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The relationship between motor skills, social problems, and ADHD symptomatology: Does it vary according to parent and teacher report?

Journal:	<i>Journal of Attention Disorders</i>
Manuscript ID:	JAD-14-12-305.R1
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Keywords:	ADHD, Social Skills, Motor Performance
Abstract:	<p>Objective: This study investigated the relationship between motor performance, attentional, hyperactive and impulsive symptoms, and social problems. Correlations between parents' versus teachers' ratings of social problems and ADHD symptomatology were also examined. Method: A total of 129 children aged 9 to 12 years were included. ADHD symptoms and social problems were identified based on Conners' Rating Scales-Revised: L, and the McCarron Assessment of Neuromuscular Development was used to assess motor skills. Results: After controlling for ADHD symptomatology, motor skills remained a significant predictor of social problems in the teacher model but not in the parent model. After controlling for motor skills, inattentive (not hyperactive-impulsive) symptoms were a significant predictor of social problems in the parent model, whereas, hyperactive-impulsive (not inattentive) symptoms were a significant predictor of social problems in the teacher model. Conclusion: The findings suggested that intervention strategies should consider the interaction between symptoms and environmental contexts.</p>

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Running head: MOTOR SKILLS, SOCIAL PROBLEMS AND ADHD SYMPTOMS

Abstract

Objective: This study investigated the relationship between motor performance, attentional, hyperactive and impulsive symptoms, and social problems. Correlations between parents' versus teachers' ratings of social problems and ADHD symptomatology were also examined.

Method: A total of 129 children aged 9 to 12 years were included. ADHD symptoms and social problems were identified based on Conners' Rating Scales-Revised: L, and the McCarron Assessment of Neuromuscular Development was used to assess motor skills.

Results: After controlling for ADHD symptomatology, motor skills remained a significant predictor of social problems in the teacher model but not in the parent model. After controlling for motor skills, inattentive (not hyperactive-impulsive) symptoms were a significant predictor of social problems in the parent model, whereas, hyperactive-impulsive (not inattentive) symptoms were a significant predictor of social problems in the teacher model. Conclusion: The findings suggested that intervention strategies should consider the interaction between symptoms and environmental contexts.

Key-words: ADHD, social skills, motor performance

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3 The relationship between motor skills, social problems, and ADHD symptomatology: Does it
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5 vary according to parent and teacher report?
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10 Introduction

