High school	29.4%	53.3%	14.3%			
University/college	33.3%	42.2.7%	85.7%			
QDQ						
Delay aversion	3.76 (.92)	3.15 (.87)	2.69 (.98)	25.14***	.20	1 > 2 > 3
Delay discounting	2.74 (.77)	2.49 (.77)	1.88 (.64)	29.52***	.23	1, 2 > 3

Note. *ns* = nonsignificant.
*** $p < .001$.

study, and these individuals were recruited from a larger sample of 1000 individuals aged 18–45 years, living in or around the central parts of Stockholm, Sweden. In addition, 61 individuals (26 men, 35 women) were recruited through announcements at a major Swedish university, and this sample consisted of undergraduate students. Thus, the nonclinical sample consisted of 105 individuals in total (44 men, 61 women).

Clinical samples. The first clinical sample included 51 adults (20 men, 31 women) diagnosed with ADHD. The second clinical sample included 46 individuals (13 men, 33 women) diagnosed with clinical disorders other than ADHD (primarily anxiety disorders and depression, see further details below). Participants in both groups were recruited from three outpatient psychiatric clinics in Stockholm, Sweden, using flyers distributed in the waiting room of the clinics. The participants in the ADHD group underwent a neuropsychiatric assessment conducted by a licensed psychologist. The assessment included a clinical judgment using the second version of the Diagnostic Interview for ADHD in Adults (DIVA 2.0; Kooij, 2013). This diagnostic interview has been shown to have a diagnostic accuracy of 100% when compared with the diagnoses obtained with the Conners' Adult ADHD Diagnostic Interview, and it has also been shown to correlate highly with several self-report scales assessing ADHD severity (e.g., Ramos-Quiroga et al., in press). The interview is freely available as a PDF on the website of the DIVA Foundation (www.DIVAcenter.eu). In addition to DIVA (which assesses both current and childhood symptoms of ADHD), current levels of ADHD symptoms were assessed using the Adult ADHD Self-Report Scale (ASRS-v1.1; Kessler et al., 2005). The psychologist also interviewed a close relative of the participant, in most cases the mother, to obtain a detailed anamnesis. All participants in the ADHD group met the full diagnostic criteria for ADHD combined subtype ($n = 38$) or inattentive subtype ($n = 13$) as specified in the *DSM–5* (American Psychiatric Association, 2013). Finally, all participants underwent testing of global intellectual ability using the fourth edition of Wechsler Adult Intelligence Scale (WAIS-IV; Wechsler, 2008a). Exclusion criteria were an IQ score of <80 on WAIS-IV and the presence of substance-related disorders. All participants in the ADHD group met at least the minimum symptom criteria for ADHD according to *DSM–5* (i.e., 5 symptom of either hyperactivity/impulsivity and/or inattention) based on both the DIVA 2.0 diagnostic interview and self-rating using the ASRS.

In addition to a primary ADHD diagnosis, some participants in the ADHD group also met the *DSM–IV* criteria for the following comorbid diagnoses: mood disorders including "major depression" (15.8%), bipolar disorder (5.3%), unspecified anxiety disorder (5.3%), panic disorder (3.5%), obsessive–compulsive disorder (1.7%), social phobia (1.7%), and personality disorders (5.3%). Five participants had more than one comorbid diagnosis. The diagnoses in the clinical control group were the following: mood disorders including "major depression" (43.4%), bipolar disorder (11.3%), anxiety disorder UNS (15.1%), social phobia (9.4%), panic disorder (1.8%), obsessive–compulsive disorder (5.7%), general anxiety disorder (5.7%), posttraumatic stress disorder (5.7%), eating disorders (1.8%), and personality disorders (11.3%). Fifteen participants had more than one diagnosis.

Procedure and Measures

Procedure. For the clinical sample, an information letter was sent by mail to individuals who had shown interest in participating in the study after reading the flyers distributed in the waiting rooms of the clinics. For the nonclinical sample, the flyers included a link to a website, where more information about the study was presented. Individuals who wanted to participate in the study were instructed to complete a questionnaire, which assessed ADHD symptom levels, delay-related behavior and functional impairments using the instruments described below (see heading "Questionniare data"), either through an Internet-based platform or completion of a paper-and-pencil version. Two males in the clinical sample, but none of the participants in the two controls groups, showed interest in participating in the study but failed to take part of the neuropsychological testing.

