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Brief Report

Emotion-recognition and theory of mind in high-functioning children with ASD: Relationships with attachment security and executive functioning

C. Sivaratnam[a,*], L. Newman[b,c], N. Rinehart[a]

[a] Deakin Child Study Centre, School of Psychology, Deakin University, Burwood, Victoria, Australia
[b] Centre for Womens' Mental Health, The Royal Women's Hospital, Melbourne, Victoria, Australia
[c] Department of Psychiatry, University of Melbourne, Parkville, Victoria, Australia

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ABSTRACT

This study explored the relationships that attachment security and executive functioning (EF) (working memory and inhibition) had with emotion-recognition and theory of mind (ToM) in children with high-functioning Autism Spectrum Disorder (ASD) aged between 6 and 12 years (n = 26), while controlling for cognitive ability. Group differences in attachment security were also explored in this group, compared to a typically-developing group (n = 27) matched on age and cognitive ability. Attachment security was not found to be significantly different between groups, however studies employing larger sample sizes are needed to further clarify this finding. Cognitive processes and attachment insecurity appear to relate to performance on structured behavioural measures of emotion-recognition and ToM differentially in children with high-functioning ASD and typically-developing children. Implications for the mechanisms underlying socio-emotional processes in childhood are discussed.

Executive functioning (EF) deficits are prevalent in children with ASD (Wang et al., 2017; Corbett, Constantine, Hendren, Rocke, & Ozonoff, 2009), and have been found to relate to social cognition abilities in this population, including Theory of Mind (ToM) and emotion-recognition (Torske, Nærland, Merete, Stenberg & Andreassen, 2017; Pellicano, 2010). EF is an umbrella term which refers to physical, cognitive, and emotional control and regulatory processes necessary to plan and maintain effective goal-directed behavior (Pennington & Ozonoff, 1996; Corbett et al., 2009). Dorsolateral pre-frontal cortical regions have been found to underlie EF, which include faculties of inhibition, planning, working memory, behavioral monitoring, and cognitive flexibility (Chan, Shum, Toulopoulou, & Chen, 2008; Hill, 2004; Miyake et al., 2000). Empirically-based models such as the SOCIAL model (Beauchamp & Anderson, 2010) posit that neuro-cognitive processes such as EF underlie higher-order social cognition processes. There is currently growing evidence for a positive link between social-cognition ability, commonly encompassing emotion-recognition and ToM ability, and faculties such as inhibition and working memory in cognitively-able children with ASD in early and middle childhood (Oerlemans et al., 2013; Pellicano, 2010; Pellicano, Maybery, Durkin, & Maley, 2006), independent of the influence of cognitive ability. Inhibition refers to the ability to suppress a prepotent response in favour of a novel response (Fuster, 1989), while working memory refers to the ability to process information while temporarily holding it in mind (Baddeley, 1986).

In addition to individual factors such as EF ability, theories of differential susceptibility in the TD literature posit that the environment interacts with child factors to shape socio-emotional development (Belsky & Pluess, 2009; Belsky, 2005). While findings of structural and functional cortical abnormalities in regions underlying socio-emotional functioning in ASD populations have clearly

* Corresponding author.
E-mail address: carmel.sivaratnam@deakin.edu.au (C. Sivaratnam).

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established the neural basis of such deficits in ASD (Di Martino et al., 2009; Dalton et al., 2005), the influence of environmental factors such as attachment security in shaping socio-emotional functioning alongside neurological deficits has largely been unexplored in ASD (Sivaratnam, Newman, Tonge & Rinehart, 2015). In the context of findings that attachment security can act as a protective factor against poor mental health outcomes and adjustment in typically-developing children and those with developmental disabilities (Al-Yagon, Forte, & Avrahami, 2017), together with high rates of emotional and behavioural difficulties in children with ASD, there is a need to examine the impact of attachment security on socio-emotional functioning alongside established explanations such as EF. This study provides a starting point for these explorations by examining the relationships that attachment security and EF have with ToM and emotion-recognition in ASD.

In typically-developing (TD) children, security of attachment has been positively linked to emotion-recognition ability (e.g. Steele, Steele, & Croft, 2008), which commonly encompasses the ability to identify, label, and be aware of the emotions of oneself and others (Heerey, Keltner, & Capps, 2003; Lipton & Nowicki, 2009). Secure attachments have also been positively linked to ToM ability across childhood, where ToM is conceptualised as the ability to understand and predict the beliefs, intentions, and emotional states of oneself and others (Baron-Cohen, 1989; Baron-Cohen, Leslie, & Frith, 1985). Despite the breadth of literature linking attachment security with ToM and emotion-recognition ability in TD children, little is known about the relationship that attachment security has with emotion-recognition and ToM in children with high-functioning Autism Spectrum Disorders (ASD).