11 During childhood, movement experiences are crucial for providing learning
12 opportunities and promoting the development of important daily skills, such as using cutlery,
13 drawing, and playing games. The recognition of the importance of motor competence for
14 social and emotional development is now also increasing given the numerous studies
15 showing a significant link between these domains (Cummins, Piek, & Dyck, 2005; Piek,
16 Bradbury, & Elsley, 2008; Rigoli, Piek, & Kane, 2012; Skinner & Piek, 2001). Furthermore,
17 psychosocial problems are hypothesized to be secondary consequences to motor problems
18 (Cairney, Rigoli, & Piek, 2013) and tend to appear once a child is challenged by social and
19 peer demands in the school years (Piek et al., 2008). This is partly supported by longitudinal
20 studies showing that motor skill difficulties earlier in childhood are related to later
21 psychosocial problems (Lingam et al., 2012; Losse et al., 1991).
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36 The relationship between the motor and psychosocial domains may be partly
37 explained by the fact that in many countries, the ability to perform well in sports and games is
38 highly valued (e.g., Vannatta, Gartstein, Zeller, & Noll, 2009). Participation in such
39 activities also promotes the development of supportive interpersonal relationships and social
40 ties in children (McHale, Crouter, & Tucker, 2001). This creates a problem for those who
41 experience difficulties with movement skills. Research has shown that children with motor
42 problems are less likely to participate in organized (e.g., sport teams) and unorganized (free
43 play) activities (Cairney et al., 2005). Other studies have revealed greater self-reported
44 loneliness in boys with motor problems compared to their coordinated peers, furthermore,
45 team sports participation was found to significantly mediate the inverse relationship between
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3 loneliness and physical coordination (Poulsen, Ziviani, Cuskelly, & Smith, 2007). Skinner
4 and Piek (2001) highlighted how children with motor difficulties often try to avoid
5 participation in such activities for fear of failure and/or peer criticism. By avoiding
6 participation, children then limit their opportunity to practice skills and to participate in a
7 social environment, thereby creating a vicious circle.
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14 Studies investigating the relationship between motor difficulties and the social domain
15 have revealed that children with movement problems have self-reported fewer playmates and
16 are asked to play with other children less often (Boyer, Geurts, & Van der Oord, 2014). They
17 also spend more time alone or watching other children play without participating themselves
18 (Smyth & Anderson, 2000). Livesey, Lum Mow, Toshack, and Zheng (2011) found that these
19 children receive lower scores on a measure of peer preferences in play settings when rated by
20 their peers. According to teacher-report, they also experience greater peer exclusion (e.g.,
21 more likely to be ignored and ridiculed by peers) (Livesey et al., 2011). Problems in the
22 social domain for children with motor difficulties have also been reported by parents
23 (Cummins et al., 2005). Other research has also found a relationship between peer-
24 victimization and movement problems in children (Campbell, Missiuna, & Vaillancourt,
25 2012; Losse et al., 1991). Furthermore, it appears that children with motor problems are
26 aware of these difficulties as they have reported lower levels of perceived social acceptance
27 and support (e.g., Boyer et al., 2014; Skinner & Piek, 2001). Most of these studies have been
28 carried out with primary school aged children (i.e., 6-12 years old), however, it has also been
29 suggested that the relative importance of social support and acceptance may increase from
30 childhood to adolescence (Skinner & Piek, 2001). For example, Skinner and Piek (2001)
31 found a significant difference in perceived social acceptance between adolescents with and
32 without motor coordination difficulties, but not for younger children. Accumulating evidence
33 for an important link between the motor and social domains is concerning given that social
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3 support may act as an important buffer, protecting against possible internalizing problems for
4 children with motor difficulties (Cairney et al., 2013). Furthermore, in addition to
5 interpersonal difficulties, children with motor difficulties have an increased risk of social
6 difficulties, including nonverbal facial emotion cues (Cummins et al., 2005). Importantly, in a
7 recent paper, social skills were found to mediate the relationship between motor skills and
8 internalizing problems in young pre-primary children (Wilson, Piek, & Kane, 2013).
9 Therefore, further research examining the relationship between these areas is needed,
10 particularly as social competence may mediate the relationship between motor and
11 internalizing problems.
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23 Although accumulating evidence now suggests that motor problems are significantly
24 related to social difficulties, many previous studies have not accounted for the role of
25 attention deficit hyperactivity disorder (ADHD) symptomatology in this relationship
26 (Pettersson et al., 2014; Skinner & Piek, 2001). This is important given the strong overlap
27 between motor difficulties and ADHD, which has been recognized for decades and estimated
28 to be around 50% (Fliers et al., 2008; Pitcher, Piek, & Hay, 2003). Additionally, there are
29 numerous studies linking ADHD symptoms with problems in social functioning (Frederick &
30 Olmi, 1994; Marques et al., 2013; Nijmeijer et al., 2008; Schlack, Mauz, Hebebrand, &
31 Holling, 2014; Wehmeier, Schacht, & Barkley, 2010). In fact, some of the behaviors that are
32 related to the social problems evident in children with ADHD are listed in the DSM-5 ADHD
33 criteria, for example, “often interrupts or intrudes on others” (i.e., impulsivity), “often talks
34 excessively” (hyperactivity), “often does not seem to listen when spoken to directly” (i.e.,
35 inattention) (American Psychiatric Association, 2013). It is widely acknowledged that
36 children with ADHD symptoms are at increased risk for peer relationship difficulties, such as
37 peer rejection, compared to typically developing children without these symptoms (Tseng,
38 Henderson, Chow, & Yao, 2004). Hoza et al. (2005) found that children with ADHD scored
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3 lower on social preference, higher on social impact, were less well-liked, and had fewer
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5 dyadic friendships. It has also been suggested that ADHD symptomatology may have
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7 differential impacts on social outcomes (Tseng et al., 2004), for example, social dysfunction
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9 seen in those individuals with hyperactive/impulsive symptoms may be characterized by
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11 disruptive and aggressive behaviors, ultimately leading to interpersonal difficulties such as
12
13 peer rejection. Conversely, social difficulties in inattentive children may be characterized by