Two to 4 weeks later after completing the questionnaire, participants underwent a neuropsychiatric assessment. For the nonclinical sample, this also included completion of a laboratory measure of delay discounting and completing the QDQ a second time. Participants performed the tests at the clinic (clinical samples and random nonclinical sample) or at the university laboratory (nonclinical student sample). Altogether, the testing took approximately 1 hr. An experimenter was present in the room during the testing, and instructions were standardized and either read out loud to the participants or displayed on a computer screen. The neuropsychological tests were administered in a fixed order, with the QDQ always being administered before the delay discounting task. Exclusion criteria for the clinical group were an IQ score of <80 on WAIS-IV and the presence of any substance-related disorder. Exclusion criteria for the nonclinical group were the presence of any psychiatric disorders. As compensation for participating, the individuals in the two clinical groups received two movie tickets (value approx. 20 Euros), and those in the control group received 50 Euros. The local ethics committee approved the study.

Questionnaire data. The QDQ is a 10-item questionnaire, and all items are presented in the original publication (Clare et al., 2010). As mentioned in the introduction, the QDQ has been used in several previous studies, although the psychometric properties of the QDQ scores have not been thoroughly examined. The items included in the QDQ were originally selected from a larger number of items. The final set of items were selected based on the result of a factor analysis, the need to include both positive and negative items in the scale, and the need to minimize overlap of content (see Clare et al., 2010, for more detailed information). In the present study, all participants filled out the QDQ at the time of entering the study, and the nonclinical sample also completed the QDQ a second time as part of the neuropsychological assessment. Ratings were made on a 5-point Likert scale ranging from 1 ("*not like me at all*") to 5 ("*very like me*"). Because the original version of the QDQ is in English and the present study was conducted in Sweden, the questionnaire was translated and back-translated with the help of two bilingual researchers. It should be noted that translation could have a significant impact on a scale. However, because the items included in the QDQ are very clear, both translation and back-translation was completed without any problems.

In addition to the QDQ, participants' ADHD symptom levels (both nonclinical and clinical samples) were assessed using the Adult ADHD Self-Report Scale (ASRS; Kessler et al., 2005).

The scores used in the dimensional analyses were sums for the nine items measuring hyperactivity/impulsivity ($\alpha = .89$) and the nine items measuring inattention ($\alpha = .88$). Scores on the ASRS have been shown to have high test–retest reliability ($r = .88$), and high correlations have been found between ASRS scores and the DSM-oriented symptom scales included in the Conners Adult ADHD Rating Scales (rs $\geq .66$; Kim, Lee, & Joung, 2013). Finally, ASRS scores have been shown to discriminate well between adults with ADHD and controls, with a total classification accuracy of 96.2% (Kessler et al., 2005).

Functional impairment was addressed first of all using questions about educational attainment and unemployment (current and previous). In addition, the ADHD Daily Problem Questionnaire (ADPQ), which was designed within the present project, was used. The ADPQ is similar in design to Barkley's Functional Impairment Scale (BFIS; Barkley, 2011a), in that it 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*"). However, whereas the BFIS contains relatively broad items (e.g., problems "in your home life with your immediate family"), the ADPQ contains more specific items within four problem areas: (1) economic problems (2 items: "handling money in a responsible way" and "paying bills on time"), (2) daily chores/responsibilities (4 items: "cooking," "cleaning," "doing laundry," "grocery shopping"), (3) time management (4 items: "keeping appointments," "being on time for work/school," "getting up in time in the morning," "going to bed on time when having to get up early"), and (4) social relations (2 items: "socializing with friends" and "going to a party when I do not know the other guests well"). The reason for focusing on these four areas is that previous research has shown that the most serious impairments among individuals with ADHD are found in these areas (e.g., Barkley, Murphy, & Fischer, 2008). Finally, we assessed criminality. Ratings were made on a 5-point scale (0 = *never*, 1 = *1 time*, 2 = *2–3 times*, 3 = *4–10 times*, 5 = *more than 10 times*) and included the following areas: (1) violent criminal behavior (2 items: "physical abuse" and "hitting someone so severely that he/she needed professional medical help"), (2) nonviolent criminal behavior (4 items: "shoplifting," "pickpocketing," "eating and running," and "breaking and entering"), *3) driving-related problems (3 items: "driving under the influence," "driving without a license," and "exceeding the speed-limit by more than 30 kilometers/hour") and (4) police contact (1 item: "being arrested"). In the present study, we used the mean of all items as a measure of criminality.

Neuropsychological assessment. The measures of executive functioning used in the present study were selected from either the Delis Kaplan Executive System (D-KEFS; Delis, Kaplan, & Kramer, 2001a) or WAIS-IV (Wechsler, 2008a). These are two of the most well-known test batteries for examining executive functioning in adults. In addition, a delay-discounting task was included for participants in the nonclinical sample. Below a detailed description of all included measures is provided.