Attachment refers to the relational system that infants develop with their primary caregiver, which results from the child's experiences in interacting with the caregiver across the first year of life, and drives the formation of mental representations of the self, the caregiver, and the relationship (Ainsworth, Blehar, Waters, & Wall, 1978; Bowlby, 1969, 1982). Bowlby (1987), cited in Ainsworth, 1990), suggested that representations of attachment in middle childhood tend to shift from depending on physical proximity of the caregiver for assistance as seen in infancy and early childhood, to representations and perceptions of the emotional availability of the caregiver. Some studies have purported that children with ASD are as securely attached to their caregivers as are matched TD children in middle childhood (Bauminger, Solomon, & Rogers, 2010; Chandler & Dissanayake, 2013; Sanini, Ferreira, Souza, & Bosa, 2008). Chandler and Dissanayake (2013) found that in a sample of 21 eight-to–12 year old children with Autistic Disorder and normative cognitive functioning (Full Scale IQ ≥ 70), attachment security did not differ from TD controls. Bauminger et al. (2010) investigated attachment security, social-cognitive capacities and friendships in 44 eight-to–12 year old children with ASD with normative cognitive functioning (VIQ ≥ 80) and also found no significant differences in attachment security between ASD and TD children in middle childhood.

With the exception of the above studies, the majority of studies exploring attachment in ASD have focused on children under the age of 6 and have relied largely on the measurement of attachment using the Strange Situation Procedure (Ainsworth et al., 1978). These studies suggest that although children with ASD are able to form secure attachment relationships, secure attachments may be underrepresented in this group (Capps, Sigman, & Mundy, 1994; Rogers, Ozonoff, & Maslin-Cole, 1993; Rutgers, Bakermans-Kranenburg, van Ijzendoorn, & van Berckelaer-Onnes, 2004).

Both verbal and non-verbal cognitive ability have also been found to positively relate to attachment security (Rutgers et al., 2004) as well as performance on structured measures of emotion-recognition and ToM in children with ASD (Buitelaar, van der Wees, Swaab-Barneveld, & van der Gaag, 1999; Grossman, Klin, Carter, & Volkmar, 2000). Thus, controlling for individual differences in cognitive ability when exploring the relationships that EF and attachment security have with emotion-recognition and ToM in children with ASD will enable the consolidation of relationships in this group without the confounding influence of individual differences in cognitive ability.

While some existing studies have explored the relationships that attachment and EF and have with emotional factors in ASD (Oerlemans et al., 2013; Pellicano, 2010; Bauminger et al., 2010), there has been a large focus on the early childhood focus, and no studies to date have examined and compared the influence of both factors on emotion-recognition and ToM outcomes in children with high-functioning ASD while controlling for cognitive ability within the same sample and study. Thus, the aims of this study were twofold; firstly, to assess whether there were differences between levels of attachment security, avoidance and ambivalence in children with high-functioning ASD and TD children across the middle-childhood period, spanning from 6 to 12 years of age, where the two groups were matched on overall cognitive ability. Based on previous findings by Chandler and Dissanayake (2013) and Bauminger et al. (2010), it was hypothesized that the ASD and TD groups would not differ significantly on levels of attachment security, as measured by the Kerns Security Scale (Kerns, Aspelmeier, Gentzler, & Grabill, 2001), as well as on levels of attachment avoidance and ambivalence as measured by the Attachment Style Classification Questionnaire (Finzi, Har-Even, Weizman, Tyano, & Shnit, 1996).

Secondly, this study aimed to examine the relationships that attachment security and EF have with emotion-recognition and ToM ability in ASD and TD groups, while controlling for the influence of cognitive ability on these relationships. It was hypothesized that in both ASD and TD groups, attachment security would positively correlate with emotion-recognition and ToM performance, and attachment avoidance and ambivalence would correlate negatively with emotion-recognition and ToM performance, both before and after controlling for cognitive ability. It was predicted that EF (inhibition and working memory) would positively correlate with emotion-recognition and ToM performance in both groups, before and after controlling for cognitive ability.

1. Method

1.1. Participants

53 children between 6 and 12 years of age participated in this study. The ASD group comprised 26 participants (four females and

Table 1
Age, SRS and WISC-IV Profiles of ASD and TD groups.

	Group		t-test		
	ASD (n = 26) Mean (SD)	TD (n = 27)	t	p	Cohen's d
Age	8.77 (2.00)	9.02 (1.80)	−.48	.64	.13
FSIQ	96.58 (15.75)	100.37 (8.52)	−1.10	.28	.30
VCI	100.33 (17.71)	99.07 (9.93)	.32	.75	.09
PRI	102.79 (15.37)	101.70 (11.41)	.29	.77	.08
WMI**	86.86 (14.39)	97.26 (9.23)	−3.06	.00	.86
PSI*	90.96 (13.55)	101.96 (14.15)	−2.80	.01	.79
SRS Total**	71.58 (10.67)	45.60 (5.99)	10.66	.00	3.00

Note. ASD = Autism Spectrum Disorder; TD = Typically-Developing; FSIQ = WISC-IV Full-Scale IQ; VCI = WISC-IV Verbal Comprehension Index; PRI = WISC-IV Perceptual Reasoning Index; WMI = WISC-IV Working Memory Index; PSI = WISC-IV Processing Speed Index; SRS Total = Social Responsiveness Scale Total *T*-score; SD = Standard Deviation.
*$p < .05$.
**$p < .01$.

