Chapter 3

Predicting Children’s Academic Achievement from Working Memory: The Possible Role of Conduct Problems and Problematic Peer Relationships

Barbara Menting
Hans M. Koot
Jaap Oosterlaan
Pol A.C. van Lier

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Abstract

Children with poorer working memory ability are more likely to have academic difficulties. Therefore, knowledge about the pathway through which poorer working memory leads to academic difficulties is of importance. Apart from possible direct links, poorer working memory may increase children’s risk of showing conduct problems, being rejected by peers or to affiliate with aggressive friends, which in turn may hamper children’s academic achievement. Therefore, this study tested whether these behavioral and social relational factors added to the explanation why children with poorer working memory end up having poorer academic achievement. Five hundred ninety four (594) children were followed from grade four to six elementary school. Academic achievement was assessed with a standardized Dutch national end of primary school test in grade six. A computerized n-back task was used to test working memory ability. Conduct problems were obtained through teacher reports, and peer rejection and best friend’s aggression through peer nominations. Above and beyond a direct path from working memory to academic achievement, indirect pathways were found through peer rejection and friend’s aggression, but not through conduct problems. The results applied to both boys and girls, except the pathway through friend’s aggression, which applied to boys only. The results of this study suggest that in order to understand the influence of working memory abilities on academic success, we have to account also for the social experiences that children with poorer working memory abilities may encounter.

Introduction

Working memory, the ability to temporally store and process information, is “assumed to be necessary to keep things in mind while performing complex tasks such as reasoning, comprehension and learning” (Baddeley, 2010, p. 136). Such working memory skills have been described to be important for children’s success at learning and acquiring knowledge and new skills (Alloway & Alloway, 2010). As a consequence, having a poor working memory likely hampers children in their academic development. Links between children’s working memory skills and academic difficulties in elementary school have indeed been found (Alloway, Gathercole, Kirkwood, & Elliott, 2009; Aronen, Vuontela, Steenari, Salmi, & Carlson, 2005; Bull & Scerif, 2001), even when general IQ was taken into account (Alloway, 2009; Alloway & Alloway, 2010). One possible explanation for such links is that children with poorer working memory abilities have difficulties remembering classroom instructions, the simultaneous processing and storage of visuo-spatial and verbal material, and keeping track of progress in complex school tasks (Alloway & Alloway, 2010; Gathercole, Lamont, & Alloway, 2006). However, it is largely unknown whether in addition to such direct links between working memory and academic achievement other pathways exist through which poorer working memory skills may impede academic success. That is, in addition to having a direct link with academic achievement, poorer working memory capacity
may also affect the behavioral and social relational development of children, which in turn may add to the impairment of academic achievement. This study’s aim is to examine such additional pathways. Specifically, we aim to test whether in addition to possible direct links, children’s conduct problems and relationships with peers should be taken into account to understand why children with poorer working memory skills end up having lower academic achievement test scores at the end of elementary school. This was tested in a general population sample followed longitudinally from grade 4 to 6.

**Working Memory, Academic Achievement, and Conduct Problems**

To understand the pathways through which children with poorer working memory may end up having poorer academic success by the end of elementary school, and the plausibility that behavioral and social relational factors may play an important additional role in this process, we need to understand the specific deficiencies that are implied by poorer working memory. One possible pathway of children’s poor working memory skills to lower academic achievement is through children’s conduct problems. Higher cognitive functions such as working memory have their neurological basis mainly in the prefrontal cortices, which are important for organizing, executing and inhibiting behavior, and behaving appropriately (Ishikawa & Raine, 2003; Séguin, 2004). Neurocognitive deficits may thus lead to an impaired ability to generate proper responses in complex and challenging situations that the school context might provide, and to inhibit inappropriate responses, such as acting aggressively and swearing (Giancola, 1995; Ishikawa & Raine, 2003). It has indeed been suggested that problems with neurocognitive functions including working memory underlie the early manifestation of conduct problems (Loeber, Farrington, Stouthamer-Loeber, & Van Kammen, 1998b; Moffitt, 1993; Nigg & Huang-Pollock, 2003). In accordance with this, empirical support has been found for an association between neurocognitive functions including working memory and conduct problems and related behaviors (e.g., aggression) (Morgan & Lilienfeld, 2000; Ogilvie, Stewart, Chan, & Sum, 2011; Séguin, Boulerice, Harden, Tremblay, & Pihl, 1999).