Delay discounting was measured using a delay-discounting task developed by Scheres, Tontsch, Thoeny, and Kaczkurkin (2010), using the Psytools software (Delosis, London). In this computerized task, participants were instructed to make repeated choices (40) between a small variable reward (values equivalent of approximately 2, 4, 6, or 8 cents in Swedish currency) that would be delivered after 0 s and a large constant reward (approximately 10 cents) that would be delivered after a variable delay (5, 10, 20, 30, or 60 s). For example, on some trials, participants had to choose between 6 cents now or 10 cents after waiting 20 s. Participants were not informed about the delay durations. Instead, they experienced each delay during task practice, giving them a sense of the delay duration associated with each level, without revealing the actual duration. After task completion, participants received the total amount of money won (maximum 40 SEK [approximately €4]). The measure used was the "area under the curve" (AUC; see Myerson, Green, & Warusawitharana, 2001; Scheres et al., 2006, for a detailed description of how to calculate this score). In general, a smaller AUC reflects a steeper discounting function (i.e., less willingness to wait as the delay duration increases). Split-half reliability, estimated using Spearman-Brown coefficient, was excellent (.985) for the scores from the delay-discounting task within the present study. With regard to validity, previous studies have shown that scores on delay-discounting tasks have high discriminative validity, as individuals with impulse-control problems—including ADHD—show increased preferences for immediate rewards compared with typically developing controls (see meta-analyses by Jackson & Mackillop, 2016 and Patros et al., 2016).

Verbal working memory was measured using two subtests from the WAIS-IV: Letter-Number Sequencing and Digit Span. In Letter-Number Sequencing, participants have to repeat a series of randomly mixed letters and numbers, starting with the numbers in ascending order, followed by the letters in alphabetical order. In Digit Span Backward, participants have to repeat the series in the backward order. In Digit Span Sequencing, the numbers are randomly presented and must be repeated in the correct number order. Digit Span Forward was not included, as this test primarily measures short-term memory (STM). According to the WAIS-IV technical manual (Wechsler, 2008b), the test–retest reliability for the scores from the Letter Number Sequencing and Digit Span Task is good (all rs $\geq .80$), and the construct validity high, because scores from these two measures of verbal working memory are highly correlated ($r = .69$).

Inhibition was measured using the third trial (i.e., interference trial) of the Color-Word Interference Test from the D-KEFS. In this part of the task, participants are presented with rows of words printed in incongruent colors and are instructed to inhibit reading the words and, instead, name the colors in which the words are printed. The number of seconds needed to complete the trial was used as a measure of inhibition. The test–retest reliability for the scores from the interference part of the Stroop task is reported to be adequate ($r = .75$) in the D-KEFS manual, and there are also other studies available showing high test–retest reliability ($r = .86$; Siegrist, 1997). Regarding construct validity, a significant correlation has been found between scores from this task and scores from for example the executive cluster from the Woodcock-Johnson III Tests of Cognitive Abilities ($r = .39$; Floyd et al., 2006). High discriminative validity when comparing individuals with ADHD and healthy controls has also been reported (see meta-analysis by Homack & Riccio, 2004).

Set shifting was measured by using the shifting trials from the Color-Word Interference Task from the D-KEFS. In this part of the task, participants are asked to switch back and forth between naming the discordant ink colors and reading the words. Comple-

tion time was used as a measure of set shifting. The test–retest reliability for scores from the switching trial has been shown to be moderate (r = .65; Delis, Kaplin, & Kramer, 2001b). Regarding construct validity, scores from this task have been shown to be significantly correlated with, for example, scores from the shifting trial from the Trailmaking subtest from D-KEFS (r = .41; Delis et al., 2001b).

