Reduced Motor Interference in Preschoolers with Autism Spectrum Disorder and Williams Syndrome

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ABSTRACT

Motor interference occurs when action execution is hindered by the observation of an incongruent action. The present study used a novel eye-tracking paradigm to test the motor interference effect in 22 preschoolers with autism spectrum disorder (ASD), 14 preschoolers with Williams syndrome (WS), and 18 typically developing (TD) peers. In TD children, performance of a pre-determined action was slower after the observation of an incongruent motor action and faster following observation of a congruent motor action, indicating a motor interference effect. In both the ASD and WS groups, performance was unaffected by the congruent versus incongruent nature of the observed motor action.

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There is an increasing interest in the role played by the motor system on social cognition, both in typical development and in disorders affecting motor and social behavior, such as autism spectrum disorder (ASD) and Williams syndrome (WS) (Casartelli, Molteni, & Ronconi, 2016; Gallese & Rochat, 2018; Williams, 2008). Recent research in the area has focused on the phenomenon of ‘motor interference’, i.e., the decrease in motor performance that occurs when observing and executing incongruent actions (Brass, Bekkering, & Prinz, 2001; Brass, Bekkering, Wohlschlager, & Prinz, 2000; Kilner, Paulignan, & Blakemore, 2003). In a motor interference paradigm, participants are typically asked to execute a pre-specified action, such as opening their hand, during, or immediately after, observation of an opening hand movement (congruent condition) or a closing hand movement (incongruent condition; Edwards, Humphreys, & Castiello, 2003; Krishnan-Barman, Forbes, & Hamilton, 2017). Execution in the incongruent condition is typically slower and more prone to error, a phenomenon believed to reflect the co-activation of conflicting sensorimotor representations (Blakemore & Frith, 2005; Kilner et al., 2003; Prinz, 1990). Motor interference/facilitation has been documented across age ranges, including preschool age (Saby et al., 2011; van Schaik, Endedijk, Stapel, & Hunnius, 2016), school age (Liuzza, Setti, & Borghi, 2012; O’Sullivan et al., 2018) and adulthood (Bouquet, Shipley, Capa, & Marshall, 2011; Stanley, Gowen, & Miall, 2007), with no apparent effect of age when different age groups are compared (O’Sullivan et al., 2018). Conversely, factors appearing to modulate the interference effect include whether the observed actions reflect a biological versus ‘artificial’ motion and the degree of similarity and affiliation between observer and agent executing the actions (Krishnan-Barman et al., 2017; Marshall, Bouquet, Thomas, & Shipley, 2010; van Schaik et al., 2016).

Recent theoretical frameworks propose a link between motor interference and social cognition (Blakemore & Frith, 2005; Sommerville & Decety, 2006), based on the reasoning that (1) facilitation of motor execution in the congruent condition and interference in the incongruent condition are indexes

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of a common coding for action execution and observation, whereby observation of actions activates the same motor programs used to execute the observed action (Gallese, Fogassi, Fadiga, & Rizzolatti, 2002; Prinz, 1990); (2) such ‘action-perception coupling’ (thought to be implemented by the mirror neuron system; Rizzolatti & Fogassi, 2014) is foundational to social understanding and other social dimensions such as empathy and imitation, as it presumably allows the observer to understand others’ behaviors ‘as if’ he or she is engaging in the same behavior (Gallese, 2007; Rizzolatti & Sinigaglia, 2008; see Pulvermüller, Moseley, Egorova, Shebani, & Boulenger, 2014; for a review on the empirical evidence for this perspective). A corollary of this theoretical framework is that motor interference can provide insight into neurodevelopmental disorders associated with impairments in social cognition, such as ASD and WS (Becchio & Castiello, 2012; Gowen, Stanley, & Miall, 2008).

ASD, estimated prevalence 1:59, (Baio et al., 2018) is a neurodevelopmental disorder characterized by core impairments in social communication and reciprocity and behavioral flexibility. Motor difficulties are also frequently reported in this population (Hocking & Caeyenberghs, 2017; Esposito & Vivanti, 2013). The theoretical proposal that social symptoms of ASD might be linked to abnormalities in the ‘action-perception coupling’ process that underlies motor interference (Iacoboni & Dapretto, 2006; Williams, Whiten, Suddendorf, & Perrett, 2001) has lead several scholars to investigate motor interference in this population. The first study in the area (Gowen et al., 2008) reported no differences in motor interference between adults with and without ASD in a task assessing execution of actions congruent or incongruent with observed arm movements. Similar results were reported by Grecucci et al. (2013) in a study involving school-age children with ASD, and by Press, Richardson, and Bird (2010), in a task testing motor interference in response to congruent/incongruent emotional expressions in adults with ASD.

Conversely, a recent study by Cook, Swapp, Pan, Bianchi-Berthouze, and Blakemore (2014) documented a lack of motor interference in adults with ASD in a task examining execution of pre-specified arm movements during observation of incongruent movements. Finally, some studies have reported increased motor interference in adults with ASD (Bird, Leighton, Press, & Heyes, 2007; Deschrijver, Wiersema, & Brass, 2017; Sowden, Koehne, Catmur, Dziobek, & Bird, 2016; Spengler, Bird, & Brass, 2010). Spengler et al. (2010) also showed a positive correlation between the magnitude of motor interference and social-cognitive deficits in individuals with ASD, whereas no relationship was found between motor interference and social cognition amongst the typically developing controls.