Conduct problems have in turn been associated with children’s academic achievement, perhaps because they interfere with appropriate classroom behavior (Hinshaw, 1992). Children who show conduct problems in the classroom may learn less because their problem behavior disturbs the child’s ability to pay attention to the instructions, disturbs the lessons altogether, or because the child may miss the lessons due to absence (truancy) or suspension. As a result, children with conduct problems may be more likely to end up having poorer academic achievement (Finn, 1989; Mullis, Rathge, & Mullis, 2003). Prospective associations were indeed found between conduct problems in eighth grade and academic achievement two years later (French & Conrad, 2001), but also between childhood behavior problems at age 5 and academic underachievement at age 18 (Timmermans, Van Lier, & Koot, 2009).
Working Memory, Academic Achievement and Peer Social Relational Risks

In addition to children’s conduct problems, two peer relational factors, including a poor social preference among mainstream peers and their association with deviant friends, should be considered when trying to understand pathways through which poor working memory may express itself in poor academic achievement. Children with poorer working memory may encounter difficulty in becoming liked by peers, and may be at risk of choosing non-adaptive peers as their friends. For instance, higher cognitive functions including working memory are important for the development of social competence, as they may influence the decoding and interpretation of dynamic social cues (Lezak, 2004; Phillips, Tunstall, & Channon, 2007), which is important for building satisfying relationships with mainstream peers and preventing peer rejection (Hay, Payne, & Chadwick, 2004). Furthermore, poor working memory may hamper peer socialization by impeding children’s ability to learn and understand social norms and game rules, follow conversations or cope with the demands of complex peer interactions, resulting in inappropriate behavior in the peer group (Beauchamp & Anderson, 2010; Ishikawa & Raine, 2003; Nigg & Huang-Pollock, 2003; Rinsky & Hinshaw, 2011).

In addition to affecting the development of relations with the peer group, working memory may also affect the decision-making process in befriending peers. Having a poorer working memory capacity limits the access to and consideration of multiple options with their possible consequences, resulting in impulsive choices (Finn, 2002). Poorer working memory skills were indeed found to be predictive of impulsive decision-making (Hinson, Jameson, & Whitney, 2003). As a consequence of the impairments that a poorer working memory may impose, children’s working memory likely affect their attractiveness for mainstream peers to associate with, in addition to affecting children’s choice behavior with respect to the selection of friends. Children with poorer working memory abilities may thus be at risk of becoming poorly liked or rejected by mainstream peers and they may affiliate with deviant, aggressive friends.

Some empirical evidence supports associations between higher cognitive functions including working memory and social relational factors. Working memory was found to be positively associated with social development in a sample of preschoolers (Alloway et al., 2005), and negatively with boys’ social problems, such as problems in their relations with peers (Kofler et al., 2011). Moreover, higher cognitive (executive) functions were associated with girls’ social functioning (e.g., peer preference) five years later (Rinsky & Hinshaw, 2011), and impulsiveness/inattention also predicted peer rejection (Snyder, Prichard, Schrepferman, Patrick, & Stoolmiller, 2004). In addition to evidence supporting a link between working memory and impulsive decision-making (Hinson et al., 2003), there is also support for a link between working memory skills and affiliation with deviant peers, although this link may be through attention deficit hyperactivity disorder (ADHD). Specifically, children with ADHD symptoms, who often have poorer working memory (Martinussen,
3. Working Memory, Conduct Problems, Peer Relations, and Academic Achievement

Hayden, Hogg-Johnson, & Tannock, 2005), have been found to be more likely to affiliate with deviant peers than children without ADHD (Marshal, Molina, & Pelham, 2003).

Being rejected by peers and affiliating with aggressive friends affects children’s school achievement. Children who are rejected by their peers are likely less motivated for school work, have negative school attitudes, participate less in classroom activities, and avoid school more often, processes that hamper academic achievement (Buhs, Ladd, & Herald, 2006; Osterman, 2000). Similarly, affiliation with deviant friends who may not be highly engaged in school activities might reduce children’s own motivation to behave and perform well at school, for instance because non-academic (or even antisocial) activities are prioritized in such friend groups, or learning is viewed as “not cool” (Kindermann, 2007). Empirical evidence supports links between peer relational risk and academic achievement. For instance, peer rejection has indeed been found to be a strong predictor of children’s academic achievement within a school year (Buhs & Ladd, 2001), as well as over multiple years in early elementary school (O’Neil, Welsh, Parke, Wang, & Strand, 1997). Children with deviant friends were also found to be less involved in school-based activities, such as making homework (Li, Lynch, Kalvin, Liu, & Lerner, 2011). Moreover, having antisocial friends at age 14 was found to predict early school dropout two years later partly because of associated poor academic achievement (Battin-Pearson et al., 2000).

