Cognitive and Behavioural Predictors of Adolescents' Communicative Perspective-taking and Social Relationships

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Abstract

Given the pivotal role that social interactions play for adolescents' well-being, understanding the factors that influence communication is key. The present study examined relations between adolescents' communicative perspective-taking, executive function skills, and ADHD traits and explored the role communicative perspective-taking plays in peer relations. Data was collected from a community sample of 15 to 19-years-olds (*N*=46) in Waterloo, Canada. Two communicative perspective-taking tasks required participants to infer speakers' communicative intentions. A battery of tasks assessed adolescents' working memory and inhibitory control. Elevated ADHD traits were associated with weaker working memory, inhibitory control, and communicative perspective-taking. Working memory was the strongest predictor of communicative perspective-taking. Highlighting the importance of communicative perspective-taking for social interactions, adolescents with weaker skills in this area reported worse peer relations. Findings underscore the importance of communicative perspective-taking for adolescents' social relations and have relevance for understanding the social difficulties faced by adolescents with elevated ADHD traits.

Keywords: communicative perspective-taking; ADHD; executive functioning; working memory; adolescence; communication

Adolescents' social relationships play a crucial role in their psychological well-being (Corsano, Majorano, & Champretavy, 2006; Hay & Ashman, 2003; Parker, Rubin, Erath, Wojslawowicz, & Buskirk, 2006; Sarkova et al., 2014; Vernberg, 1990). Thus, difficulties with socio-communicative skills may be particularly detrimental within this developmental stage. The present study examined adolescents' ability to successfully decipher communicative intentions, specifically, whether executive functioning and behavioural traits predicted ability in this area and whether this skill related to social relations with peers.

Effective interactions require that conversational partners appreciate each other's perspective during the production and comprehension of utterances (i.e., communicative perspective-taking). Within our language system the same utterance can give rise to different meanings depending on a speaker's intentions, which necessitates that listeners reason about speakers' perspectives to successfully interpret messages. For example, if someone said, "Nice job!" after a presentation, you could use his cues (e.g., facial expression, tone of voice) to determine whether he was intending to be sarcastic or sincere. Though communicative perspective-taking can appear effortless, it is a complex process that requires conversational partners to rapidly manage the flow of information while simultaneously tracking social, linguistic, and contextual information (e.g., What does the other person know? What can they see? What verbal/nonverbal cues are they providing? What is happening in the current situation? Etc.). Thus, it is proposed that successful use of a conversational partner's perspective to guide communicative behaviour requires the support of executive functions (Nilsen & Fecica, 2011), referring to a set of higher-order cognitive skills (e.g., working memory, inhibitory control, cognitive flexibility, planning), which aid in monitoring control of thought and action and

facilitate goal-directed behaviour (Burgess, 1997; Carlson, 2005; Miyake et al., 2000; Pennington & Ozonoff, 1996).

Several components of executive functions may facilitate individuals' ability to utilize information about their conversational partner's perspective during communicative exchanges. For instance, inhibitory control may allow for an individual to suppress his/her own perspective to attend to the perspective of a partner. Working memory may allow for an interlocutor to hold a communicative partner's perspective in mind throughout a conversation. If the process of using a communicative partner's perspective during the act of comprehending or producing statements generates too much cognitive load, an individual may revert to a more 'egocentric' communication style. Supporting this premise, when the cognitive demands of a task are increased, speakers and listeners show less appreciation for communicative partners' perspective (Lin, Keysar, & Epley, 2010; Roßnagel, 2000). Moreover, children and adults with weaker executive functioning (e.g., working memory and inhibitory control) have more difficulty using the perspective of a speaker to successfully interpret their statements (Apperly, Samson, & Humphreys, 2009; Lin et al., 2010; Nilsen & Graham, 2009).

The importance of executive functions for communicative perspective-taking has implications for adolescents with weaker executive functioning, such as youth with elevated ADHD traits (Martel, Nikolas, & Nigg, 2007). Indeed, though not a diagnostic feature of ADHD, communicative weaknesses are commonly found in children with a diagnosis of ADHD (Bignell & Cain, 2007; Bishop & Baird, 2001; Geurts, Broeders, & Nieuwland, 2010; Green, Johnson, & Bretherton, 2014; Leonard, Milich, & Lorch, 2011), including on tasks that require attending to the perspective of a conversational partner (Nilsen, Mangal, & MacDonald, 2013; Nilsen, Varghese, Xu & Fecica, 2015). While the communicative abilities of adolescents with ADHD

have not been examined extensively, Sibley and colleagues (Sibley, Evans & Serpell, 2010) found that adolescents (with a mean age of 12 years) with ADHD were impaired in their comprehension of the social intentions of others, suggesting that during communicative exchanges using a partner's perspective may be difficult.