Statistical Analyses

First, the reliability of the QDQ scores was investigated using measures of Cronbach's alpha to assess internal consistency. Test–retest reliability was investigated by studying correlations between Time 1 and Time 2 (separated by a 2- to 4-week interval). Second, convergent validity was investigated by studying correlations between scores from the QDQ and the delay-discounting task. Third, correlations between the QDQ scores and symptoms of ADHD were investigated within the nonclinical sample. To investigate whether the scores on the two QDQ subscales were specifically related to either one of the two ADHD symptom domains, partial correlation analyses were used to control for hyperactivity/impulsivity when studying relations to inattention and vice versa. Fourth, the ability of QDQ scores to discriminate between individuals with ADHD and either nonclinical or clinical controls was investigated. Here, we used analyses of variances (ANOVA), and these analyses were complemented with measures of effect sizes using η_p^2, where η_p^2 = .01 is considered to be a small effect, η_p^2 = .06 a medium effect, and η_p^2 = .14 a large effect (Cohen, 1988). Tukey Honest Significance Differences was used as the post hoc test to compare the ADHD group with either the clinical or nonclinical control group. Effect sizes for these post hoc tests were computed using Hedges g, which uses pooled SDs. In line with recommendations, g = .30 was considered to be a small effect, g = .50 a medium-sized effect, and g = .80 a large effect (Cohen, 1988). In addition, logistic regression analyses were used to obtain measures of sensitivity and specificity for scores on the QDQ. Here, we first of all conducted two regression analyses that only included scores on the QDQ, and thereafter two hierarchical regression analyses that included scores from a set of executive function measures in the first step and scores on the two QDQ subscales in the second step. This allowed us to examine whether adding QDQ scores would increase the sensitivity and/or specificity of belonging to the ADHD group above and beyond the influence of executive functioning deficits. Finally, correlation analyses were used to examine associations between QDQ scores and functional impairments. In line with Cohen (1988), r = .10 was considered a small effect, r = .30 and medium-sized effect, and r = .50 a large effect. Only the two clinical samples had data available for investigating relations to functional impairments, and only the nonclinical sample had data available for studying test–retest reliability and convergent validity. For the remaining analyses, both the two clinical samples and the nonclinical sample were included.

Results

Descriptive data and group differences with regard to demographic variables are presented in Table 1. No significant group differences were found for age or gender, but the groups differed significantly with regard to educational level. As expected, the clinical ADHD group had the lowest proportion of individuals with a university education and the nonclinical control group the highest. We therefore reran the analyses using educational level as a covariate, but this did not result in any changes in the results.

Reliability and Validity of the QDQ Scores

Internal consistency was found to be adequate for scores on the two QDQ subscales, α = .71 for delay aversion and α = .83 for delay discounting, when including all participants. Similar results were found when studying internal consistency separately for the clinical and nonclinical sample (αs ranging between .71–.81). With regard to test–retest reliability, correlations between QDQ scores collected 2–4 weeks apart were shown to be good for delay aversion, r = .78, $p < .001$, but less satisfactory for delay discounting, r = .65, $p < .001$.

Convergent validity of QDQ scores was examined by studying associations to the AUC measure from the laboratory task tapping into delay discounting. The results showed that scores on the two QDQ subscales were not significantly correlated with scores on the delay-discounting task, r = −.07 (delay aversion) and r = −.08 (delay discounting). When plotting the relation between the AUC measure and the scores on the two QDQ subscales, no indications of nonlinear relations (i.e., cubic or quadratic) were found. The mean AUC was .48 (SD = .27, range = .09–.83), which indicates that the data from the delay-discounting task for the nonclinical sample showed enough variance to be able to detect any associations that might be present.

Relations Between the QDQ Scores and ADHD Symptoms

With regard to the dimensional analyses (i.e., correlations between scores on the two QDQ subscales and ADHD symptom levels in the nonclinical samples), the results showed that scores on the two QDQ subscales were both strongly related to inattention (r = .50 for delay aversion and r = .36 for delay discounting, ps < .001) and hyperactivity/impulsivity (r = .61 for delay aversion and r = .35 for delay discounting, ps < .001). When controlling for the overlap between the two ADHD symptom domains, no significant relations were found for delay discounting (both rs < .19, ns). However, for delay aversion, a significant relation was found to hyperactivity/impulsivity, r = .42, $p < .001$, but not to inattention (r = .19, ns).

With regard to the categorical analyses, the results showed a significant main effect of group for both delay aversion and delay discounting (Table 1). The effect sizes for the overall comparison were large (both $\eta_p^2 > .20$). Post hoc analyses revealed that participants in both the ADHD group and the clinical control group rated themselves significantly higher with regard to both delay aversion and delay discounting compared with participants in the nonclinical control group. Effect sizes when comparing the ADHD group with the nonclinical control group were large for both delay aversion (g = 1.11) and delay discounting (g = 1.26). Compared with the clinical control group, participants in the ADHD group had significantly higher scores on delay aversion, but not on delay discounting. Effect sizes were medium for delay aversion (g = .68) and small for delay discounting (g = .32).