22 males) and TD group comprised 27 participants (seven females and 20 males). Participants in the ASD group were recruited through private pediatric services in metropolitan Melbourne, as well as through AMAZE (formerly Autism Victoria). Participants in the TD group were recruited from state and independent schools in metropolitan Melbourne.

This study received ethical approval from Monash University, the Department of Education and Early Childhood Education and Monash Health. Only children with a Full-Scale IQ (FSIQ) of 70 and above were included in the study to ensure similar levels of cognitive ability between the two groups. Participants across both groups in this study met the criteria of an FSIQ of 70 or greater. Another criterion for participation was that the participant's first language was English, as the tasks and questionnaires involved this study assumed a reasonable level of English comprehension. Participants were excluded if they had previous diagnoses of comorbid neurological (e.g. epilepsy) or genetic disorders (e.g. Fragile X syndrome) other than the primary diagnosis of Autistic Disorder or Asperger's Disorder. All participants in the ASD group had previously received a DSM-IV-TR diagnosis of either Autistic Disorder or Asperger's Disorder based on extensive clinical assessments administered by experienced clinicians (eg. pediatricians, neuropsychologists, clinical psychologists) independent of this study. Table 1 displays participant characteristics by group. As seen in Table 1, ASD and TD groups did not differ significantly on age, FSIQ as well as on the Verbal Comprehension and Perceptual Reasoning indexes.

1.2. Procedure and measures

Participants and their parents attended one 2–2.5-h testing session which took place either at Monash University or at the participant's home, where the WISC-IV, attachment-security, emotion-recognition, ToM, and EF measures were administered to the child by a post-graduate level researcher experienced in conducting assessments and interventions with ASD populations.

Table 2 provides an outline and description of the measures administered. The Attachment Style Classification Questionnaire was only administered to 7-to-12-year-olds as it was observed in initial administration of the measure to three 6-year-old participants in the ASD group and three 6-year-old participants in the TD group, that the ability to comprehend some of the wording and concepts on this questionnaire was inconsistent across the 6-year-old respondents.

1.3. Data analysis

Two-tailed *t*-tests were utilized for analyses of group differences across the ASD and TD groups. Correlational analyses were conducted by group using two-tailed Pearson's correlations. All analyses utilized an alpha level of .05. Two-tailed Fisher's *z*-tests were utilized to measure differences in correlations between the ASD and control groups.

The NEPSY-II manual (Korkman, Kirk & Kemp, 2007) does not provide age-normed standard scores for the NEPSY ToM subtest for samples beyond the age of 6. Given that age-normed standard scores were not available for the NEPSY ToM subtest, partial correlations controlling for age were conducted for correlational analyses involving this variable (NEPSY ToM Total, NEPSY ToM Verbal, NEPSY ToM Contextual).

2. Results

Table 3 outlines descriptive statistics and independent samples *t*-tests for group differences on attachment security, emotion recognition, ToM and EF variables. The *t*-tests revealed that there were no significant group differences on attachment security as measured by the KSS, attachment avoidance as measured by the ASCQ Avoidant subscale, and attachment anxiety as measured by the ASCQ Anxious/Ambivalent subscale. Nevertheless, a medium effect size was noted for group differences on the KSS, where the ASD group scored lower on attachment security. Similarly, while there were no significant group differences across emotion-recognition,

Table 2
Summary and Description of Study Measures.