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15 more passive behaviors, including shyness, anxiety, and withdrawal (Schlack et al., 2014).
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17 Children with attention difficulties may also be less likely to attend to social cues and implicit
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19 rules for social interactions (Bierman, Smoot, & Aumiller, 1993).
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23 Although ADHD symptomatology may predispose children to social problems, it is
24
25 not clear whether social dysfunction is inherent to ADHD or is mediated by the existence of
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27 co-occurring difficulties, such as motor problems. Limited research has taken this into
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29 account, however, some studies have shown that ADHD with motor problems is linked to
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31 greater social problems when compared to ADHD-only, according to both parent and teacher
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33 observations (e.g., Tervo, Azuma, Fogas, & Fiechtner, 2002). A recent study investigated the
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35 relationship between motor coordination and social problems in individuals with ADHD and
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37 found a significant inverse relationship between these areas. Specifically, better motor
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39 performance was related to fewer social problems, as rated by parents (Ayaz, Ayaz, Yazgan,
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41 & Akin, 2013). Further research is needed, particularly since social competence has been
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43 highlighted as a significant predictor for optimal developmental outcomes in both the short
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45 term and the long term (Alonso Bde et al., 2014). For example, childhood peer rejection has
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47 been shown to be one of the strongest predictors of current and future adjustment problems
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49 (Bagwell, Newcomb, & Bukowski, 1998). Furthermore, numerous studies have demonstrated
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51 an important relationship between early peer difficulties and later maladaptive outcomes,
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3 such as anxiety, depression, delinquency, dropping out of school, and substance abuse
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5 (Pedersen, Vitaro, Barker, & Borge, 2007).
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8 The current study examined whether motor performance predicts social competence
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10 in children aged nine to 12 years, after accounting for ADHD symptomatology. Furthermore,
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12 the predictive relationship between ADHD symptomatology and social problems, after
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14 controlling for motor skills, is also examined. In addition, given the persistent deficits in
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16 social communication and social interaction associated with autism spectrum disorder (ASD)
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18 (American Psychiatric Association, 2013), and the strong association ASD has with ADHD,
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20 and motor problems (Gustafsson et al., 2014), the current study did not include any children
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22 with a previous diagnosis of ASD.
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25 Importantly, the study uses both parent and teacher-report for social problems and
26
27 ADHD symptomatology. Achenbach, McConaughy, and Howell (1987), in their meta-
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29 analysis of 119 studies, highlighted the impact of informant discrepancies (e.g., parents,
30
31 children, teachers) when rating social, emotional, or behavior problems in children, a finding
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33 now replicated by many studies. For example, Wolraich et al. (2004) found a low agreement
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35 between the parent and teacher reports of ADHD symptoms (inattention,
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37 hyperactivity/impulsivity and performance impairment) according to DSM-IV–based
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39 questionnaires. Other research has revealed non-significant cross-informant consistency
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41 between parent and teacher ratings of social competence (Fagan & Fantuzzo, 1999). In their
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43 study, Antrop, Roeyers, Oosterlaan, and Oost (2002) found a non-significant association
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45 between parent and teacher ratings of inattention and hyperactivity/impulsivity symptoms. It
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47 has been suggested that disagreement in parent and teacher ratings may be due to the
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49 different environments in which behavior is observed (Martin, Scourfield, & McGuffin,
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51 2002). For example, parents may report higher rates of problem behaviors due to the lack of
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53 structure in the home environment compared to the highly structured school environment.
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3 Parent-teacher discrepancies may also be due to bias via contrast effects as parents may see
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5 contrast between their own children's behaviours rather than having a variety of children to
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7 compare them to (Hartman, Rhee, Willcutt, & Pennington, 2007).
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10 For the current study, it is hypothesized that better motor performance will predict
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12 fewer social problems, after controlling for ADHD symptomatology. It is also hypothesized
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14 that motor performance will predict social competence for both parent and teacher models.
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16 Secondly, it is also hypothesized that ADHD symptomatology will predict social problems,
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18 after taking motor skills into account, for both parent and teacher models. Finally, modest
19
20 correlations between parent versus teacher ratings of social problems and ADHD symptoms
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22 are expected. This study examined the social problems item loadings across informants, with
23
24 a focus on individual item content, which may increase the understanding of the relationship
25
26 between ADHD symptoms and motor impairment.
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29 30 **Method**