In the next step, we used a logistic regression analysis to determine how well QDQ scores could discriminate between adults with ADHD and adults without any psychiatric disorder (Model 1). Measures of sensitivity, specificity and the total proportion of participants classified into the correct category are presented in Table 2. Model 1 was shown to be significant, $\chi^2 = (2, n = 156) = 55.69$ $p < .001$, with a sensitivity of 56.9 and a specificity of 91.4. In total, Model 1 could classify 80.1% of the participants into the correct category. Next, adults with ADHD were compared with adults with other psychiatric disorders (Model 2). Model 2 was also shown to be significant, $\chi^2 = (2, n = 97) = 10.83$, $p < .01$, with a sensitivity of 70.6 and a specificity of 54.3. In total, Model 2 could classify 62.9% of the participants into the correct category.

In addition to examining how well QDQ scores could discriminate between adults with ADHD and either nonclinical or clinical controls, we also wished to examine to what extent QDQ scores could increase the classification rate above and beyond the influence of executive functioning tests. These analyses would also allow us to compare the discriminative validity of the QDQ scores (presented in Model 1 and 2) with scores from a battery of laboratory tests of executive functioning (Step 1 in Model 3 and 4). The results (Table 2) showed that when trying to discriminate between adults with ADHD and nonclinical controls (Model 3), Step 1 of the model was significant, $\chi^2 = (4, n = 150) = 52.14$, $p < .001$, with a sensitivity of 57.8, a specificity of 91.4, and a total classification rate of 81.3%. When adding the scores from the two QDQ subscales, Step 2 was significant, $\chi^2 = (2, n = 150) = 36.47$, $p < .001$, and the sensitivity (68.9), the specificity (93.3), and the total classification rate (86.0) were increased. The influence of both the delay aversion (Wald = 12.69, $p < .001$) and delay-discounting subscales (Wald = 3.93, $p < .05$) were significant. Finally, Model 4 tested whether QDQ scores could increase the classification rate also when comparing adults with ADHD to adults from a clinical sample. The results showed that Step 1 of the model was significant, $\chi^2 = (4, n = 89) = 20.38$, $p < .001$, with a sensitivity of 62.2, a specificity of 77.3, and a total classification rate of 69.7%. When adding the QDQ subscales in Step 2, this step was also significant, $\chi^2 = (2, n = 89) = 13.76$, $p < .001$. The sensitivity for Model 4 was 73.3, the specificity was 75.0 and the total classification rate was 74.2. The influence of scores on the delay aversion subscale was significant (Wald = 10.70, $p < .001$), but not the influence of scores on the delay-discounting subscale (Wald = 0.14, *ns*).

Relations Between QDQ Scores and Daily Life Functioning

Our last research question concerned to what extent scores on the two QDQ subscales are significantly related to functional impairments among individuals in the two clinical groups. As can be seen in Table 3, QDQ scores on both subscales were significantly related to criminality and problems with money management and daily chores/responsibilities. In addition, scores on the delay aversion subscale were significantly related to problems with daily chores/responsibilities, and scores on the delay-discounting subscale were significantly related to both substance use and problems with time management. However, no significant associations were found to educational level. The direction of all significant effects was as expected, with higher levels of delay-related behavior being related to higher levels of functional impairment. When using the Bonferroni-Holm correction for multiple comparisons, delay aversion was only significantly related to criminality, whereas delay discounting was significantly related to criminality, substance abuse, as well as to money management problems. The sizes of the effects surviving control for multiple comparisons were all in the medium range. When controlling for ADHD symptom levels, delay discounting was significantly related to money management and criminality, but none of the other associations remained significant.

Discussion

Recent models of heterogeneity have emphasized the need to not only regard ADHD as an executive disorder, but as a disorder related to multiple neuropsychological deficits (e.g., Nigg et al., 2005). Delay-related behaviors have repeatedly been linked to ADHD in children, but few studies focusing on delay-related behaviors have been conducted on adult ADHD samples. One major reason for this is probably the lack of ratings with good psychometric properties for assessing constructs such as delay aversion and delay discounting in adults. The present study, which aimed at investigating the psychometric properties and clinical utility of QDQ scores, therefore provides highly useful information

Table 2
Results of the Logistic Regression Analyses

Variable	Sensitivity	Specificity	Total correctly classified
Model 1: ADHD vs. nonclinical controls			
Step 1. Only QDQ	56.9%	91.4%	80.1%
Model 2: ADHD vs. clinical controls			
Step 1. Only QDQ	70.6%	54.3%	62.9%
Model 3: ADHD vs. nonclinical controls			
Step 1. Only executive function tasks	57.8%	91.4%	81.3%
Step 2. Executive function tasks + QDQ	68.9%	93.3%	86.0%
Model 4: ADHD vs. clinical controls			
Step 1. Only executive function tasks	62.2%	77.3%	69.7%
Step 2. Executive function tasks + QDQ	73.3%	75.0%	74.2%

Note. ADHD = attention-deficit/hyperactivity disorder; QDQ = Quick Delay Questionnaire.