Past research provides a guide to understanding the interplay between the aforementioned cognitive, behavioural, and social characteristics; however, several questions remain unanswered. For example, while executive functioning and communicative perspective-taking show continued development into adolescence (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; Dumontheil, Apperly, & Blakemore, 2010; León-Carrión, García-Orza, & Pérez-Santamaría, 2004; Luna, Garver, Urban, Lazar, & Sweeney, 2004), their relation to each other is unknown. It is also not known whether adolescents with elevated ADHD traits are more challenged by communicative perspective-taking per se, and if so, whether this difficulty may be attributable to weaker executive functioning. Certainly, previous work has found associations between executive functioning and socio-communicative skill in children with ADHD (Bunford et al., 2015; Chiang & Gau, 2014; Kofler et al., 2011) and typically developing children (McQuade, Murray-Close, Shoulberg, & Hoza, 2013), but these associations have tended to rely on report-measures which assess general social functioning as opposed to a specific skill and have not been examined in adolescent samples. Finally, while adolescents with elevated ADHD traits are rated as less socially competent in their interactions with peers (Bagwell, Molina, Pelham, & Hoza, 2001; Hinshaw, Owens, Sami, & Fargeon, 2006; Sibley et al., 2010), the degree to which difficulties relate to communicative perspective-taking is unclear.

Addressing these gaps, this study had two main aims. First, the degree to which aspects of executive functioning (working memory and inhibitory control) related to adolescents'

communicative perspective-taking was assessed. We anticipated that adolescents with more proficient executive skills would be better able to decipher the communicative intentions of speakers. Moreover, the unique contributions of executive functioning and the behavioural correlates of executive difficulties, namely, ADHD traits, on communicative performance was examined. We were interested in determining whether adolescents with elevated ADHD traits showed less proficient communicative perspective-taking, with weaker executive functioning accounting for this proposed relation. Second, the degree to which communicative perspective-taking related to the general social competencies of adolescents, namely their prosocial behaviour and peer problems was explored. We anticipated that adolescents with weaker communicative perspective-taking would report less successful social outcomes. Extending this inquiry, mediation analyses investigated whether communicative-perspective taking could account for the relation between ADHD traits and poor social outcomes that has been previously found (e.g., Hoza et al., 2005). Our investigation focused on adolescents given that few studies have focused on such relations in this developmental period. Moreover, it represents a time when social relationships with peers becomes increasingly important (Bryan et al., 2013) and social interactions, particularly with peers, impacts adolescents' psychological health (Corsano et al., 2006; Hay & Ashman, 2003; Parker et al., 2006; Sarkova et al., 2014; Vernberg, 1990).

Method

Participants

Participants were 46 adolescents, 15- to 19-years of age, who were recruited with flyers posted at community organizations in a small city in Canada (i.e., Waterloo, Ontario; M_{age} = 17 years; 1 month; *SD* = 16 months; 23 females). All adolescents were fluent in English and parental occupations reflected a middle to high socioeconomic status sample (See Table 1 for sample information). Adolescents with and without a previous diagnosis of ADHD were able to

participate, with seven of the adolescents having received a previous diagnosis of ADHD. While no exclusion criteria was noted on recruitment material, no other neurodevelopmental concerns (e.g., Autism Spectrum Disorder, intellectual deficits) were reported by participants[1]. One adolescent (i.e., of those diagnosed with ADHD) was taking medication while participating. The pattern of data did not change when this participant was removed, thus his data remained in the analyses.

Procedure

This work, which was part of a larger study on adolescents' socio-communication, received approval from the Office of Research Ethics at the University of Waterloo. Both a parent and the adolescent provided consent. Adolescents were individually administered tasks in a fixed order, during a 2-hour visit, in a laboratory while parents completed questionnaires in a separate room. So that constructs represented performance on more than one task, composite measures were created for each skill area, where appropriate (i.e., mean of task z-scores [with scores reversed when a higher score related to weaker performance]).

Communicative perspective-taking. Adolescents' communicative perspective-taking was assessed through two tasks. The first communicative perspective-taking task assessed adolescents' ability to determine a speaker's intended meaning based on the successful interpretation of social cues (e.g., facial expression, tone of voice). Two subtests from the Awareness of Social Inference Test (TASIT; Rollins, Flanagan, & McDonald, 2002) were used for this purpose. Namely, 6 items from Social Inference Minimal and 4 items from Social Inference Enriched were chosen. This allowed for 10 items with 2 items tapping into each of the different communicative intents (sincerity, simple sarcasm, paradoxical sarcasm, lie, sarcasm). Participants watched ten videos of a conversational exchange wherein a speaker conveyed

particular communicative intent to a listener and then were asked questions regarding what the speaker was doing, what message the speaker was trying to convey, and what the speaker was thinking and feeling. The measure of interest was participants' score across the 10 items (/40). This task is considered appropriate for an adolescent population (McDonald et al., 2013; 2015).