Present Study

In sum, previous studies indicate that academic achievement is influenced by children’s working memory capacity. However, both theory and empirical evidence suggest that the pathway through which a poorer working memory ability impedes academic success may also run through associated conduct problems, peer preference and affiliation with aggressive friends. We aim to test such pathways in predicting children’s scores on the standardized Cito End of Primary School Test (Dutch: Cito Eindtoets Basisonderwijs), which is part of the Dutch Pupil Monitoring System (Van Boxtel, Engelen, & De Wijs, 2011). This test is used by virtually all Dutch elementary schools to determine their sixth grade children’s final elementary school qualifications. Moreover, the Cito Test is a major factor in determining the level of secondary school (e.g., pre-vocational or pre-university level), comparable to for instance the Independent School Entrance Examination (ISEE Middle Level; Educational Records Bureau, 2012), and is thereby an important factor in forecasting the future academic achievement of children.

In testing our hypothesis, we started off by confirming the in previous empirical studies described links from each of our hypothesized pathway variables (conduct problems, social preference, best friend’s aggression) to academic achievement. We then tested the two following hypotheses. First, we hypothesized to find a predictive association between fourth grade working memory and the sixth grade academic achievement test above and beyond conduct problems, social preference and best friend’s aggression. Second, we expected that
above and beyond a direct link between working memory and academic achievement, pathways of working memory through conduct problems, peer social preference and affiliation with aggressive friends would add to the explanation of children’s performance on the sixth grade academic achievement test.

When testing the possible role of conduct problems, peer rejection and having aggressive friends in the link between working memory and academic achievement, it is important to explore possible sex differences. Compared to girls, boys are at increased risk of having conduct problems, being rejected by peers and to affiliate with aggressive friends (Moffitt, Caspi, Rutter, & Silva, 2001). Moreover, poorer working memory may differently affect boys’ and girls’ development of conduct problems, peer rejection and affiliation with aggressive friends. Poor executive functioning was for example found to be associated with increased peer rejection only for girls (Diamantopoulou, Rydell, Thorell, & Bohlin, 2007).

Methods

Participants

Children came from 30 elementary schools. Schools were recruited from two urban areas in the western part of the Netherlands and a rural area in the eastern part of the Netherlands. The first 30 schools that accepted our invitation to participate in the project were included in the project. In this study, children were eligible for inclusion if they were in participating classrooms in grade 4 (spring 2008), when working memory was assessed, and grade 6 (spring 2010), when academic achievement was assessed, resulting in a group of 673 children. Signed parental consent was obtained before the study started for 91% of these children resulting in a target sample of 610 children (51% females). These children’s mean age in grade 4 was 10.3 years ($SD = 0.51$). Sixty-nine percent of the children were from Dutch/Caucasian background. Other ethnic backgrounds were Morocco (9%), Turkey (8%), Netherlands Antilles (4%), Surinam (4%), and other ethnic backgrounds (6%), which is somewhat higher than the percentage of non-Caucasian backgrounds ($\approx 20\%$; Statistics Netherlands, 2012a) in the Dutch general population. Thirty percent of the children came from low SES families, which conforms to the distribution in the Dutch general population (Statistics Netherlands, 2009).

Working memory and academic achievement scores were available for 594 children (97% of the target sample). Scores were mostly missing because children were absent during the measurement. These 594 children did not differ from the target sample with respect to sex ($\chi^2(1) = 0.71, p = .40$), grade 4 scores of conduct problems ($F(1,608) = 0.09, p = .77$), social preference ($F(1,608) = 0.35, p = .56$) and friend’s aggression ($F(1,462) = 0.05, p = .83$).

Part of the children received a preventive intervention targeting problem behavior (Good Behavior Game; Barrish, Saunders, & Wolf, 1969) prior to the study period of the current study in grades 1 and 2. Classes were randomly assigned to the GBG or control condition. Testing for intervention effects was not an objective of this study. Details on the
intervention study and on GBG impact were described previously by Witvliet and colleagues (Witvliet, Van Lier, Cuijpers, & Koot, 2009). The study protocol was approved by the Medical Ethics Committee of the VU University Medical Center.

Measures and Procedure

Academic achievement was measured with the Dutch national Cito End of Primary School Test (Cito), constructed to assess the academic achievement level of sixth grade children in the Netherlands (Van Boxtel et al., 2011). The Cito test is a standardized test used by virtually all elementary schools in the Netherlands. It was found to be a reliable and valid test to measure learning progress/academic achievement (Van Boxtel et al., 2011). The test consists of 290 multiple choice items in four different categories: language (100 items), mathematics (60 items), study skills (e.g., handling information, reading graphs, tables, maps; 40 items), and environmental studies (history, geography, science; 90 items). Percentile scores were derived for each of the four category tests (range 0-100). The children were tested at the schools on three consecutive days in February 2010, supervised by their teacher. Schools provided the Cito scores with permission of the parents.