Table 3
Correlations Between the Quick Delay Questionnaire (QDQ) and Functional Impairments Among Participants in the Two Clinical Groups (n = 95)

Variable	Delay aversion	Delay discounting
Educational level	.03	.12
Substance abuse	.20	**.31****
Criminality	**.29****	**.29****
ADHD Daily Problem Questionnaire		
Money management	.23*	**.41*****
Time management	.12	.21*
Social relations	.09	.11
Daily chores/responsibilities	.24*	.18

Note. ADHD = attention-deficit/hyperactivity disorder. Bold font denotes relations that remained significant after Bonferroni-Holm correction. For all variables, high values indicate poor functioning.
* $p < .05$. ** $p < .01$. *** $p < .001$.

from both a theoretical and clinical point of view. The results showed that the scores for the QDQ had good test–retest reliability with regard to the delay-discounting subscale, but less satisfactory reliability for scores on the delay aversion subscale. Scores from the two QDQ subscales (i.e., delay aversion and delay discounting) were not significantly related to a laboratory measure of delay discounting. Adults with ADHD were shown to have higher scores on both QDQ subscales compared with normal controls. They were also shown to have higher levels of delay aversion, but not delay discounting, than adults with other psychiatric disorders. When trying to discriminate between adults with ADHD and nonclinical controls, the sensitivity and specificity of scores from the QDQ and the laboratory measures of executive functioning were similar, with very high specificity (> .90), but relatively low sensitivity (< .60). Finally, the results showed that scores on the QDQ correlated highly with some important areas of daily functioning, of which relations to criminality and problems with money management remained significant after controlling for ADHD symptom severity in the clinical sample.

Reliability of the QDQ Scores

Generally, .70 or above is considered adequate test–retest reliability. In the present study, the reliability for scores on the delay-discounting subscale was above this cut-off ($r = .78$), whereas the reliability for scores on the delay aversion subscale was somewhat below it ($r = .65$). Low reliability has also been found for other ratings designed to measure neuropsychological functions, such as the self-motivation subscale ($r = .61$) included in the Barkley Deficits in Executive Functioning Scale (BDEFS; Barkley, 2011b). However, of more importance is the fact that our finding is not in line with what Clare and colleagues (2010) found when they introduced the QDQ, because they reported a test–retest reliability of about .80 for scores from both subscales. In future studies and in clinical practice, it would be of value to adapt the QDQ for use by a close relative/friend to assess the consistency between different raters, and thereby get a better estimate of delay-related behaviors in the patient.

Relations Between Scores on the QDQ and the Delay-Discounting Task

We only found weak, nonsignificant, associations between QDQ scores and scores from a laboratory measure of delay discounting. To our knowledge, only one previous study (Mies et al., 2016) has studied this relation. This study did find significant relations to the two QDQ subscales, but the size of the effect was very small. When discussing this finding, it should be of value to draw a parallel to studies comparing laboratory measures and self-ratings of executive functioning. As shown in a review by Toplak, West, and Stanovich (2013), only 24% of the studies reported a statistically significant relation between tests and ratings of executive functioning, and the overall median correlation was only .19. The authors argue that one important distinction between laboratory measures and self-ratings—and this applies both to executive functions and delay-related behaviors—is that participants are estimating the frequency and typicality of how well they perform in day-to-day situations when they complete self-ratings, whereas neuropsychological measures are instead assessing optimal/maximum performance in a well-structured test situation at one point in time. Another difference that perhaps could explain the weak association between scores on the QDQ and scores on the delay-discounting task is that we used a laboratory task in which all delays were experienced and all rewards were paid. It is likely that there is a discrepancy between how people *think* they behave, as measured with the QDQ, and how they actually behave, as measured with a delay-discounting laboratory measure (cf. Scheres et al., 2008). As already mentioned in the introduction, another apparent difference between the QDQ and the temporal discounting task is that the test only includes the choice to wait or not to wait, whereas the QDQ includes both items related to choices (e.g., "I often give up on things that I cannot have immediately") and items measuring the subjective feeling of waiting (e.g., "Having to wait for things makes me stressed and tense"). Finally, it is also possible that the delays in the task we used were too short to measure delay discounting in a similar way as was done with the QDQ (i.e., the delays were a maximum of 60 s, which is usually not comparable to delays people encounter in real life). In line with such an interpretation, Scheres and colleagues (2010) showed that choices in a hypothetical delay-discounting task with long delays and large rewards did not correlate with choices in real and hypothetical tasks with short delays and small rewards. Thus, not even all delay-discounting tasks appear to measure exactly the same construct, and this might explain why Mies and colleagues (2016) did find a relation between scores on the QDQ and scores on a delay-discounting task with hypothetical rewards, whereas QDQ scores were not significantly related to scores on the task with real choices used in the present study.