The second task, a computerized communicative perspective-taking task, developed by Apperly and colleagues (2010; based on a task by Keysar, Barr, Balin, & Brauner, 2000), required that participants use the perspective of a speaker to determine which objects she was referring to. Areas of the brain associated with reasoning about others' intentions show activation during this task (Dumontheil, Küster, Apperly, & Blakemore, 2010).

The program was run on E-Prime and presented on a laptop. The screen showed a 4×4 display shelf containing eight different objects. Five slots were blocked from the view of the speaker who stood on the other side of the display. Participants were presented with instructions from the speaker as to how to locate objects within the display (i.e., to click on objects using the computer mouse). Initially, participants were shown an example grid and were told that the speaker could not see the blocked objects and then shown the grid from the speaker's perspective. There were 128 trials: 16 experimental, 16 control, and 96 filler trials, presented in the same order for all participants. Experimental trials required that adolescents use the perspective of the speaker to correctly respond to the instruction (Figure 1). Control trials had identical instructions and arrangement of objects (with the exception of one object), but did not require perspective-taking, as the best referential match was always visible to the speaker. There were two types of experimental items, relational items and ambiguous items (8 of each). Relational items were those that involved three similar objects in the display (e.g., three different-sized balls or three hammers on different levels of shelves) and the description provided by the speaker included either a

location (e.g., "Click on the top hammer") or a scalar adjective (e.g., "Click on the small ball"). The blocked object was the best referential match (e.g., the hammer on the highest shelf). Thus, to be correct, participants had to realize that the speaker was referring to the object she could see (e.g., hammer on the middle shelf) as opposed to the object she could not see. Ambiguous items involved two homophone objects [e.g., bat (animal) and bat (baseball bat)] wherein one of the object pairs was blocked [(e.g., the bat (animal)]. Thus, when participants heard the instruction (e.g., "Click on the bat'), they were required to appreciate that the speaker was referring to the object she could see (e.g., baseball bat) as opposed to the 'distractor' object she could not see.

A proportion of accurate experimental trials was created so that trials in which participants did not provide a response were not included. This measure significantly related to adolescents' ability to read the communicative intentions of speakers, as per their performance on the TASIT, $r = .51$, $p = .001$. Thus, the composite of these measures reflected participants' ability to use the perspective of the speaker to guide interpretations of statements[2].

Executive functioning.

Working memory. Working memory capacity was assessed through three span tasks designed to evaluate adolescents' ability to hold in mind information. Span tasks have been found to load onto a working memory dimension of executive function in factor analyses (Fournier-Vicente, Larigauderie, & Gaonac'h, 2008; Pennington, 1997). First, adolescents were administered the sentence span task from the Stanford-Binet intelligence scales (Roid, 2003). They were asked to recall the last word in a set of questions presented by the researcher with the number of sentences in the set increasing through the trials. Participants score reflected total correct items until the discontinue criteria of two consecutive scores of zero was met. Adolescents were also administered the backward digit span task from the Wechsler Intelligence Scale for

Children, Fourth Edition. (WISC-IV; Wechsler, 2003), wherein they were instructed to repeat random strings of digits in a backward order. In order to include a nonverbal component of working memory, participants were administered the Finger Windows subtest from the Wide Range Assessment of Memory and Learning Second Edition (WRAML2; Sheslow & Adams, 2003). The task was administered according to standardized procedures in which the researcher indicated a series of spatial locations by inserting a pencil through a series of randomly spaced holes ("windows") on an 8×11 inch card. Each participant then reproduced the same sequence by putting his/her finger through the holes. Total items correct were recorded.

Performance on the working memory tasks were related: sentence span/backward digit span, $r = .38$, $p = .01$; backward digit span/finger windows, $r = .39$, $p = .01$; sentence span/finger windows, $r = .30$, $p = .06$. The composite of working memory was reflective of adolescents' ability to attend to, retain, and manipulate information in mind[3].

Inhibitory control. Inhibitory control was assessed through an interference control task (Stroop, 1935) and a response inhibition measure. The Stroop task has long been considered a benchmark measure of inhibitory control (Wright, Waterman, Precott, & Murdoch-Eaton, 2003). To complete this task, adolescents read words from a list of colours with congruent font colours. They were then asked to identify the colours of the font from a list of words with incongruent colours. Items were discontinued if the youth did not complete all items within 2 minutes (as was the case for 21 participants). Interference control was calculated by regressing the incongruent color-word naming score on the congruent color naming scores and saving the unstandardized residual wherein higher scores reflect better performance.