Working memory was assessed in grade 4 with a computerized n-back task, measuring visuo spatial working memory. An adapted version for children was used with a picture of an apple and four holes from which a caterpillar could emerge (Van Leeuwen, Van den Berg, Hoekstra, & Boomsma, 2007). The task consisted of four difficulty levels, starting with 1-back up to 4-back. Each new level started with a practice block of ten trials. When a minimum of four correct responses were made, the 32-trial test block started. A child commenced to the next level when it made a minimum of eight correct responses in a test block. Before each new level, standardized instructions were given and possible questions were answered. Children were tested in small groups in a separate room in the school, each assisted individually by a trained test administrator. Children wore headphones during the test to minimize possible auditory interference.

Working memory scores were calculated using the number of correct responses in each test block. If a child (1) failed a practice block three times, or (2) made less than eight correct responses in a test block (i.e., the average number of correct responses based purely on chance), the test was discontinued and scores in subsequent test levels were discarded. Because some children may have been good guessers (just reaching 8 and having a chance to score points again in the next level(s)), and other children were unlucky guessers (when making 7 or less correct responses, there was no possibility to do the next level(s)), all missing scores and scores below eight were set at eight. Then, the scores in each level were standardized within the whole group of children, in order to better interpret the scores of children who reached the higher levels as compared to children who did not make it to the end of the test. Finally, the four standardized scores were summed for each child to compute an overall working memory accuracy score. Note that results remained essentially unchanged
if working memory scores were derived using other methods (e.g., the raw sum of correct answers without correction for not reaching the end of the test and guessing).

*Teacher ratings of conduct problems* were assessed in grade 4 and 5 with the Problem Behavior at School Interview (PBSI; Erasmus MC., 2004). The PBSI is a 42-item face-to-face teacher interview, in which teachers rated behaviors on a five-point Likert scale, 0 (*never*) to 4 (*often*). The conduct problems scale consisted of 12 items, such as “*this child starts fights*”, “*this child swears*”, “*this child is truant or absent without reason*”, and “*this child destroys property belonging to others*”. Cronbach’s alpha’s were .93 (grade 4) and .91 (grade 5). Grade 4 and 5 conduct problem scores were obtained by dividing the sum score by the number of items.

*Peer social preference* was obtained in grade 4 and 5 using a peer nomination procedure (Coie, Dodge, & Coppotelli, 1982). Children filled out the peer nomination questionnaire in the classroom, with one test administrator reading instructions and other test administrators providing assistance. Peer social preference scores were obtained by asking the children to nominate an unlimited number of classmates whom they liked and whom they disliked. For each child, these total liked and disliked scores were divided by the total number of children in the classroom minus one (children could not nominate themselves). Subsequently, the ‘dislike’ scores of each child were subtracted from its ‘like’ scores. Scores ranged from -1 (poorly accepted/rejected by all classmates) to 1 (well accepted/no rejection).

*Best friend’s aggression* was also measured in grade 4 and 5 with peer nominations using a two stage procedure. First, information on reciprocal friendships (as friendships have been agreed to be reciprocal relationships; Rubin, Bukowski, & Parker, 2006) was obtained by asking each child to nominate an unlimited number of children he/she considered friends. Subsequently, the child was asked to nominate his/her best friend. For each child, a reciprocated friendship was considered if the child’s best friend in turn nominated the child as a friend. Secondly, children were asked to nominate all classmates “*who ever hit other children*”, to obtain an aggression score, which was divided by the number of children in the classroom minus one. Best friend’s aggression was the aggression score of the reciprocal best friend of each child.

*Household socioeconomic status (SES)* was measured using the working population classifications of occupations scheme (Statistics Netherlands, 1993, 2009). The highest SES score of the parents was used. Low SES was defined as being unemployed, or holding an elementary job or less.

*Male sex and intervention status* were dummy-coded (0 = female, 1 = male, and 0 = control, 1 = GBG, respectively).

**Statistical Analyses**

Structural models were estimated using Mplus 5.2 (Muthén & Muthén, 1998-2010). Model fit was determined using the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI)
with values > .90 indicating acceptable fit and values > .95 indicating close fit (Bentler & Bonett, 1980), and Root Mean Square Error of Approximation (RMSEA) with values ≤ .08 indicating acceptable fit (Marsh, Hau, & Wen, 2004). An MLR estimator, which produces robust standard errors, was used to account for possible non-normal distribution of scores. Standard errors were adjusted for nesting of data within classrooms by using a sandwich estimator (Williams, 2000). All models were controlled for intervention status and SES.

**Results**

**Descriptive Statistics**

Descriptive statistics in Table 3.1 show that boys scored higher on the Cito mathematics and environmental studies subtests, had higher levels of conduct problems, lower levels of social preference scores, and that their best friend was on average more aggressive than girls’ best friends. Correlations between the variables are given in Table 3.2. As expected, significant positive correlations were found between grade 4 working memory and the four Cito subtests assessed in grade 6. Moreover, working memory correlated significantly and negatively with conduct problems, and for boys also with friend’s aggression. Working memory was positively related to peer social preference. Significant correlations were also found between conduct problems, social preference and friend’s aggression, and the four Cito subtests.