31 32 **Participants and Procedures**

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34 A total of 129 children, 91 boys and 38 girls, aged 9 to 12 years ($M = 11.2$ $SD = 0.8$),
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36 participated in this study. Participants were recruited through schools, public advertisement
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38 via the Learning and Attentional Disorder Society (LADS), community newspapers in
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40 metropolitan Perth, and community radio. Thirty-three schools from the Perth metropolitan
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42 area participated in this study and information letters and parent consent forms were
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44 distributed to all students within the age-range for this study. Following consent, a
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46 demographic/health screening questionnaire and a reply-paid envelope were sent to parents.
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48 Subsequently, the MAND was individually administered to children at school and parents
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50 and teachers were provided the CRS-R:L forms to complete. Those participants recruited via
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52 advertisement were mailed out the information letter and consent forms, CRS-R: L forms, a
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3 demographic/health screening questionnaire and a reply-paid envelope. These children were
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5 then administered the MAND individually in a quiet room at the University.
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8 All children had normal to corrected vision, normal hearing, no neurological disorder,
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10 and absence of physical disability. There was minimal evidence of birth complications in this
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12 sample and no pre- or existing neurological or severe behavioral disorders (i.e. autism,
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14 intellectual developmental disorder, etc.). This information was obtained from the parents'
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16 reports on the screening questionnaire.
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19 Ethics approval was obtained from the University Human Research Ethics Committee
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21 and the ethical guidelines outlined by the National Health and Medical Research Council of
22
23 Australia were followed.
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25 Measures

26
27 **Conners' Rating Scales-Revised: L (CRS-R:L).** The CRS-R:L (Conners, 1997),
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29 suitable for children aged three to 17, provides an assessment of impairment across a range of
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31 behavioral problems that is consistent with the DSM-IV criteria (Conners, 1997). The Parent
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33 (Conners' Parental Rating Scale-Revised: L; CPRS-R: L) and Teacher (Conners' Teacher
34
35 Rating Scale-Revised: L; CTRS-R: L) versions of the long forms of CRS-R were used for
36
37 this study. The CPRS-R:L (Conners, 1997) is an 80 items scale that produces T-scores for the
38
39 14 subscales of cognitive problems/inattention, oppositional behavior, hyperactivity, anxiety
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41 and shyness, perfectionism, social problems, psychosomatic behavior, Connors Global Index
42
43 (comprising Restless-Impulsive and Emotional Lability), ADHD Index, and DSM-IV
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45 Symptoms subscales (comprising DSM-IV Inattentive and DSM-IV Hyperactive-Impulsive).
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47 The CTRS-R:L (Conners, 1997) is a 59 items scale that produces T-scores for the same
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49 subscales as the CPRS-R:L except for psychosomatic behaviour. The parent and teacher-
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51 rated Social Problems, and DSM-IV Inattentive and Hyperactive-Impulsive T-scores were
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56 used for the current study. These subscales demonstrate good internal reliability, with total
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3 reliability coefficients by gender ranging from .826 to .865 and .876 to .934 for the CPRS-
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5 R:L Social Problems and DSM Inattentive and Hyperactive-Impulsive subscales respectively
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7 (Conners, 1997). Total reliability coefficients range from .87 to .87 and .89 and .94 for the
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9 CTRS-R:L Social Problems and DSM Inattentive and Hyperactive-Impulsive subscales
10
11 respectively (Conners, 1997).
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14 **McCarron Assessment of Neuromuscular Development (MAND).** The MAND
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16 (Tarver, Daley, & Sayal, 2014) is an individually administered, norm-referenced assessment
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18 tool comprising five fine motor tasks (putting beads in a box, putting beads on a rod, finger
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20 tapping, putting a nut on a bolt, and sliding a rod) and five gross motor tasks (touching the
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22 nose and the finger of opposite extended arm, standing broad jumping, heel to toe walking,
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24 standing on one foot, and grip strength). The sum of the ten scaled scores is converted to the
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26 Neuromuscular Developmental Index (NDI; Mean = 100, SD = 15), representing a measure
27
28 of overall motor skills. An NDI score of 71 to 85 represents a mild disability; 55 to 70 a
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30 moderate disability; and below 55 a severe disability. Test-retest reliabilities after a month
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32 interval over the 10 tasks range from .67 to .98 (Tarver et al., 2014). The MAND also
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34 demonstrates good concurrent validity (Brantner, Piek, & Smith, 2009; Dyck, Piek, Kane, &
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36 Patrick, 2009).
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40 **Data Analysis**