Response inhibition was measured using a computerized stop signal reaction task, STOP-IT (Verbruggen, Logan, & Stevens, 2008). Stop signal paradigms have been shown to load onto a

factor of cognitive inhibitory control (Kindlon, Mezzacappa, & Earls, 1995). Adolescents were required to press a different key on a laptop depending on the shape that was presented on the screen. However, they were required to inhibit this pre-conditioned key-press response if they heard a beep following the presentation of the shape (25% of trials). The computer program varied the delay between the presentation of the shape and the presentation of the beep (i.e., *stop-signal* delay) until adolescents inhibited the key-press response on fifty percent of the trials. This *stop-signal* delay was subtracted from the *go-signal* delay (the delay between the presentation of the shape and the key press) to yield the *stop-signal reaction time* (SSRT) for each trial. Better response inhibition was thus indicated by shorter SSRTs. The accompanying ANALYSE-IT scoring program (Verbruggen et al., 2008) was used to score adolescents' responses unless they inhibited on less than fifty percent of the *stop-signal* trials, in which case the scores were calculated by hand. Adolescents' scores were excluded if they either did not respond, or responded incorrectly for more than fifty percent of the *go-signal* trials ($n = 7$).

The measures for the two aspects of inhibitory control, namely response inhibition and interference control were not found to be significantly correlated, $r = -.15$, $p = .37$. As such, these aspects of inhibitory control were examined separately.

ADHD traits. Adolescents' ADHD symptoms were assessed using the Swanson-Nolan-And-Pelham-IV Rating Scale (SNAP-IV; Swanson, 1992), completed by parents. Parent report was used as past work has suggested that youth may underestimate their ADHD traits (Loeber, Green, Lahey, & Stouthamer-Loeber, 1991). The SNAP-IV, a measure of ADHD traits based on the criteria listed in the DSM-IV (American Psychiatric Association, 1994), has acceptable psychometric properties (Bussing et al., 2008; Collett, Ohan, & Myers, 2003). Internal consistency of the SNAP was reported to be high ($\alpha = .94$; Bussing et al., 2008). Parents rated the

frequency of behavioural descriptors of Inattention and Hyperactivity/Impulsivity using a four-point Likert scale ranging from *(0) Not At All* to *(3) Very Much.* Due to recent findings that a general ADHD composite is the most appropriate way of representing the traits of ADHD (Normand, Flora, Toplak, & Tannock, 2012), inattention and hyperactivity/impulsivity were combined in an ADHD composite score (relation between these two scales: $r = .81$, $p < .001$).

Social relationships. Finally, to assess youths' perceptions of their social relationships, they completed the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). Specifically, adolescents completed all 25 items, but the 10 items that loaded onto the Peer Problems and Prosocial Behaviour subscales were used in the analyses (5 Items per scale). Ratings were made using a 3-point scale: (0) *Not True*, (1) *Somewhat True*, and (2) *Certainly True*. The SDQ has been used as a measure of social competence (Dunn & Cutting, 1999; Rydell, Thorell, & Bohlin, 2007) and shows adequate psychometric properties (Kelley, Reitman, & Noell, 2003) such as an internal consistency of $\alpha = .73$ (Goodman, 2001). While previous work has found that children with ADHD are generally not impaired in prosocial behaviour, but show increased negative behaviours (e.g., Buhrmester, Whalen, Henker, MacDonald, & Hinshaw, 1992; Mikami, Huang-Pollock, Pfiffner, McBurnett, & Hangai, 2007; Pelham & Bender, 1982), we choose to assess both aspects of social competence in order to capture a range of behaviours within our community sample. Adolescents' view of their peer problems was negatively correlated with their self-reported prosocial behaviour, $r = -.48$, $p = .001$. A composite of these scores was created (with peer problems reverse scored), such that higher scores reflect perceptions of more positive social relationships.

Results

Preliminary Analyses

Descriptive statistics and bivariate correlations were based on all available data, but regressions were based on the participants who had data for all composite measures (n=38). Statistical outliers were Winsorized to be within 3 standard deviations of the mean (as per Tabachnick & Fidell, 2007; computerized perspective-taking task [n = 2], the TASIT [n = 1] and the Stop-It Task [n = 1]). The standardized residuals of all regressions were found to be normally distributed.

Adolescents' executive functions, ADHD traits, and communicative perspective-taking performance (raw scores) are displayed in Table 1. The average level of ADHD traits was within the non-clinical range with four participants exceeding the clinical cut-off for Inattentive symptoms (i.e., 1.78) and three of those four also exceeding the cut-off for Hyperactive/Impulsive symptoms (i.e., 1.44). Age and participant sex were unrelated to all independent and dependent variables (ps > .25) and were not included in subsequent analyses.