**Table 3.1**

**Means and Standard Deviations of Academic Achievement (Cito Subtests), Conduct Problems, Social Preference, Friend’s Aggression, and Working Memory**

<table>
<thead>
<tr>
<th></th>
<th>Boys (n = 295)</th>
<th>Girls (n = 299)</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Cito Language</td>
<td>42.2</td>
<td>30.6</td>
<td>45.8</td>
</tr>
<tr>
<td>Cito Mathematics</td>
<td>51.9</td>
<td>28.9</td>
<td>41.3</td>
</tr>
<tr>
<td>Cito Study Skills</td>
<td>48.9</td>
<td>30.9</td>
<td>44.3</td>
</tr>
<tr>
<td>Cito Environmental Studies</td>
<td>50.8</td>
<td>30.7</td>
<td>40.3</td>
</tr>
<tr>
<td>Conduct Problems 4</td>
<td>0.72</td>
<td>0.72</td>
<td>0.37</td>
</tr>
<tr>
<td>Conduct Problems 5</td>
<td>0.62</td>
<td>0.62</td>
<td>0.33</td>
</tr>
<tr>
<td>Social Preference 4</td>
<td>0.09</td>
<td>0.33</td>
<td>0.18</td>
</tr>
<tr>
<td>Social Preference 5</td>
<td>0.11</td>
<td>0.32</td>
<td>0.21</td>
</tr>
<tr>
<td>Friend’s Aggression 4</td>
<td>0.23</td>
<td>0.24</td>
<td>0.09</td>
</tr>
<tr>
<td>Friend’s Aggression 5</td>
<td>0.20</td>
<td>0.20</td>
<td>0.07</td>
</tr>
<tr>
<td>Working Memory</td>
<td>0.09</td>
<td>1.04</td>
<td>-0.04</td>
</tr>
</tbody>
</table>

*Note.* Entries of Cito subtest scores are percentile scores; conduct problems, social preference, friend’s aggression are raw scores; working memory are standardized scores. *p < .01.
Table 3.2  
*Bivariate Correlations Among Academic Achievement (Cito Subtests), Conduct Problems, Social Preference, Friend’s Aggression, and Working Memory of Boys (Below the Diagonal) and Girls (Above the Diagonal)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
<th>6.</th>
<th>7.</th>
<th>8.</th>
<th>9.</th>
<th>10.</th>
<th>11.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cito Language</td>
<td>—</td>
<td>.76</td>
<td>.81</td>
<td>.85</td>
<td>-.23</td>
<td>-.24</td>
<td>.25</td>
<td>.25</td>
<td>-.18</td>
<td>-.28</td>
<td>.46</td>
</tr>
<tr>
<td>2. Cito Mathematics</td>
<td>.70</td>
<td>—</td>
<td>.79</td>
<td>.68</td>
<td>-.23</td>
<td>-.15</td>
<td>.25</td>
<td>.21</td>
<td>-.17</td>
<td>-.23</td>
<td>.50</td>
</tr>
<tr>
<td>3. Cito Study Skills</td>
<td>.79</td>
<td>.74</td>
<td>—</td>
<td>.80</td>
<td>-.21</td>
<td>-.18</td>
<td>.28</td>
<td>.26</td>
<td>-.16</td>
<td>-.18</td>
<td>.47</td>
</tr>
<tr>
<td>4. Cito Environmental Studies</td>
<td>.72</td>
<td>.55</td>
<td>.70</td>
<td>—</td>
<td>-.22</td>
<td>-.21</td>
<td>.26</td>
<td>.24</td>
<td>-.18</td>
<td>-.16</td>
<td>.41</td>
</tr>
<tr>
<td>5. Conduct Problems 4</td>
<td>-.24</td>
<td>-.29</td>
<td>-.29</td>
<td>-.32</td>
<td>—</td>
<td>.64</td>
<td>-.35</td>
<td>-.28</td>
<td>.32</td>
<td>.10</td>
<td>-.12</td>
</tr>
<tr>
<td>6. Conduct Problems 5</td>
<td>-.23</td>
<td>-.23</td>
<td>-.26</td>
<td>-.33</td>
<td>.61</td>
<td>—</td>
<td>-.30</td>
<td>-.19</td>
<td>.30</td>
<td>.22</td>
<td>-.17</td>
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<tr>
<td>7. Social Preference 4</td>
<td>.12</td>
<td>.12</td>
<td>.13</td>
<td>.15</td>
<td>-.40</td>
<td>-.25</td>
<td>—</td>
<td>.68</td>
<td>-.02</td>
<td>-.06</td>
<td>.21</td>
</tr>
<tr>
<td>8. Social Preference 5</td>
<td>.15</td>
<td>.12</td>
<td>.17</td>
<td>.23</td>
<td>-.33</td>
<td>-.26</td>
<td>.69</td>
<td>—</td>
<td>.03</td>
<td>.06</td>
<td>.15</td>
</tr>
<tr>
<td>9. Friend’s Aggression 4</td>
<td>-.17</td>
<td>-.20</td>
<td>-.24</td>
<td>-.27</td>
<td>.30</td>
<td>.23</td>
<td>-.21</td>
<td>—</td>
<td>.12</td>
<td>—</td>
<td>.33</td>
</tr>
<tr>
<td>10. Friend’s Aggression 5</td>
<td>-.29</td>
<td>-.25</td>
<td>-.27</td>
<td>-.27</td>
<td>.21</td>
<td>.24</td>
<td>-.17</td>
<td>-.17</td>
<td>.43</td>
<td>—</td>
<td>-.10</td>
</tr>
<tr>
<td>11. Working Memory</td>
<td>.28</td>
<td>.41</td>
<td>.35</td>
<td>.33</td>
<td>-.14</td>
<td>-.19</td>
<td>.12</td>
<td>.09</td>
<td>-.27</td>
<td>-.31</td>
<td>—</td>
</tr>
</tbody>
</table>