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43 Separate Generalized Linear Mixed Models (GLMMs) were tested for parent and
44
45 teacher ratings. For each model, the dependent variable (DV) was social problems and the
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47 predictors were motor skills, inattentive symptoms, and hyperactivity/impulsive symptoms.
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49 Social problems, inattentive symptoms, and hyperactivity/impulsive symptoms were analyzed
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51 as T-scores. The GLMMs were implemented through SPSS's (Version 22) GENLIMIXED
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53 procedure. The GLMM represents a special class of regression model. The GLMM is
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55 'generalized' in the sense that it can handle DVs with markedly non-normal distributions,
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3 such as the DVs in this study; the GLMM is ‘mixed’ in the sense that it includes both random
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5 and fixed effects.
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8 For the teacher GLMM, there were three scale fixed effects (motor skills, inattentive
9 symptoms, hyperactivity/impulsive symptoms) and three nominal random effects (school,
10 teacher, child). The parent model had the same three fixed effects. Even though the parent
11 ratings were not expected to be strongly impacted by the child’s school or teacher, it was
12 decided to include these as random effects in the parent model to enhance its comparability to
13 the teacher model. After controlling for the clustering in the data attributable to the random
14 effects (which would be minimal for the parent model), a three predictor GLMM would
15 require 55 participants to capture ‘moderate’ relationships ($f^2 = .15$) between each predictor
16 and the DV. Both the parent model ($N = 113$), and the teacher model ($N = 77$) satisfied this
17 requirement.
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30 A multi-step model testing was used for both parent and teacher modeling. The Stage
31 1 has considered the GLMMs predicting social problems from motor skills, and the Stage 2
32 has controlled the role of the inattentive symptoms and hyperactivity/impulsive symptoms in
33 this relationship.
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39 Other statistical procedures included the Wilcoxon Signed Ranks Test for comparing
40 parents and teachers in terms of their mean ratings of children’s social problems, inattentive
41 symptoms, and hyperactivity/ impulsive symptoms; and a principal components analysis with
42 promax rotation to determine whether the parent-rated and teacher-rated social problem items
43 loaded on distinct factors.
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49 Results

50 Comparing Parent and Teacher Ratings

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52 Results suggested differences in the frequency of reported ADHD and social problems
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54 between parents and teachers, consistent with previous findings (Antrop et al., 2002; Coates,
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3 Taylor, & Sayal, 2014; Fagan & Fantuzzo, 1999). According to parent-report, 25% of
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5 children demonstrated “clinically significant” ADHD problems (i.e., T-score above 65),
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7 whereas, the prevalence of ADHD problems according to teachers was 12%. For inattention,
8
9 25% of children demonstrated problems in this area according to parents and 10% were
10
11 classified as having attention problems by teachers. According to parents, 30% of children
12
13 demonstrated problems with hyperactivity/impulsivity compared with 14% for teachers.
14
15 Similarly, the prevalence of social problems according to parent-report was 26%, whereas,
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17 teacher-rated social problems was at 11%. In the current sample, eight children (6.2%)
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19 demonstrated motor skill difficulties on the MAND (at or below 15th percentile), in line with
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21 DSM-V estimates of 5 to 6%.
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25 Wilcoxon Signed Ranks Test showed no significant difference between parents and
26
27 teachers in terms of their average ratings of children’s social problems ($z[N = 77] = 1.93, p =$
28
29 $.054$); however, compared to teacher ratings, parent ratings were significantly higher in terms
30
31 of inattentive symptoms ($z[N = 77] = 3.99, p < .001$) and hyperactivity/impulsive symptoms
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33 ($z[N = 77] = 4.20, p < .001$). Table 1 contains the descriptive statistics for the NDI scores and
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35 for the parent and teacher reports of inattentive symptoms, hyperactivity-impulsive
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37 symptoms, and social problems.
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40 [Insert table 1 here]
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43 There was no significant relationship between parents and teachers in terms of their
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45 ratings of children’s social problems ($r[N = 77] = .169, p = .143$); however, there were
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47 significant - but not strong - relationships between parents and teachers in terms of their
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49 ratings of children’s inattentive symptoms ($r[N = 77] = .536, p < .001$) and
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51 hyperactivity/impulsive symptoms ($r[N = 77] = .313, p = .006$).
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54 Table 2 describes the factor analysis of the individual items for the social problems.
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56 Teacher and parent ratings of social skills load neatly on different factors. The factor analysis
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3 was conducted to show that, even when items are common to both questionnaires (e.g. has no
4 friends), they still load on different factors.