Relations between EF, ADHD traits, and communicative perspective-taking

To examine the relation between cognitive and behavioural predictors and communicative perspective-taking, bivariate correlations were conducted (Table 2). Adolescents with smaller working memory capacities were found to have worse communicative perspective-taking. Adolescents with elevated ADHD traits showed weaker performance on the working memory and interference control tasks, as well as on the communicative perspective-taking tasks.

Hierarchical regression analyses were conducted to assess how much of the relation between ADHD traits and communicative perspective-taking was explained by executive functioning. Although we sought to explicate mechanisms, we did not conduct mediation analyses, as has been done in the past (see Huang-Pollock, Mikami, Pfiffner, & McBurnett, 2009; Tseng & Gau, 2013), due to the assumption of causality that is implicit within mediation analyses

(i.e., that the mediator is 'caused' by the predictor; Baron & Kenny, 1986). Theoretical accounts posit that executive deficits give rise to ADHD symptoms, rather than being a consequence of the disorder (Crosbie, Pérusse, Barr, & Schachar, 2008). Using hierarchical regression, we were able to test our prediction that the relation between ADHD traits and communicative perspective-taking may be accounted for by weaknesses in executive functioning, without implying that ADHD traits *cause* executive function weakness per se. As no significant relations emerged between the inhibitory control measures and communicative perspective-taking, regression analyses did not include inhibitory control.

ADHD traits were entered into the regression as a first step, predicting a significant amount of variance in communicative perspective-taking performance, $F(1,37) = 8.29$, $\beta = -.43$, $p = .007$, Specifically, ADHD traits accounted for 18% of the variation in communicative perspective-taking performance. When working memory was entered in the second step alongside ADHD traits, a 13% increase in the variance of communicative perspective-taking performance was explained by the model. This change in R^2 was significant, $F(1,36) = 6.75$, $p = .013$. Together, working memory and ADHD traits accounted for 31% of the variance in communicative perspective-taking performance. When examining the regression weights of the predictors, working memory ($\beta = .43$, $p = .013$) was the only significant predictor while ADHD traits no longer significantly predicted communicative perspective-taking ($\beta = -.28$, $p = .08$). As represented in Figure 2, when the variance accounted for by working memory was controlled, the strength of the relation between ADHD and communicative perspective-taking is reduced.

Relations between ADHD traits, communicative perspective-taking, and social relationships

The second research aim was to investigate whether communicative perspective-taking accounted for a relation between ADHD traits and social relationships. Adolescents with elevated

ADHD traits rated themselves as having weaker social competencies (Table 2). However, there was a significant relationship between ADHD traits and communicative perspective-taking, and as well between communicative perspective-taking and youths' self-reported social relations. Such a pattern is indicative of mediation (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002; Woody, 2011). To further examine these relations, we performed mediation analyses in SPSS using bootstrapping with 5000 samples (Hayes & Preacher, 2014). The indirect effect between ADHD traits and social outcome, through communicative perspective-taking was significant, (β = -.16, *SE* = .12, 95% confidence interval from -.53 to -.004; Figure 3). Thus, adolescents with elevated ADHD traits have difficulty with reading the communicative intentions of speakers, which is related to worse social outcomes[4].

Discussion

The findings highlight the relations between working memory, ADHD traits, and adolescents' ability to successfully interpret intentions of conversational partners. Moreover, results underscore the importance of communicative perspective-taking for adolescents' social relationships generally.

First, adolescents with smaller working memory capacities were found to have more difficulty accurately interpreting statements based on the speakers' perspectives. Greater working memory capacity allows individuals to put more resources towards tasks that are attentionally and cognitively demanding (Just & Carpenter, 1992), such as attending to a conversational partner's perspective (Wardlow, 2013). Thus, we suspect that adolescents' working memory capacities dictated the degree to which they could manage the cognitive demands of holding in mind speaker cues while forming an interpretation of his/her statement. With greater resources available, an adolescent would be better able to hold in mind, evaluate, and ultimately choose the most accurate

interpretation of a speaker's message. Indeed, Lin and colleagues (2010) found that adults with weaker working memory tended to ignore the speaker's perspective as demonstrated by more 'egocentric' interpretations of a communicative partner's statement. The result that working memory relates to the communicative perspective-taking skills of adolescents extends previous findings that youth with more proficient executive functioning show better socio-cognitive abilities in other domains, such as affective theory of mind (Vetter, Altgassen, Phillips, Mahy, & Kliegel 2013).