The mixed pattern of results reported above may reflect variability in task presentation and stimulus content. Individuals with ASD often show reduced or atypical visual attention to stimuli that are presented to them during experimental tasks, particularly those involving social content (e.g., facial features, emotional displays; Klin et al., 2015). Altered gaze patterns in response to social stimuli have been shown to influence task performance in imitation and motor tasks (Gonsiorowski, Williamson, & Robins, 2016; Vivanti et al., 2011; Vivanti, Trembath, & Dissanayake, 2014). Therefore, it is possible that stimuli that differed in social content (e.g., a surprised facial expression in Press et al., 2010; finger lifting movements in Spengler et al., 2010) elicited different attentional patterns and therefore affected performance of participants with ASD differently across studies.

Less is known about motor interference in individuals with WS, a rare neurodevelopmental disorder (estimated prevalence of 1:7500–1:20,000; Stromme, Bjornstad, & Ramstad, 2002) characterized by mild to moderate intellectual disability, visuospatial impairments, and an increased drive for social approach (Brock, Einav, & Rivy, 2009; Hocking & Caeyenberghs, 2017; Karmiloff-Smith, 2007). Despite their socially disinhibited personality, individuals with WS present with social cognitive difficulties, including impairment in joint attention, social reasoning, and pragmatic aspects of language (Skwerer et al., 2013; Vivanti, Fanning, Hocking, Sievers, & Dissanayake, 2017c). Motor impairment is also frequently observed in this population (Hocking, Bradshaw, & Rinehart, 2008). The atypical social and motor profile of individuals with WS has been linked to disruptions in the ‘action-perception coupling’ process thought to underlie motor interference, a notion supported by preliminary evidence on structural abnormalities in the mirror neuron system.
in this population (Jarvinen, Korenberg, & Bellugi, 2013; Ng et al., 2016). However, there have been no studies to date that have investigated motor interference in individuals with WS.

In light of the theoretically proposed link between motor interference and social cognition in typical development and neurodevelopmental disorders affecting social cognition, the aim in the current study was to investigate motor interference in TD preschoolers as compared to those with ASD and WS. To date, no research on motor interference has been undertaken with very young children with these conditions nor have there been any cross-syndrome studies to elucidate the mechanisms underlying motor interference and its relationship to social cognition. Research on individuals with neurodevelopmental disorders at a younger age allows the investigation of basic processing abnormalities before these are clouded by atypical compensatory strategies, and minimize the potential confounding factor of learning history on task performance (Anagnostou, Bear, & Dawson, 2011; Rodgers et al., 2012).

Based on the theorized link between motor interference and social cognition, our working hypotheses were that children with ASD and those with WS would show reduced motor interference compared to TD children, and that the motor interference effect would be associated with measures of social functioning across groups.

**Methods**

**Participants**

The sample comprised 22 preschoolers with ASD, 14 preschoolers with WS, and 18 TD children who were matched on chronological age and, in the case of the ASD and WS groups, cognitive and language level (see Table 1 for sample characteristics). Six additional participants (four in the ASD group and one each in the WS and TD groups) were initially recruited but refused to engage with the task materials, and were thus excluded from the current study.

Participants with ASD were recruited through the Victorian Autism Specific Early Learning and Care Centre, an intervention program located at the La Trobe University Community Children’s Centre. Participants with WS were recruited through the Williams Syndrome Family Support Group (Victoria) and the Williams Syndrome Association Australia. The TD participants were recruited through childcare services located at La Trobe University and Macquarie University. Parents provided informed consent after reading a participant information statement about the study, and ethics approval was provided by the La Trobe Human Ethics Committee (reference no. 14–007). Diagnoses of ASD were previously made by community-based health care professionals and confirmed using the Autism Diagnostic Observation Schedule (ADOS 2, Lord et al., 2012), administered by a clinician with demonstrated reliability in the use of this measure.

All participants in the WS group had their diagnosis confirmed with the positive fluorescent in situ hybridization (FISH) test and displayed the typical ~1.6 Mb heterozygous microdeletion at 7q11.23 (Porter et al., 2012). Exclusion criteria across groups included the presence of uncorrected hearing or vision impairment, the presence of major medical problems, and lack of cooperation/refusal to engage in the experiment.

Participants’ cognitive level was assessed using the Mullen Scales of Early Learning (MSEL; Mullen, 1995), and their adaptive behavior was tested using the Vineland Adaptive Behavior Scales (VABS; Sparrow, Balla, & Cicchetti, 2005). As subscale raw scores in the MSEL for most participants in the clinical groups fell outside standard ranges for calculation of T scores, following previous research (e.g., Lord et al., 2006) developmental quotient (DQ) scores were obtained from the MSEL scores according to the formula: DQ = age equivalent scores/chronological age × 100, and averaged to create an overall DQ, a verbal DQ (encompassing the receptive and expressive language subscales), and a non-verbal DQ (encompassing the visual reception and fine motor subscales).