*Note.* All entries are significant at $p < .05$ except bold entries which are non-significant.
3. Working Memory, Conduct Problems, Peer Relations, and Academic Performance

**Working Memory, Conduct Problems, Social Preference, Friend’s Aggression and Academic Achievement**

We first aimed to confirm the previously demonstrated links (Battin-Pearson, et al., 2000; Buhs & Ladd, 2001; French & Conrad, 2001) from each of the hypothesized pathway variables (conduct problems, social preference, and best friend’s aggression) to academic achievement. A structural model was fitted in which a latent factor was considered for academic achievement, using the observed percentile scores from the four Cito subtests (i.e., language, mathematics, study skills and environmental studies) as indicators for the latent factor. This latent factor was predicted by the grade 5 conduct problems, social preference and best friend’s aggression scores, which in turn were each predicted by their grade 4 predecessors. Working memory was not entered in the model at this stage. Results showed significant links from grade 5 conduct problems ($B = -5.52, SE = 2.51, \beta = -.11, p = .03$), peer social preference ($B = 14.01, SE = 4.17, \beta = .16, p < .01$), and friend’s aggression ($B = -33.06, SE = 6.75, \beta = -.21, p < .001$) to grade 6 academic achievement. Together these three factors explained 20% of the variance in academic achievement.

We then aimed at testing our first hypothesis, namely that working memory has a unique predictive link with academic achievement beyond our hypothesized pathway variables. We therefore included working memory in the model and allowed for the hypothesized direct path from working memory to academic achievement in addition to the pathways from grade 5 conduct problems, social preference and friend’s aggression. At this stage, no links were allowed between working memory and conduct problems, social preference and friend’s aggression. The model showed a significant link from working memory to academic achievement ($B = 9.40, SE = 1.23, \beta = .36, p < .001$). After adding working memory, both social preference and friend’s aggression remained significant, but conduct problems became non-significant ($B = -4.20, SE = 2.43, \beta = -.09, p = .08$). In this model, 29% of the variance was explained.

In the final step, we tested our pathway hypothesis. We allowed for the links from working memory to conduct problems, social preference and friend’s aggression in order to test the hypothesized indirect paths from working memory to academic achievement via conduct problems, social preference and friend’s aggression. This model had an acceptable fit to the data (CFI = .95, TLI = .93, RMSEA = .05). More importantly, adding the three pathways from working memory to conduct problems, social preference and friend’s aggression significantly improved the model fit compared to the model without these three pathways, $\Delta \chi^2(3) = 16.69, p < .01$ (Satorra, 2000). As no cross links between grade 4 conduct problems, social preference and friend’s aggression to grade 5 conduct problems, social preference and friends’ aggression were found, such links were not included in the final model. When allowing for the direct as well as indirect influence of working memory, 31% of the variance in academic achievement was explained.
The results are presented in Figure 3.1. The link between working memory and academic achievement was significant. Furthermore, in addition to predicting academic achievement, working memory also significantly predicted conduct problems, social preference scores and friend’s aggression scores. As social preference and friend’s aggression predicted academic achievement, we tested whether the indirect link from working memory to academic achievement through social preference and friend’s aggression was significant by estimating the significance of the indirect pathways (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). The indirect pathways via grade 4 and grade 5 social preference \((B = 0.38, SE = 0.16, \beta = .014, p = .02)\) and grade 4 and 5 friend’s aggression \((B = 0.25, SE = 0.13, \beta = .010, p = .05)\) were significant. This indicates that in addition to a direct link, part of the association between working memory and the sixth grade academic achievement test is explained by the children’s levels of experienced peer preference and their friend’s aggression.