Measure	Description
Kerns Security Scale (KSS) (Kerns et al., 2001)	• 15-item self-report measure used to assess children's perceptions of attachment security in caregiver-child relationships between middle childhood and early adolescence. • Individual items are rated on a 4-point scale with higher scores indicating a more secure attachment. • Individual items yield an overall score (ranging from 15 to 60) on a single, continuous dimension of security, based on the average of the item scores, with higher scores indicating a more secure attachment. • The KSS has been used reliably in ASD populations (eg. Bauminger et al., 2010), and appeared to have good internal consistency in the present study, α = .80.
Attachment Style Classification Questionnaire (ASCQ) (Finzi, Cohen, Sapir, & Weizman, 2000; Finzi, Har-Even, Weizman, Tyano, & Shnit, 1996)	• 15-item self-report measure measuring children's perceptions of attachment security with close others, including peers. • Respondents rate on a 5-point Likert scale ranging from 1 (not at all) to 5 (very much), the extent to which each item characterizes them. • Individual item scores yield three subscale scores based on Ainsworth's three attachment patterns: secure, anxious/ambivalent, and avoidant. Only the avoidant and anxious/ambivalent subscale scores were computed, in line with recommendations that measuring continuous dimensions of attachment security and insecurity enables greater validity in measurement than the categorical assignment of attachment classifications (Finzi-Dottan, Manor and Tyano, 2006; Brennan, Clark, & Shaver, 1998). • Higher scores on the Avoidance and Anxious/Ambivalent subscales indicate higher avoidance or higher anxiety respectively. • The ASCQ has been reported to have good internal consistency (Finzi-Dottan, Cohen, Iwaniec, Sapir, & Weizman, 2006). In the current study, the 2-subscale ASCQ (avoidant and anxious/ambivalent subscales) appeared to have good internal consistency, α = .71.
NEPSY-II Affect Recognition subtest (NEPSY AR) (Korkman, Kirk, & Kemp, 2007).	• Measures the child's ability to recognize emotional facial expressions (happiness, sadness, anger, fear, disgust, and neutral). • The child is shown pictures of children with different emotional expressions, and is asked to match two faces expressing the same emotion out of three or more alternatives. Higher scores indicate greater affect-recognition ability. • Raw scores obtained were converted to corresponding age-normed scaled scores (*M* = 10; *SD* = 3).
NEPSY-II Theory of Mind (NEPSY ToM) (Korkman et al., 2007)	• The NEPSY ToM was selected due to its ability to measure both verbal and contextual aspects of Theory of Mind. • The verbal domain measures the understanding of others' beliefs and intentions, as well as comprehension of figurative language. Items comprised verbal scenarios with (six items) or without (11 items) pictures. Two items also measured the child's verbal and gestural imitation abilities as imitation abilities are thought to be a background factor for the ToM. With the exception of the imitation question, responses are provided verbally, and can be provided by pointing for 2 items. • The 5-item contextual domain measures the child's ability t understand link understand and link emotions to social contexts., For each item, the child is shown a drawing of a social scenario, and is asked to point to one of four photographs, (each depicting either happiness, sadness, anger, fear, disgust and neutral emotion) which best depicts how the child in the social scenario feels. Responses can be provided by pointing or providing a verbal response. • The NEPSY-II provides non-continuous percentile ranges rather than standard scores for this subtest, so raw scores from this subtest were used in analyses. Higher scores indicate greater ToM ability. • Given that age-normed standard scores were not provided for the NEPSY ToM variable, age was included as a control variable in all correlational analyses involving NEPSY ToM.

(*continued on next page*)

Table 2 (*continued*)

Measure	Description
NEPSY-II Inhibition subtest (NEPSY Inhibition) (Korkman et al., 2007)	● Evaluates the child's ability to inhibit automatic responses and to shift between automatic and inhibitory response types during naming of visual stimuli. – In the Naming condition (NEPSY INN), the child is shown black and white shapes or arrows and is instructed to name the shape of squares and circles or the up or down direction of arrows within a specified time limit. – When the child has completed the Naming condition, the Inhibition condition (NEPSY INI) is administered, where the child is required to provide the opposite naming response on the same stimuli within a specified time limit, by inhibiting the prepotent response in favour of a novel response. An error is considered to have occurred when a child provides an incorrect response, even if he/she subsequently self-corrects an incorrect response. The child's completion time for each condition was measured (with a 4-min time-limit). – In each of the two conditions, the completion time and number of errors are combined to provide an age-normed scaled score for each child. ● Each child completed the initial Naming condition and a subsequent Inhibition condition. ● The NEPSY-II subtests have adequate-to-high internal consistency, test-retest reliability, validity, and interscorer agreement (Korkman et al.).
Wechsler Intelligence Scale for Children–Fourth Edition (WISC-IV) (Wechsler, 2003)	● Measures cognitive ability and intellectual functioning. ● Age-normed scaled scores from the 10 core subtests ($M = 10$, $SD = 3$) generate four index scores, namely, the Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Processing Speed Index (PSI) and Working Memory Index (WMI), as well as an index of overall cognitive ability derived from the four index scores, the Full-Scale IQ score (FSIQ) ($M = 100$, $SD = 15$). ● The WMI, which comprises three core tasks, namely, Digit Span-Digits Forward, Digit Span-Digits Backward and Letter-Number Sequencing was used as a measure of working memory. The tasks on the WMI measure short-term auditory memory, particularly the child's ability to attend to, mentally manipulate and sequence numbers and letters.

Table 3
Emotion-recognition, ToM, EF and Attachment Security Profiles of ASD and TD groups.