Speaking to a larger theoretical debate, our results supports the notion that reading the intentions of others relies on domain-general attentional and cognitive resources (see Apperly, Samson, & Humphreys, 2005; Apperly, Riggs, Simpson, Chiavarino, & Samson, 2006). Moreover, our work supports a recent model of communicative perspective-taking which posits that while possessing mentalizing skills is important, individuals also require the support of executive functions in order to make use of this information during conversational exchanges – and, further, that weakness in executive functioning would result in difficulty with using a conversational partner's perspective (Nilsen & Fecica, 2011). This model also suggests that clinical populations where executive dysfunction was evident will demonstrate less proficient use of a conversational partner's perspective. Supporting this notion, we found that adolescents with elevated ADHD traits were less successful at detecting the communicative intentions of speakers using cues such as facial expression/tone and visual perspective. However, once working memory capacity was controlled in the analyses, ADHD traits did not significantly relate to communicative perspective-taking performance. Such a finding suggests that the cognitive mechanism underlying the relationship between ADHD traits and communicative perspective-taking may be reduced working memory capacities. That is, individuals with elevated ADHD

traits show smaller working memory capacities, which then decreases their ability to process the communicative intentions of others. This finding suggests that it is the cognitive correlates, in particular in the area of working memory, which create the socio-communicative difficulties demonstrated by adolescents with elevated ADHD traits. These findings extend previous work examining the interplay between working memory capacity, ADHD traits, and socio-communicative performance. For example, Nilsen and colleagues (2015) found that school-aged children with elevated ADHD traits had smaller working memory capacity, and that this weakness in working memory related to difficulty providing sufficient information for a conversational partner to successfully identify a target object. In addition, Tseng and Gau (2013) found that the working memory performance of 11-17 year-old youth with ADHD mediated the relation between the degree of symptomatology and caregivers' report of social behaviour. Highlighting a slightly different pattern, Kofler and colleagues (2011) found that school-age children's working memory processes related to their ADHD traits, which in turn showed a relation to their social behaviour. The present findings demonstrate that similar relations exist when focusing on a specific component of socio-communicative behaviour, that is, adolescents' ability to reason about the communicative intent of speakers.

While adolescents' performance on the interference control task related to their ADHD traits (a finding consistent with past studies, see Martel et al., 2007; Hinshaw, Carte, Fan, Jassy, & Owens, 2007; Toplak, Bucciarelli, Jain, & Tannock, 2008) we did not find that adolescents' inhibitory control related to their communicative perspective-taking performance. This is interesting to note as previous work has found that inhibitory control skills facilitate both children's and adults' ability to use the perspective of a speaker to guide interpretative choices (e.g., Brown-Schmidt, 2009; Nilsen & Graham, 2009). It may be the case that the communicative

perspective-taking tasks used in the present study, due to being presented via video, did not require as much inhibitory control as previous tasks (e.g., Nilsen & Graham, 2009), which have involved face-to-face interactions. Having more distance from the exchange may have allowed participants to be successful without requiring them to actively engage in suppressing their own perspective. However, this being said, Vetter and colleagues (2013) found that adolescents with better inhibitory control (assessed by an antisaccade task) showed better affective theory of mind, as measured by a video task. Interestingly, it was found that interference control related to adolescents' view of their social competencies, which suggests that this skill may play an important role in facilitating adolescents' ability to generally engage successfully with their peers.

Our second aim was to determine whether adolescents' communicative perspective-taking skills related to more global social relationships and whether communicative perspective-taking may account for the relation between ADHD traits and social competence found in previous studies (e.g., Bagwell et al., 2001; Sibley et al., 2010). To date, the extent to which communicative perspective-taking per se (as opposed to global communicative competencies) relates to social outcomes has not been determined, at any developmental stage. We found that adolescents who showed more successful communicative perspective-taking rated themselves as having more positive peer relations and prosocial behaviour. Proficient communicative perspective-taking could allow an adolescent to engage in more effective ways with others, for example by relying on various cues from the speaker (e.g., tone of voice, access to visual information). This ability would allow otherwise ambiguous statements to be correctly interpreted, thereby reducing miscommunication (e.g., Berman, Chambers, Graham, 2010; Nadig & Sedivy, 2001). Moreover, effective perspective-taking would allow adolescents to successfully interpret the communicative behaviour of others, which would decrease the chance that their

response would be inappropriate (e.g., the recipient of an ironic compliment would respond with more hostility if he/she interpreted the comment literally). Though, certainly the reverse pattern may also hold, that is, that more successful social experiences could allow adolescents to develop better communicative perspective-taking. Through their interactions, adolescents could be learning more about how to attend to others' perspectives (e.g., Carpendale & Lewis, 2004).