*Figure 3.1. Pathways of working memory to grade 6 academic achievement score. Estimates reflect standardized regression coefficients.

* \(p < .05\), ** \(p < .01\).

**Sex Differences**

To determine whether the results applied to both boys and girls, multiple group models were fitted comparing path estimates between boys and girls. A model in which the regression paths were held equal between boys and girls was compared to a model in which the paths were freely estimated across sex. The Satorra-Bentler chi-square difference test (Satorra, 2000) suggested sex differences in the overall model, \(\Delta \chi^2(7) = 26.54, p < .01\). Tests of each pathway separately showed that this was due to a sex difference in the pathway via friend’s aggression, \(\Delta \chi^2(2) = 14.55, p < .01\). The pathway from working memory to friend’s
aggression differed between boys and girls, $\Delta \chi^2(1) = 9.44, p < .01$, with working memory predicting friend’s aggression in boys ($\beta = -.28, p < .01$), but not in girls ($\beta = -.05, p = .45$).

We also tested whether the strength of the associations differed between children who received an intervention in grade 1 and 2 of elementary school aimed at promoting prosocial behavior (the Good Behavior Game) and control group children. No differences were found.

**Discussion**

This study explored possible pathways from working memory abilities in predicting academic achievement, assessed with the Cito End of Primary School Test, a test with excellent psychometric properties (Van Boxtel et al., 2011). This Cito test is used to assess children’s academic level at the end of elementary school, and to determine Dutch children’s secondary education entry level. It distinguishes children who will be advised to go to lower level secondary schools such as pre-vocational training, which is mainly aimed at training adolescents for the manual professions, from children who meet requirements for higher level secondary schools for instance aimed at pre-university training (Van Boxtel et al., 2011). Thus, our measure not only assessed academic achievement, but because it is used to advice what type and level of secondary education would be best for a child, it is likely also predictive of future educational and academic attainment achieved by the child (Van Boxtel et al., 2011).

This study found a predictive association between working memory and academic achievement two years later, which is in line with previous studies (Alloway et al., 2009; Aronen et al., 2005; Bull & Scerif, 2001). However, in addition to this direct effect, working memory was also found to influence academic achievement via social relational processes. More specifically, our findings suggest that children with lower working memory scores encounter difficulties in their acceptance by their peers and are more likely to affiliate with friends who are aggressive. Both these factors have a negative effect on children’s academic achievement. The results apply to both boys and girls, except for the pathway through friend’s aggression, which was found to apply only to boys.

Our findings are in line with theoretical notions that poor working memory skills may hamper children to successfully interact with mainstream peers and affect their choice behavior (Beauchamp & Anderson, 2010; Finn, 2002; Nigg & Huang-Pollock, 2003), likely increasing their risk of becoming rejected and making impulsive choices for instance with respect to the selection of aggressive friends. Such peer relational factors have in turn also been described to negatively influence academic achievement (Buhs et al., 2006; Kindermann, 2007). Moreover, by showing that working memory also indirectly predicted academic achievement via peer relational factors, this study extended previous empirical studies that only tested the link from working memory or other executive functions to social relational factors (Alloway et al., 2005; Rinsky & Hinshaw, 2011) and from peer relationships to academic outcomes (Li et al., 2011; O’Neil et al., 1997) separately. It is
important to note that the predictive links from peer social preference and friend’s aggression were significant above and beyond an association between working memory and academic achievement. This implies that social relationships with peers in part explain why children with poorer working memory end up having poorer academic achievement scores at the end of their elementary school career. Moreover, as such children likely receive a lower secondary entry level advise by the primary school teacher based on their lower achievement test score (Van Boxtel et al., 2011), it likely also influences their future academic and likely their future professional career.

It is important to note that both the direct path from working memory to academic achievement and the indirect pathway through peer social preference were sex invariant. However, our results suggested a sex difference with respect to the role of affiliation with aggressive friends in the link from working memory to academic achievement as this pathway was found to apply only to boys. More specifically, working memory capacity only predicted affiliation with aggressive friends in boys, but not in girls. This might be because elementary school boys generally interact more with other boys, who on average tend to show more aggressive behavior than girls (Parker et al., 2006; Moffitt et al., 2001), increasing the opportunity for boys with poorer working memory skills to (impulsively) affiliate with aggressive friends. Note also that we did not find a sex difference in the path from working memory to peer rejection, which differed from the findings reported by Diamantopoulou and colleagues (2007), who found that poor executive functioning was only associated with peer rejection in girls. This might be explained by the broad executive functioning deficits measure used by Diamantopoulou and colleagues, which also contained aspects of impulsivity. Impulsive behavior at early ages may be quite normative among boys, but more rare among girls. Consequently, it may lead to more peer problems among girls with executive function deficits. When using a specific working memory measure as we did, we found no such gender specific links for social preference.