	Group		*t*-test		
	ASD ($n = 26$) Mean (SD)	TD ($n = 27$)	t	p	Cohen's d
NEPSY AR	10.40 (2.68)	11.23 (2.07)	−1.24	.22	.35
NEPSY ToM Total	20.39 (3.91)	20.41 (4.24)	−.01	.99	.00
NEPSY ToM Verbal	15.83 (3.26)	15.81 (3.72)	.01	.99	.01
NEPSY ToM Contextual	4.58 (1.06)	4.59 (1.08)	−.03	.98	.01
NEPSY INN	8.54 (4.23)	9.74 (3.88)	−1.06	.30	.30
NEPSY INI	8.70 (3.66)	10.44 (2.81)	−1.91	.06	.53
ASCQ Av[a]	13.41 (3.34)	13.15 (3.79)	.22	.83	.07
ASCQ Anx/Ambi[a]	13.82 (5.64)	13.40 (3.53)	.28	.78	.09
KSS	42.96 (8.04)	46.04 (7.52)	−1.38	.17	.40

Note. ASD = Autism Spectrum Disorder; TD = Typically-Developing; NEPSY AR = NEPSY Affect Recognition; NEPSY ToM Total = NEPSY Theory of Mind Total; NEPSY ToM Verbal = NEPSY Theory of Mind Verbal; NEPSY ToM Contextual = NEPSY Theory of Mind Contextual; NEPSY INN = NEPSY Inhibition-Naming; NEPSY INI = NEPSY Inhibition-Inhibition; ASCQ Av = ASCQ Avoidant subscale; ASCQ Anx/Ambi = ASCQ Anxious/Ambivalent subscale; KSS = Kerns Security Scale; SD = Standard Deviation.
$^{*}p < .05$; $^{**}p < .01$.
[a] $n_{ASD} = 17$, $n_{Control} = 20$.

ToM and EF variables, medium effect sizes were observed in group differences on the NEPSY AR and NEPSY INN scores, and a large effect size was observed in the difference between the ASD and control group on NEPSY INI scores, where the ASD group performed more poorly than the control group across these variables.

Table 4 outlines two-tailed Pearson's correlations separately for both groups illustrating relationships between attachment security variables (KSS, ASCQ Avoidant, ASCQ Ambivalent), emotion-recognition (NEPSY AR) and EF variables (NEPSY INN, NEPSY INI, WISC WMI). Two-tailed partial correlations controlling for age are displayed for NEPSY ToM variables (NEPSY ToM Total, NEPSY ToM Verbal and NEPSY ToM Contextual).

In the ASD group, there was a strong, positive correlation between WISC WMI and NEPSY ToM Total (r (17) = .61, $p = .006$, $r^2 = .37$, two-tailed) and between WISC WMI and NEPSY ToM Verbal (r(17) = .59, $p = .007$, $r^2 = .35$, two-tailed), indicating that better working memory ability was related to higher overall as well as verbal ToM performance in this group. Two-tailed Fisher's z-

Table 4
Pearson's Correlations of Affect Recognition, ToM, Attachment Security and EF Measures.

Variable	1	2	3	4	5	6	7	8	9	10
r (n)										
1 NEPSY AR	-	.31 (26)	.35 (26)	.29 (26)	**.55**** (24)	.24 (23)	.25 (21)	-.18 (17)	.14 (17)	-.26 (24)
2 NEPSY ToM Total[a]	-.16 (27)	-	**.95**** **(23)**	**.70**** **(23)**	.02 (23)	-.23 (23)	**.61**** **(20)**	.01 (17)	-.02 (17)	-.24 (23)
3 NEPSY ToM Verbal[a]	-.18 (27)	**.94**** **(27)**	-	**.46*** **(23)**	-.04 (23)	-.19 (23)	**.59**** **(20)**	-.10 (17)	-.21 (17)	-.24 (23)
4 NEPSY ToM Contextual[a]	-.02 (27)	**.44*** **(27)**	.11 (27)	-	.16 (23)	-.23 (23)	.36 (20)	.24 (17)	.45 (17)	.22 (24)
5 NEPSY INN	-.04 (25)	-.01 (27)	-.04 (27)	.06 (27)	-	**.57**** **(23)**	.12 (21)	-.31 (17)	-.08 (17)	.19 (23)
6 NEPSY INI	.30 (26)	-.04 (27)	.05 (27)	-.24 (27)	.09 (27)	-	-.13 (20)	-.12 (17)	.22 (17)	.23 (23)
7 WISC WMI	.19 (26)	.29 (26)	.26 (27)	.15 (27)	-.02 (27)	.22 (27)	-	-.13 (15)	.11 (15)	.18 (21)
8 ASCQ Av	.21 (19)	.20 (20)	.12 (20)	.24 (20)	.23 (20)	.01 (20)	-.30 (20)	-	.35 (17)	-.30 (17)
9 ASCQ Anx/Ambi	.40 (19)	-.02 (17)	-.21 (17)	.33 (20)	-.19 (20)	.34 (20)	-.02 (20)	.34 (20)	-	-.26 (17)
10 KSS	-.00 (23)	.22 (23)	.20 (23)	.10 (24)	.29 (24)	-.07 (24)	.16 (24)	-.16 (19)	-.40 (19)	-