In summary, scores on the QDQ and scores on the delay-discounting task showed little overlap, and it is difficult to determine what conclusions can be drawn from this finding. One interpretation is that the delay-discounting task should be regarded as the "gold standard" for measuring delay-related behaviors and that the weak association between scores on this task and scores on the QDQ should be taken as support for poor validity of the QDQ. On the other hand, when discussing measures of executive functioning, it has been argued that the scores obtained from ratings

have higher ecological validity compared with those obtained from laboratory tasks (e.g., Barkley & Fischer, 2011). In our opinion, ratings and laboratory tasks appear to measure different aspects of delay-related behaviors, and both have limitations and strengths, albeit different ones. Thus, it will be important for future research to conduct further examination of the overlap between different delay-related measures to determine how to best capture the multifaceted nature of this construct.

Associations Between QDQ Scores and ADHD

Regarding the dimensional analyses, scores from the two QDQ subscales were shown to be associated with both symptoms of hyperactivity/impulsivity and symptoms of inattention. However, when controlling for the overlap between the two ADHD symptom domains, our results indicated that delay aversion, but not delay discounting, was primarily related to hyperactivity/impulsivity rather than inattention. These findings are in line with theoretical propositions claiming that "cold" executive functions such as working memory and inhibitory control are primarily related to inattention, whereas "hot" executive functions such as delay aversion and gambling are primarily related to symptoms of hyperactivity/impulsivity (e.g., Castellanos et al., 2006). Some empirical support for this notion has also been found in studies of children (Thorell, 2007), but to our knowledge, the present study is the first study finding support for a specific link between delay aversion and hyperactivity/impulsivity among adults.

With regard to discriminative validity, our results showed that the scores from the QDQ had high specificity, but relatively low sensitivity when trying to discriminate between adults with ADHD and nonclinical controls. Thus, scores on the QDQ show a good ability to correctly classify the controls (i.e., few controls have high levels of delay-related behaviors), but a poor ability to correctly classify individuals with ADHD (i.e., only a subgroup of individuals with ADHD have high levels of delay-related behaviors). Because the present study is the first to examine the discriminative validity of scores on the QDQ, a comparison with previous findings is not possible. However, our finding of high specificity and low sensitivity is similar to several previous studies examining executive functioning in ADHD samples (e.g., Berlin, Bohlin, Nyberg, & Janols, 2004; Doyle, Biederman, Seidman, Weber, & Faraone, 2000; Lovejoy et al., 1999). In addition, these findings are in line with current theoretical models in which it is argued that ADHD is a neuropsychologically heterogeneous disorder, with only some individuals displaying high levels of delay-related behaviors, either alone or in combination with other neuropsychological deficits such as poor executive functioning (e.g., Castellanos et al., 2006; Nigg et al., 2005; Sonuga-Barke & Fairchild, 2012). Based on current models of heterogeneity, we therefore also aimed to investigate to what extent QDQ scores could increase the prediction rate, above and beyond the influence of executive functioning deficits. The results showed that especially sensitivity increased when scores from both the laboratory measures of executive functioning and the QDQ were entered into the model. Thus, a larger number of adults with ADHD were correctly classified when QDQ scores were also included in the assessment. This is exactly what should be expected based on the dual-pathway model, which suggests independent pathways of delay-related behavior and executive functioning in relation to ADHD (Sonuga-Barke, 2002, 2003).

Unlike most previous studies investigating the discriminative validity of different neuropsychological measures, we did not only compare adults with ADHD with nonclinical controls, but also with clinical controls diagnosed with other psychiatric disorders. The results showed that when studying the first step of Model 3 and 4 (i.e., models including only executive functioning measures), the total classification rates were very similar to those found when only including QDQ scores (i.e., Model 1 and 2). Thus, scores from the QDQ is about equally good at discriminating between the two clinical groups as scores from laboratory measures of executive functioning are. With regard to sensitivity versus specificity, the results showed that sensitivity was slightly higher when including only scores from the laboratory measures of executive functioning, whereas specificity was slightly higher when only including QDQ scores.