In contrast to our expectations, there was no pathway from working memory to academic achievement through behavioral problems, despite the finding that working memory was indeed significantly associated with conduct problems, which was in line with theory (Moffitt, 1993) and empirical evidence (Ogilvie et al., 2011). The finding of a non-significant link between conduct problems and academic achievement was in contrast to previous studies (e.g., French & Conrad, 2001; Timmermans, et al., 2011). The link from conduct problems to academic achievement became non-significant when accounting for the predictive link of working memory to academic achievement. The previous studies did not simultaneously test for working memory and problem behavior in predicting academic achievement. It may indeed be less likely to find effects of conduct problems in addition to higher cognitive functions such as working memory in forecasting poorer academic achievement in childhood. This might be because minor neurocognitive deficits are
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A study hypothesized that working memory capacity is an underlying factor of conduct problems (Moffitt, 1993), and may therefore likely statistically account for a link of conduct problems with poor outcomes.

The finding that working memory also affects academic achievement through peer relational factors provides support for an interplay between biologically based child abilities and the social environment in children’s (mal)adaptive development. More specifically, although working memory skills are described to be trainable to some extent (Klingberg, 2010) and may therefore not be fully based on biological and innate (or genetic) factors, it has been described to be related to brain structure/functioning (Fuster, 2008; Séguin, 2004) and to be partially influenced by genes (Blokkand et al., 2008). Working memory thus is biologically based, at least to some extent. If working memory can be seen as an endophenotype of genetically dependent brain process, this study’s results do suggest a mechanism comparable to a person-environment correlation, in which the biological child factor influences the social environment (Rutter et al., 1997). Specifically, it showed how social relational factors, as evoked by working memory abilities, added to the explanation of academic achievement, and are therefore needed to understand the link between the biological based risk factor and children’s academic achievement.

This study has several limitations. First, although participants were from schools in urban as well as rural areas in the Netherlands and the percentage of low SES households was comparable to the general Dutch population, the inclusion of schools was not completely random, and the ethnic division differed somewhat from the general population in the Netherlands. The results may therefore not be generalized to all children in Dutch elementary schools. Secondly, children were only allowed to nominate their best friend inside the classroom. Although elementary school children of ten have friends in the classroom, they might also have friends outside of school (Rubin, Bukowski, & Parker, 2006), whom they could not nominate (and be nominated by in return to obtain information on reciprocity, a requirement of friendship; Rubin et al., 2006). Moreover, only the aggression score of the best friend, not other possible friends, was used to measure affiliation with aggressive friends. However, a child’s best friend likely has more influence on the child’s own behavior (Rubin et al., 2006). Finally, despite the longitudinal design of this study, our findings do not imply causality. There might be factors that account for the associations found between working memory, peer relations and academic achievement, for instance risky decision-making. Another possibility is that underlying genetic factors are actually driving our results. To rule this possibility out, our hypothesis should be retested in a genetically informative design.

Conclusion

This study’s results show that children’s working memory capacity predicted academic achievement test scores at the end of elementary school, but that this link was also explained by peer rejection and affiliation with aggressive friends, even when tested...
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simultaneously with the children’s behavior problems. This implies that researchers should also take social relational factors into account when studying the role of working memory on academic achievement. Moreover, future research should be directed at gaining insight in how poorer working memory skills lead to peer relational problems, for instance through problematic social information processing or risky decision-making. Practitioners should, when encountering children with poorer working memory capacity such as children with ADHD symptoms (Martinussen et al., 2005), pay attention to the quality of these children’s peer relations, because their social relational problems may also contribute to their risk of academic underachievement, which itself is a precursor of negative future outcomes including school dropout and unemployment (French & Conrad, 2001; Woodward & Fergusson, 2000). Moreover, problematic peer relationships have also shown to predict various serious negative outcomes, such as antisocial problems, delinquency, or substance use (Deater-Deckard, 2001; Parker, Rubin, Erath, Wojslawowicz, & Buskirk, 2006). To prevent children with poorer working memory skills from developing academic difficulties, methods aimed at improving working memory skills (e.g., Klingberg, 2010; Van der Molen, Van Luit, Van der Molen, Klugkist, & Jongmans, 2010) or reducing consequences of cognitive impairments may help reduce these vulnerable children’s risk of academic underachievement especially if they are simultaneously supported in their efforts to develop adequate peer relations.