Note. Correlations in bold refer to statistically significant relationships ($p < .05$). Correlations shaded in grey pertain to the control group, and correlations without shading pertain to the ASD group. NEPSY AR = NEPSY Affect Recognition; NEPSY ToM = NEPSY Theory of Mind; ASCQ Av = ASCQ Avoidant subscale; ASCQ Anx/Ambi = ASCQ Anxious/Ambivalent subscale; KSS = Kerns Security Scale; NEPSY INN = NEPSY Inhibition-Naming Component; NEPSY INI = NEPSY Inhibition-Inhibition Component; WISC WMI = WISC-IV Working Memory Index.
*$p < .05$. **$p < .01$.
[a]Partial correlations controlling for age were computed for this variable.

tests indicated that these correlations were significantly higher in the ASD group than in the control group, $z = 1.28$, $p < .05$, and $z = 1.30$, $p < .05$ respectively. There was also a strong, positive correlation between NEPSY INN scores and NEPSY AR scores ($r(22) = .55$, $p = .005$, $r^2 = .30$) in the ASD group that was significantly higher than that of the control group, $z = 1.90$, $p < .05$, two-tailed. After controlling for WISC FSIQ, a moderate positive correlation was still observed between INN and NEPSY AR scores in the ASD group, $r(21) = .46$, $p = .03$, $r^2 = .21$. This finding indicated that performance on the Naming component of the NEPSY Inhibition task was positively related to emotion-recognition ability even after controlling for the influence of cognitive ability on this relationship.

No other significant correlations were found between NEPSY INI and WISC WMI variables and NEPSY AR and ToM scores in either group. In both groups, no significant correlations were found between the KSS, ASCQ Avoidant, ASCQ Anxious/Ambivalent scores and scores on the NEPSY AR and ToM variables. Despite not reaching statistical significance, a number of correlations between EF and Attachment variables and Affect Recognition and ToM variables in the ASD and TD groups indicated medium effect sizes.

In the ASD group, there was a moderate, positive correlation between WISC WMI and NEPSY ToM Contextual, r (17) = .36, p = .13, r^2 = .13, two-tailed. This correlation was found to be significantly higher than that of the control group, $z = 0.71, p > .05$, two-tailed. In the control group, there was moderate, positive correlation between NEPSY INI and NEPSY AR scores (r(24) = .30, p = .14, r^2 = .09, two-tailed), which was significantly higher than that of the ASD group ($z = 0.21, p > .05$).

Moderate, positive correlations were noted between ASCQ Anxious/Ambivalent and NEPSY ToM Contextual scores in both the ASD (r(14) = .45, p = .08, r^2 = .20, two-tailed) and control groups (r(17) = .33, p = .16, r^2 = .11, two-tailed). A two-tailed Fisher's z-test indicated that the correlation between NEPSY ToM Contextual and ASCQ Anxious/Ambivalent scores were significantly higher ASD group in comparison to the control group ($z = 0.39, p < .05$). There was also a moderate, positive correlation between ASCQ Anxious/Ambivalent and NEPSY AR scores in the control group (r (17) = .40, p = .09, r^2 = .16, two-tailed), which was significantly higher than that of the ASD group, $z = 0.77, p < .05$.

3. Discussion

This study aimed to assess whether there were differences between levels of attachment security in children with high-functioning ASD and TD children in middle childhood when groups did not differ on cognitive ability. A further aim of the study was to assess the relationships that attachment security and EF had with emotion-recognition and ToM ability in ASD and TD groups, while controlling for the influence of cognitive ability on these relationships by group.

As predicted, ASD and TD groups were not found to be different in levels of attachment security on the KSS, as well as in levels of attachment avoidance or anxiety/ambivalence on the ASCQ, indicating that children with high-functioning ASD may be as securely attached as TD children with similar cognitive abilities. This finding corroborates existing findings that in children with high-functioning ASD, levels of attachment security are comparable to TD controls in middle childhood (Bauminger et al., 2010; Chandler & Dissanayake, 2013). Nevertheless, given that a medium effect size was detected in group differences on attachment security on the KSS, it is possible that the small sample size in this study hindered the elucidation of group differences in attachment security between groups. Future studies comparing larger sample sizes of cognitively-able ASD and TD samples will be useful in clarifying possible differences in attachment security these groups.