Consistent with previous research, which has relied on parent/peer report of adolescents' social abilities (e.g., Sibley et al., 2010; Tseng & Gau, 2013), we found that adolescents with elevated ADHD traits perceived themselves to have weaker social competency. Key to our research purpose, adolescents' communicative perspective-taking ability mediated this relation. That is, those adolescents with elevated ADHD traits showed weaker communicative perspective-taking (likely driven by smaller working memory capacities), which in turn related to ratings of worse social relationships. The results of the present study extend the work of Leonard and colleagues (2011) who found that, within a younger population (9- to 11-year-olds), parent-rated pragmatic language skills mediated the relation between ADHD traits and social skills problems. Thus, across the developmental span, communicative ability is one mechanism by which youth with ADHD may have worse social outcomes. It would be of interest to track the strength of the relation between communicative perspective-taking and social outcomes across development. One might expect that there is a weaker relation between communicative perspective-taking and social outcomes at earlier stages in development, but that as youth get older and the social demands are higher (particularly within the adolescent period where relationships become more complex, Bryan, Puckett, & Newman, 2013) there may be a stronger relation. Moreover, given the importance of social interactions for socio-cognitive development (see de Rosnay & Hughes, 2006), it may be that communicative perspective-taking weaknesses are exacerbated over time as

youth experience less successful peer interactions. Another avenue for future work would be to examine whether the communicative perspective-taking skills of other populations, such as those with autism spectrum disorder (ASD; e.g., Begeer, Malle, Nieuwland, & Keysar, 2010) show similar relations to executive functioning and social behaviour as demonstrated here (i.e., building on existing work examining the role of executive functioning for the social outcomes for youth with ASD, e.g., Landa & Goldberg, 2005; McEvoy et al., 1993).

Understanding the mechanisms behind social difficulties, particularly within the adolescent years, is essential to the development of successful interventions. Present findings suggest that interventions geared towards improved detection of the communicative intentions of others may be important. Indeed, past work has demonstrated that training on a collaborative computer game improves the social communication skills of children who previously showed weakness in this area (Murphy, Faulkner & Reynolds, 2014). Past work has also demonstrated the success of interventions which promote social skills and perspective training, such as the PEERS program (Laugeson, Frankel, Gantman, Dillon, & Mogil, 2012) and Social Thinking Program (Winner & Crooke, 2009). It is important to note, however, that interventions geared towards improving the social behaviour of children with ADHD improve behaviour, they tend not to influence social standing, that is, how their peers perceive them (Hoza et al., 2005; Mikami & Normand, 2015). Findings also suggest that enhancing the cognitive skills that support communicative perspective-taking, namely working memory, may be another avenue through which to bolster socio-communicative performance. Training in working memory has been shown to be beneficial for youth, including those with ADHD (e.g., Holmes et al., 2010; Klingberg et al., 2005; Klingberg, Forssberg, & Westerberg, 2002), and though not determined yet using current training programs (Simons et al., 2016), may generalize to other areas of functioning.

While findings highlight a mechanism behind communicative perspective-taking and the role of this skill for social behaviour generally, there are a few limitations to note. First, we examined a community sample, which, though providing insight into the relations between various factors, may not generalize to a clinical population. Moreover, the sample size was relatively small which does not provide us with as much power and prevented us from conducting certain analyses (e.g., latent variables). This being said, our sample size is comparable to previous work examining individual differences in communicative perspective-taking (e.g., Brown-Schmidt, 2009; Lin et al., 2010). Third, we relied on youths' reports of social outcomes, which may be biased. We used this measure to ensure that any relations with ADHD traits were not due to shared method variance, which would have been the case if we relied on parent report. This restriction is important, particularly when examining the relation between ADHD traits and other areas of functioning given that perceived difficulties in one domain may cloud judgment of other domains. Fourth, all data were collected at the same time point, which prevents the ability make strong arguments that certain factors may be downstream results of another (e.g., that elevated ADHD traits lead to difficulties with communicative perspective-taking, resulting in worse social outcomes). Further work, using longitudinal design, would allow for stronger claims about causal directions. It is also important to note that there was substantial variance that was not explained by the models. Thus, there are other factors that contribute to adolescents' communicative perspective-taking (e.g., processing speed, self-regulation, auditory attention, social experience, etc.). Related, the sample were not screened for various intellectual, adaptive, and/or social-emotional difficulties which may also have influenced their ability to infer others communicative intentions.

In summary, findings highlight the important role of working memory in facilitating adolescents' ability to accurately interpret the communicative intentions of others, with this skill accounting for the communicative perspective-taking difficulties associated with elevated traits of ADHD. Findings also underscore the importance of communicative perspective-taking for adolescents' peer relationships, as well as providing insight into the social difficulties faced by youth with elevated ADHD traits.

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Footnotes

[1] Participants were administered a receptive vocabulary task to ensure they all had sufficient verbal skills for the task. The mean standard score for the sample was 100.78 (*SD* = 13.15; skills within the Average range) and there were no statistical outliers.

[2] Using Fischer's z-test, we found that the strength of the correlation between each communicative perspective-taking task with the other measures did not differ from each other, all *p*s > .15 .