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7 [Insert table 2 here]

8 9 10 **Screening for Control Variables**

11 In order for an extraneous variable to confound the relationships between the social
12 problems and the predictors (motor skills, inattentive, hyperactivity/impulsive), the
13 extraneous variable needs to be significantly correlated with the DV and at least one of the
14 predictors. The potential control variables were child age and gender, and none of these was
15 correlated with the DV and therefore none needed to be controlled. It is important to note that
16 the lack of relation between age and the study's primary variables was likely due to the use of
17 standard scores that already correct for age (i.e., are based on each test's age-matched
18 normative sample).
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29 30 **Testing the GLMMs**

31 Table 3 reports the Pearson correlations between social problems and predictors for
32 the parent and teacher models. The models show the same pattern of significant correlations.
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35 [Insert table 3 here]

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37 The results of the GLMM analyses are reported in Table 4 and were divided into two stages
38 of analysis. For both the parent and teacher models, motor skills were a significant predictor
39 of social problems (Stage 1). After controlling for ADHD symptomatology, motor skills
40 remained a significant predictor in the teacher model but not in the parent model. After
41 controlling for motor skills, inattentive (not hyperactive impulsive) symptoms was a
42 significant predictor of social problems in the parent model, although parent-rated inattentive
43 fell just short of significance as a predictor of teacher-rated social problems ($F[1,73] = 3.19, p$
44 $= .078$). Hyperactive impulsive (not inattentive) symptoms was a significant predictor of
45 social problems in the teacher model (Stage 2); teacher-rated hyperactive impulsive was also
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3 a significant predictor of parent-rated social problems ($F[1,73] = 12.08, p = .001$), which
4 provides some evidence against a mono-informant bias explanation for the within-model
5 relationships.
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9 [Insert table 4 here]
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11 Discussion