In the ASD group, working memory was strongly and positively related to ToM ability as hypothesized, providing support to previous studies of TD and ASD children which suggested that the ability to hold information in mind while processing this information is positively related to the ability to understand and correctly attribute mental states to oneself and others (Oerlemans et al., 2013; Gordon & Olson, 1998; Joseph & Tager-Flusberg, 2004), as well as to theoretical models postulating a link between EF and social cognition capacities, such as the SOCIAL model (Beauchamp & Anderson, 2010). Another factor which may have accounted for findings of a ToM-working memory link in this study may be associated with the memory demands on the NEPSY ToM task, where studies have found that memory faculties such as short-term phonological memory are linked to ToM performance (Schaeffer, Van Witteloostuijn, & Creemers, 2017; Holmer, Heimann, & Rudner, 2017). While working memory was significantly more strongly correlated with overall ToM ability and verbally-based ToM tasks than with the contextual component of ToM in the ASD group, a medium effect size for the latter correlation, albeit not reaching statistical significance, suggests that to different extents, both verbal and non-verbal aspects of ToM are impacted by working memory. The specific relationship found between working memory and the verbal component of the ToM task utilized in this study suggests that the metacognitive ability to hold information in mind and manipulate this information may be more salient to contexts requiring verbally-based processing of socio-emotional stimuli rather than those involving non-verbal socio-emotional input. Further, current empirical findings indeed highlight that linguistic skills are heavily underpinned by verbal working memory skills (Wang et al., 2017; Baixauli-Fortea, Miranda Casas, Berenguer-Forner, Colomer-Diago, & Roselló-Miranda 2017). The demands of WISC-IV working memory tasks on linguistic comprehension and expression skills as well as auditory and phonological processing skills may account for the current finding of the working memory and verbal ToM link in the ASD group, but not a working-memory and contextual ToM link. This finding, together with past empirical findings that linguistic skills are linked to verbal working memory highlight the importance of distinguishing between measures capturing verbal working memory and working memory more broadly when exploring the impact of working memory on ToM skills in future studies. Future studies should also explore the mediating impact of language skills on the relationship between ToM and working memory.

It is important to note that since the measure of working memory (WISC WMI) used in this study comprised part of the overall cognitive ability measure (WISC FSIQ), the influence of overall cognitive ability could not be controlled for when examining relationships between working memory and ToM. Consequently, this correlation should be taken as a preliminary indication of the relationship between working memory and ToM in ASD groups, where future studies should aim to further clarify this relationship using alternative measures of working memory where overall cognitive ability can be controlled for.

There was a moderate positive relationship between inhibitory control (as measured by the Inhibition (INI) component of the NEPSY Inhibition task) and emotion-recognition only seen in the control group, which closely approached statistical significance, aligning with predictions and past findings indicating a link between ToM and the ability to inhibit a prepotent response in favour of a novel response in TD children (Carlson et al., 2004), but contrasting with similar findings in school-aged children with high-functioning ASD (Joseph & Tager-Flusberg, 2004). Findings of links between working memory and ToM in the ASD group, taken together with the findings that inhibitory control did not correlate with ToM or emotion-recognition in this group lend further support to the empirical notion that metacognitive executive functioning capacities in particular, rather than behavioural regulation aspects of EF, may positively predict social cognitive capacities (Torske et al., 2017) in ASD populations. A study by Leung et al. (2016) comparing relationships between EF and social impairment in groups of children with ASD and TD children suggested that there may be a distinct link between metacognitive executive function (working memory, planning, organization and initiation) and social functioning in ASD populations that is not present in TD groups.

The naming component of the Inhibition task (INN), which was administered as a prerequisite to the Inhibition task on the NEPSY-II, was found to be strongly and positively related to emotion-recognition ability in the ASD group, both before and after controlling for overall cognitive ability. This relationship persisted and decreased in strength only slightly when controlling for cognitive ability, supporting studies suggesting that while cognitive ability influences emotion-recognition ability, the relationship between emotion-recognition and the speed and accuracy of labelling persists independently of cognitive ability in children with high-functioning ASD (Pellicano et al., 2006; Joseph & Tager-Flusberg, 2004). Although the NEPSY AR task used in this study did not require verbal labelling of emotions, but rather, the non-verbal matching of emotions, the link found between the naming of general, non-emotional stimuli (shapes as well as directions of arrows) and non-verbal emotion-recognition suggests that an underlying deficit in the speed and accuracy of labelling can contribute to difficulties in accurately recognizing the emotions of others even in instances where explicit verbal labelling is not required. Accordingly, verbal concepts associated with various emotions have been found to play a role in non-verbal emotion-matching tasks (Rosenqvist et al., 2014).

Contrary to predictions, in both the ASD and TD groups, neither attachment security as measured by the KSS, nor attachment avoidance and ambivalence as measured by the ASCQ, were significantly related to performance on the emotion-recognition and ToM tasks. While past studies of TD children have proposed a link between attachment and the ability to recognize and understand emotions, it has also been suggested that while pre-verbal attachment interactions influence subsequent emotion-recognition ability, with the development of general cognitive and verbal capacities from infancy to middle childhood, emotion-recognition ability in middle childhood may be influenced by factors beyond exclusively the domain of the infant–caregiver relationship, such as general social-cognitive abilities and learning (Steele et al., 2008; Steele et al., 2003). Nevertheless, despite not reaching statistical significance, a number of moderate correlations pertaining to attachment anxiety across both groups were noted, where the small sample size may have hindered the elucidation of significant relationships. Specifically, higher levels of anxious attachment were related to better contextual ToM ability in both groups, where this relationship was found to be stronger in the ASD group than in the control group. Current theoretical and empirical support exists for the notion that children with higher levels of attachment anxiety tend to be more pre-occupied with their environment than securely attached children in relation to anxiety about the availability of their caregiver (Ainsworth et al., 1978; Bowlby, 1973; Dubois-Comtois, Moss, Cyr, & Pascuzzo, 2013). Consequently, this vigilance towards the environment may lead to a greater focus on or level of attention to the emotions, beliefs and intentions of others, thus accounting for better emotion-recognition and ToM abilities than securely or avoidantly attached children.