The low specificity of the QDQ scores when comparing adults with ADHD and clinical controls means that individuals with a diagnosis other than ADHD are quite likely to be incorrectly assigned to the ADHD group on the basis of QDQ scores (i.e., false positives). Comparing different clinical groups should be considered important. However, our findings are not unexpected, considering the fact that most participants in this group suffered from affective disorders, the majority from depression, and that previous research has shown that patients with depression, or individuals with increased levels of depressive symptoms, show steeper delay discounting of rewards (Mies et al., 2016; Pulcu et al., 2014; Takahashi et al., 2008, but see Lempert & Pizzagalli, 2010). This has been attributed to, for example, hyposensitivity to reward, pessimism about the future, but also to delays possibly being perceived as longer than they actually are (e.g., Pulcu et al., 2014), which might explain why the clinical control group scored higher on both subscales of the QDQ compared with nonclinical controls.

Associations Between QDQ Scores and Functional Impairments

When introducing the QDQ, Clare and colleagues (2010) stated that this instrument was intended to capture delay-related activities and situations of relevance to everyday adult life. However, the present study is the first to truly examine the link between scores from the QDQ subscales and measures of daily functioning. Our results showed that the QDQ scores correlated highly with criminality, substance use, as well as with daily functioning, such as time and money management. It is interesting to note that relations to criminality and problems with money management remained significant when controlling for ADHD symptom severity in the clinical sample. Thus, scores on the QDQ are able to capture important associations to functional impairments that are not explained by ADHD symptom severity. Several previous studies investigating nonclinical samples of adults have found relations between delay-discounting tasks and criminality and addictive behavior (e.g., Arantes, Berg, Lawlor, & Grace, 2013; MacKillop et al., 2011). However, to our knowledge this association has not been studied previously in a clinical ADHD sample, and our findings therefore provide important new information by showing that a subgroup of clinically referred adults with high delay-related

behavior appear to be at particularly high risk for criminality and problems with money management, above and beyond the influence of ADHD symptom severity. With regard to our failure to find a relation between QDQ scores and academic achievement, this finding is in line with previous studies of children in which executive functioning deficits, but not delay aversion, were shown to mediate the link between ADHD symptoms and academic achievement (e.g., Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Thorell, 2007). Thus, QDQ scores are associated with functional impairments, and some of these associations remain after controlling for ADHD symptoms.

Limitations, Future Directions, and Conclusions

One limitation of the present study was that data from the delay-discounting task were only available for the nonclinical sample. However, no clear ceiling effects were found, which means that it should have been possible to detect a relation between QDQ scores and scores on the laboratory task if such a relation had existed. Despite this, it would be valuable for future studies to investigate the relation between QDQ scores and scores on the delay-discounting tasks also in a clinical ADHD sample and thereby gain further information about the associations between ratings and task of delay-related behaviors. In addition, we have already noted that it would be of value to also include a task with hypothetical rewards and to adapt the QDQ to allow relatives or a close friend of the patient to make the ratings. Future studies should also include longitudinal investigations to examine to what extent scores on the QDQ can predict functional impairments over time. Before doing a longitudinal follow-up, the psychometric properties of the scores obtained from our measures used to access functional impairments (e.g., the ADPQ), need to be investigated. Finally, it would also be of value to include a clinical control group with nonaffective disorders, such as antisocial behavior or substance use.

In conclusion, it is interesting to note that scores on the QDQ can help to differentiate between ADHD and controls, above and beyond deficits in executive functioning. However, it should also be noted that when examining the discriminative validity of the QDQ scores, sensitivity was relatively low, suggesting that a substantial number of individuals with ADHD do not show high levels of delay aversion or delay discounting. This is in line with current models of heterogeneity in which ADHD is seen as a disorder related to multiple neuropsychological deficits. Given this heterogeneity, it has been suggested that neuropsychological measures should not primarily be used to differentiate between patients and controls, but rather to identify more homogeneous subgroups of individuals with ADHD, which may show differential susceptibility to functional impairments (Coghill, 2014). Our finding that scores on the QDQ are significantly related to important functional impairments associated with ADHD (i.e., primarily criminality, substance abuse, and economic management) is in line with this suggestion. This could be considered to indicate that the QDQ should be viewed as a valuable clinical instrument for identifying a subgroup of ADHD patients with high levels of delay-related behaviors. This subgroup might be at particularly high risk of certain functional impairments. However, it should also be noted that further research is needed within this area. This is especially important with regard to the association between scores on the QDQ and scores on laboratory tests of delay-related behaviors, as well as longitudinal studies investigating to what extent QDQ scores can predict functional impairment across time.

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