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14 The current findings provide further evidence for the important link between motor
15 performance and social competence (Boyer et al., 2014; Cairney et al., 2013; Cummins et al.,
16 2005; Livesey et al., 2011; Rigoli et al., 2012; Skinner & Piek, 2001; Smyth & Anderson,
17 2000), as motor skills were found to predict social problems for both the parent and teacher
18 models. The results also support the literature regarding an important relationship between
19 ADHD symptoms and social problems (Frederick & Olmi, 1994; Marques et al., 2013;
20 Nijmeijer et al., 2008; Wehmeier et al., 2010). However, the present study adds to the
21 existing research which has often overlooked the confounding effects of ADHD
22 symptomatology and motor skills in these relationships. The results of this study suggested
23 different relationships when these were taken into account. Furthermore, the study also
24 presents differential findings, depending on whether parents or teachers rated the ADHD and
25 social problems.
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40 When teachers were the informant for ADHD symptomatology and social problems,
41 motor skills remained a significant predictor of social problems over and above the ADHD
42 symptomatology. Conversely, motor skills did not significantly predict social problems after
43 controlling for ADHD symptomatology, for the parent model. These results highlight the
44 importance of considering different raters when exploring these relationships as well as also
45 suggesting that possible inconsistencies in the literature may be explained by the particular
46 informant used in the study. In order to further understand the different findings across the
47 parent and teacher models and given the low agreement between parents versus teachers-
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3 reported social problems, the present study also examined whether measurement issues were
4 a plausible explanation for the results. An inspection of the items across the parent versus
5 teacher social problems subscale suggested some differences. For example, the item “last to
6 be picked”, an important negative social outcome associated with motor problems, is
7 included in the teacher-rated social problems subscale but not for parents. However, our
8 results suggest that the weak correlation between teacher and parent ratings cannot be simply
9 attributed to the questionnaires having different items because even when items are common
10 to both questionnaires (e.g., has no friends), they still load on different factors. Therefore, it
11 is plausible that the varying results across the parent and teacher models may be explained by
12 context specific factors and differing informant perspectives (Barkley, 1998).
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25 Previous research has highlighted that specific social skills and behaviors can be
26 context dependent, which may partly explain the current findings (Murray, Ruble, Willis, &
27 Molloy, 2009). For example, it is plausible that a school environment presents higher motor
28 and social demands for a child and therefore some social behaviors may be more evident at
29 school, such as a lack of interest in, or avoidance of, particular activities that require physical
30 response, difficulties in socializing with peers or the preference for playing with young
31 children, decreased self-esteem and confidence, low frustration tolerance, and a lack of
32 motivation due to the difficulties faced in such an environment (Losse et al., 1991; Skinner &
33 Piek, 2001; Smyth & Anderson, 2000). The results of the current study reinforce this
34 hypothesis since the motor skills remained a significant predictor in the teacher model but not
35 in the parent model.
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49 In terms of the relationship between ADHD symptomatology and social problems, the
50 results revealed that once motor skills were taken into account, teacher-rated
51 hyperactive/impulsive, but not inattentive, symptoms were a significant predictor of social
52 problems. Conversely, for the parent model, inattentive but not hyperactive/impulsive
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3 symptoms were a significant predictor of social problems, after controlling for motor skills.
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5 These results further highlight the importance of taking differing raters into account when
6
7 understanding the relationships presented in the literature. During childhood, social
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9 interactions predominantly occur in the school environment. It is plausible that the
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11 relationship between hyperactive-impulsive symptoms and social problems is more evident in
12
13 this context. Restless and intrusive behaviors are often inappropriate and may be resistant to
14
15 correction (Nijmeijer et al., 2008), affecting relationships with teachers and peers. In fact,
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17 disruptive classroom behavior has been associated with lowered social status and greater peer
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19 rejection (Frederick & Olmi, 1994). Schlack et al. (2014) found that teachers reported
20
21 increased social performance deficits for ADHD-combined children compared with controls,
22
23 but not for ADHD-inattentive children. Conversely, in another study, parents reported an
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25 increased social performance deficit for both ADHD combined and inattentive subtypes
26
27 (Maegden & Carlson, 2000). The findings of the current findings suggest that inattentive and
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29 hyperactive/impulsive symptoms may have differential impacts on social functioning
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31 depending on the specific context in which these behaviors are observed.
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37 In this study, the results also revealed a moderate relationship between parent and
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39 teacher ratings of ADHD symptoms, in contrast to previous findings which have shown no
40
41 significant association between parent and teacher ratings of ADHD symptomatology (Fagan
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43 and Fantuzzo, 1999; Manz et al., 1999; Antrop et al., 2002; Coutinho et al., 2009). Martin et
44
45 al. (2002) used multiple informants to examine heritability estimates of ADHD and the
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47 impact of observer effects on these estimates in an epidemiological sample of twins. For both
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49 teacher and parent-rated data, ADHD was found to be highly heritable, however, the results
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51 revealed only a modest correlation between the two raters. Although it was suggested that the
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53 different informants may be observing the effects of different genes, other explanations are
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55 also plausible such as, scoring the same phenotype differently due to particular rater biases.
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3 Alternatively, Martin et al. (2002) note that the children may in fact be behaving differently
4 at home versus school and therefore different behaviors are being observed. Barkley (1998)
5 has also suggested that ADHD symptomatology may fluctuate across different situations and
6 contexts. In the current study, parent ratings of ADHD symptomatology were higher than
7 those reported by teachers, which has been frequently reported in clinically referred samples
8 (Antrop et al., 2002).
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16 The strength of the current study is the use of a community-based sample as clinical
17 studies tend to oversample those individuals who are relatively more impaired. The use of
18 both teacher and parent- informants is another important strength of this study. There is
19 extensive evidence demonstrating that parents and teachers are valid informants in the
20 assessment of childhood neurodevelopmental problems, but that they provide different
21 information (Antrop et al., 2002; Crippa et al., 2014; Fliers et al., 2008; Murray et al., 2009).
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30 The current study presents some limitations that should be considered in future
31 research. For example, this study did not differentiate gross from fine motor skills. It is
32 plausible that certain motor aspects may impact on social outcomes differentially. It is
33 important to note that the cross-sectional nature of this study also presents a limitation.
34 Furthermore, there may be other confounding factors which have not been considered in the
35 current study. For example, verbal ability and socio-economic status may be important
36 factors to include in future studies, given their potential predictive ability in the social
37 domain. Also, although no children in this study had a previously identified diagnosis of
38 ASD, there is the possibility that some of the children with motor problems may have
39 undiagnosed ASD or "autistic traits" (i.e., some symptoms without fulfilling a diagnosis of
40 ASD), and may have social difficulties as a part of this autism-like condition. Future research
41 should also be directed at investigating effects of motor skills, inattention, hyperactivity and
42 impulsivity on social competence over various developmental ages, using longitudinal
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3 methodology. For example, previous studies have reported a general decline in hyperactivity-
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5 impulsivity symptoms with age and a general increase in inattentive symptoms (Larsson,
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7 Dilshad, Lichtenstein, & Barker, 2011). The importance of motor competence for the social
8
9 functioning may also fluctuate over time, as the demands of the environment also change.
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11 12 **Conclusions**