[3] Using Fischer's z-test, it was found that the relations each individual working memory task had with the social tasks did not differ from each other, even when controlling for ADHD traits (all *p*s >.20)

[4] The bivariate correlations between ADHD traits and communicative perspective taking were significant for both Inattention and Hyperactivity/Impulsivity (when examined separately), *p*s < .03. Both of the SDQ subscales Prosocial and Peer Problems were significantly related to ADHD traits (both Inattention and Hyperactivity/Impulsivity), as well as communicative perspective-taking, all *p*s <.05.

Table 1

Demographic Information and Task Performance (raw scores)

	n	*M* (*SD*)
Age	46	17 years; 1 month (16 months)
Sex	M: 23; F: 23	
Adolescents with a previous diagnosis of ADHD	7 (15%)	
Other languages spoken at home		Asian (e.g., Cantonese; *n* = 3), South Asian (e.g., Tamil; *n* = 4), European (e.g., Polish, *n* = 2), Spanish (*n* = 3), Arabic (*n* = 1).
Parent reported SNAP scores	39	Inattention: .79 (.81)
		Hyp/Impulsivity: .37 (.54)
Youth reported SDQ scores	44	Peer relations: 2.61 (2.10)
		Prosocial behaviour: 7.93 (2.07)
Working Memory Tasks		
Sentence Span (/30)	46	20.11 (1.61)
Backward Digit Span	46	8.00 (2.04)
Finger Windows	43	18.26 (3.09)
Inhibitory Control Tasks		
Stroop (correct colour-word naming)	45	103.18 (11.84)
Stop-It (SSRT in ms)	39	258.71 (84.57)
Communicative Perspective-taking (CPT)		
TASIT correct response (/40)	46	34.15 (4.21)
Computerized CPT task (proportion of correct responses)	40	.90 (.18)

Table 2

Bivariate correlations between ADHD traits, executive functioning, and communicative perspective-taking composites

	ADHD traits (SNAP-IV)	Working Memory	Inhibitory Control		Communicative Perspective-taking	Social Competence (SDQ)
			Interference control	Response Inhibition		
Age	-.17	.08	.06	-.07	-.02	.19
Working Memory	-.39**					
Inhibitory Control						
Interference Control	-.65**	.44**				
Response Inhibition	.28	-.21	-.15			
Communicative Perspective-taking	-.43**	.34*	.05	-.14		
Social Competence (SDQ)	-.46**	.14	.39*	-.19	.43**	

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

Figure 1. Example of two experimental trials on the computerized perspective-taking task. On the left, a relational trial ("Click on the top hammer."), where to be accurate, participants would have to realize that the top hammer from the speaker's perspective is the middle hammer, as the actual top hammer is blocked from her perspective. On the right, an ambiguous trial ("Click on the bat.") wherein to be accurate, participants would have to realize the speaker was referring to the baseball bat as the flying bat was blocked from view. Computer program was developed by I. Apperly and collaborators.

Figure 2. Model representing the influence of ADHD traits and WM on communicative perspective-taking.

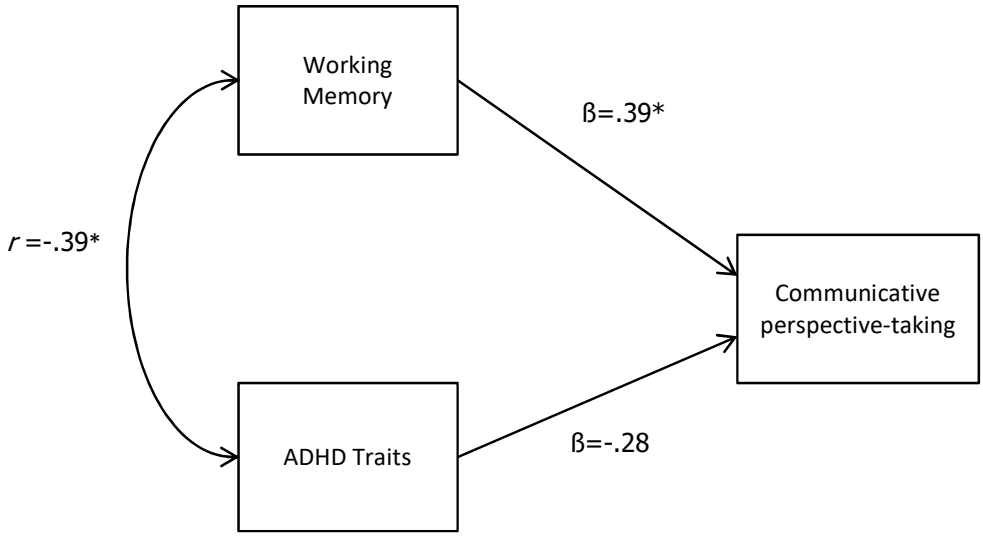

Figure 3. Mediation model for youth-reported social competence