In the ASD group, it is also notable that while attachment anxiety was linked to the aspect of ToM that did not rely on verbal ability in the current investigation (ToM Contextual), the factor correlated with the ToM Verbal component in this group was working memory, not attachment anxiety. This finding suggests that Steele et al.'s (2008, 2003 position that socio-cognitive capacities in middle childhood may be impacted by an interplay of attachment and cognitive factors may also be relevant in ASD populations, by highlighting that while attachment insecurity may impact on specific aspects of ToM abilities, other more language-dependent aspects of ToM may be mediated by neuro-cognitive factors such as executive functioning.

Further, the finding that higher attachment anxiety was linked to better emotion-recognition ability on the NEPSY in the control group but not in the ASD group supports past findings that with increasing age, there may be shift across childhood in TD groups, from a reliance on effortful neurocognitive strategies to less deliberate and cognitively-based processing of emotion (Neumann, Spezio, Piven, & Adolphs, 2006; Lerner et al., 2013).This may also account for current findings of both EF and attachment being linked to emotion-recognition in the control group, but only EF (Naming) being linked to emotion-recognition in the ASD group. Furthermore, contrary to predictions and past studies suggesting a link between EF and ToM (Carlson et al., 2004) in TD preschool children, no relationships were found between EF and ToM in the current TD sample. These findings further support past research postulating more automatic, perceptual processing in children, adolescents and adults with typical-development in comparison to relatively more effortful, deliberate cognitive processing of emotions in ASD (Neumann et al., 2006; Lerner et al., 2013).

Although comparable to studies in this area (Chandler & Dissanayake, 2013; Capps et al., 1994), the sample size for this study remained small, which may have hindered the elucidation of group differences and correlations. While non-significant findings with at least moderate effect sizes discussed should therefore be interpreted with caution, the effect sizes found in this study indicate the need for further in-depth explorations of attachment security as well as relationships between attachment, EF and socio-emotional functioning in ASD populations. Moreover, while self-report questionnaires have been found to be reliable measures of attachment security in middle childhood, in this study, the measurement of attachment security was reliant solely on the self-report of the child, thus creating the potential for biases of child, such as the positive illusory bias (Owens, Goldfine, Evangelista, Hoza, & Kaiser, 2007) to mar the objective measurement of attachment relationships. Furthermore, while self-report measures have been found to be reliable in the measurement of formal attachment categorisations in middle childhood in both ASD and TD children, such structured measures may not detect subtler differences in attachment behaviours or perceptions between groups (Grzadzinski, Luyster, Spencer, & Lord, 2014). Future studies should focus on in-depth qualitative explorations of the nature and dynamics of attachment relationships in families with children with ASD, through, for instance, behavioural observations and attachment interviews with both the caregiver and the child. Lastly, community-based diagnoses of ASD were not verified via the reviewing of diagnostic reports in this study. Future studies should review past diagnostic reports for individual participants to ensure diagnostic confirmation within the ASD sample. Furthermore, a number of past studies have demonstrated that children and adults with ASD may utilize compensatory strategies to pass structured behavioural measures of emotion-recognition and ToM (Neumann et al., 2006; Harms, Martin, & Wallace, 2010). Future studies utilizing behavioural measures closely resembling naturalistic settings as well as parent and teacher reports of everyday functioning will be useful in exploring relationships between attachment security and everyday socio-emotional functioning.

In conclusion, rates of attachment security in children with high-functioning ASD do not appear different from those of TD children in middle-childhood when cognitive ability does not differ between groups, however future studies with larger sample sizes are needed to further clarify this finding. Naming or labelling abilities, rather than attachment security, appear to relate to performance on structured behavioural measures of emotion-recognition in children with high functioning ASD, while both attachment and executive functioning (attachment anxiety and inhibition) may impact on emotion-recognition abilities in TD populations. While Working Memory was found to strongly relate to Theory of Mind abilities and in particular, verbal-based Theory of Mind in ASD, this study indicates that attachment factors, in particular attachment anxiety, may impact on less verbally-based Theory of Mind capacities in ASD, and to a lesser extent in TD groups. Further investigations of the relationships between attachment security and everyday socio-emotional functioning with larger sample sizes beyond structured experimental paradigms will aid in consolidating the influence of relational functioning on the naturalistic ToM and emotion-recognition impairments identified in ASD populations.

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