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14 Ultimately, the results presented in this study have important implications for the
15
16 assessment and intervention of ADHD and motor problems. For example, it is important to
17
18 consider the impact of motor difficulties on a child's social functioning during the assessment
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20 stage. The results also highlight the need to take possible ADHD symptomatology into
21
22 account given the strong links between ADHD, motor difficulties, and the social domain.
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24 This will contribute to an improved understanding of the psychosocial implications of these
25
26 childhood difficulties and will assist in guiding intervention and preventative efforts.
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30 The findings also highlight the low to moderate inter-informant agreement regarding
31
32 child behavior and the importance of taking multiple informants into account in the
33
34 assessment of these difficulties. When examining the relationship between motor skills,
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36 attention, hyperactivity and impulsivity, and social problems, it is important to consider the
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38 interaction between symptoms and environmental contexts as this may also point to
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40 appropriate intervention strategies.
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Table 1: Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Parent					
Inattentive	113	40	90	57.68	11.82
Hyperactivity-Impulsive	113	43	90	59.52	13.44
Social problems	113	45	90	56.16	12.47
Teacher					
Inattentive	77	41	75	52.94	9.48
Hyperactivity-Impulsive	77	42	81	52.26	10.49
Social problems	77	45	90	52.73	11.35
NDI - MAND	129	43	147	93.13	18.46

Table 2: Pattern Matrix of individual items for the social problems

	Component	
	1	2
<u>Parent items</u>		
Loses friends		.852
Does not make friends		.844
No friends		.844
Does not get invited		.759
Feels inferior		.570
<u>Teacher items</u>		
Does not make friends	.914	
No friends	.910	
Unaccepted	.853	
Last to be picked	.825	
Poor social skills	.816	

Table 3- Pearson correlations between social problems and predictors for the parent (N = 113) and teacher (N = 77) models

Predictor	Rating of social problems	
	Parent model	Teacher model
Motor skills	-.200*	-.300**
Inattentive symptoms	.653***	.459***
Hyperactivity/impulsive	.534***	.481***

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

Table 4 - Parent (N = 113) and teacher (N = 77) GLMMs predicting social problems from motor skills, inattentive symptoms, and hyperactivity/impulsive symptoms

Predictor	Beta	95% C		<i>t</i>	<i>p</i> -value
		Lower	Upper		
<u>Parent model</u>					
Stage 1					
Motor skills	-.132	-.247	-.017	2.28	.025*
Stage 2					
Motor skills	-.025	-.109	.059	0.59	.559
Inattentive symptoms	.557	.305	.809	4.38	< .000***
Hyperactivity/impulsive symptoms	.155	-.047	.357	1.52	.131
<u>Teacher model</u>					
Stage 1					
Motor skills	-.185	-.316	-.054	2.81	.006**
Stage 2					
Motor skills	-.201	-.343	-.059	2.814	.006**
Inattentive symptoms	.111	-.446	.669	0.40	.691
Hyperactivity/impulsive symptoms	.481	.072	.891	2.35	.022*

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