Finally, the Social Communication Questionnaire (Rutter, Bailey, & Lord, 2003) a parent-reported measure of social communication skills, was administered to all participants. As can be seen in
<table>
<thead>
<tr>
<th></th>
<th>ASD (N = 22)</th>
<th>WS (N = 14)</th>
<th>TD (N = 18)</th>
<th>T-test p-value ASD vs WS</th>
<th>T-test p-value ASD vs TD</th>
<th>T-test p-value WS vs TD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months): M (SD)</td>
<td>47.84 (10.34)</td>
<td>54.16 (18.27)</td>
<td>51.59 (10.90)</td>
<td>.25</td>
<td>.27</td>
<td>.64</td>
</tr>
<tr>
<td>Gender: M, F</td>
<td>20, 2</td>
<td>8, 6</td>
<td>13, 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSEL Total DQ: M (SD)</td>
<td>70.56 (30.75)</td>
<td>64.97 (10.63)</td>
<td>103.14 (12.00)</td>
<td>.52</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>MSEL Verbal DQ: M (SD)</td>
<td>64.94 (33.18)</td>
<td>63.89 (13.49)</td>
<td>103.06 (14.49)</td>
<td>.91</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>MSEL NonVerbal DQ: M (SD)</td>
<td>76.18 (30.22)</td>
<td>66.05 (11.26)</td>
<td>103.22 (12.39)</td>
<td>.24</td>
<td>.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>VABS Communication v score: M (SD)</td>
<td>73.50 (22.15)</td>
<td>75.07 (8.54)</td>
<td>107.11 (9.87)</td>
<td>.80</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>VABS Daily Leaving Skills v score: M (SD)</td>
<td>74.55 (28.53)</td>
<td>73.50 (10.71)</td>
<td>102.06 (12.54)</td>
<td>.89</td>
<td>.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>VABS Socialization v score: M (SD)</td>
<td>74.60 (12.97)</td>
<td>83.79 (12.54)</td>
<td>108.28 (15.54)</td>
<td>.04</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
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<tr>
<td>VABS Motor skills v score: M (SD)</td>
<td>75.20 (21.65)</td>
<td>71.43 (11.54)</td>
<td>103.17 (9.70)</td>
<td>.55</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
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<tr>
<td>VABS ABC v score: M (SD)</td>
<td>71.25 (20.94)</td>
<td>73.14 (9.44)</td>
<td>104.78 (11.17)</td>
<td>.75</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>SCQ Total: M (SD)</td>
<td>15.00 (5.53)</td>
<td>11.69 (5.99)</td>
<td>3.73 (3.39)</td>
<td>.12</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>ADOS-2 Social Affect: M (SD)</td>
<td>13.29 (4.29)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>ADOS-2 Repetitive Behaviours: M (SD)</td>
<td>5.00 (2.09)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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Table 1, the ASD and WS groups did not differ on language or cognitive level, motor skills, and overall adaptive behavior. However, as expected, participants with WS had higher scores on the socialization subscale of the VABS compared to those with ASD. Both the WS and the ASD group had lower parent-reported social communication skills in the SCQ compared to the TD group. As expected, the mean SCQ score was clinically significant only in ASD group. Both clinical groups had significantly lower scores on each measure compared to participants in the TD group.

Procedure
A prime action paradigm was used, in which participants were asked to perform an action immediately after observing a “prime action” that was either congruent or incongruent with the pre-determined action they were asked to execute. This approach was preferred over a simultaneous observation-execution paradigm based on previous studies in which motor interference was successfully elicited using a priming approach (e.g., Edwards et al., 2003; Grecucci et al., 2013; Sowden et al., 2016), and because it allowed for simpler task instructions, thus minimizing attrition in the clinical groups due to their young age and difficulties with processing verbal instructions such as “execute action X while you watch action Y on the computer screen”.

Participants were tested in a quiet room in one of three University or early intervention settings, depending on where the child was recruited. Three children were tested in their home. The “prime action” stimuli were presented on a Tobii T120 binocular eye-tracker monitor with an embedded camera (120-Hz, 1280 × 1024 pixel resolution, average precision of 0.5 of visual angle). The stimuli included two 17-second videos, the “Congruent Prime Action” video and the “Incongruent Prime Action” video. The Congruent Prime Action video (illustrated in Figure 1) showed a female actor inserting five coins into the slot of a toy bank according to a normal forward motion. The Incongruent Prime Action video showed the same scene in reverse motion, so that the coins appear to be taken out of the slot (Figure 2). The order of presentation was counterbalanced, so that half of the participants saw the Congruent Prime Action first and the Incongruent Prime Action next, and the other half in the reverse order. Performance across all variables examined in the study was unrelated to the order of presentation.

As illustrated in Figures 1 and 2, the video stimuli were designed to minimize social content and social processing demands, and thus did not include the actor’s face. Additionally, the pre-determined action of inserting coins in the toy-bank was selected to be as “self-explanatory” as possible,
so that children with difficulties understanding verbal instructions, such as those in the clinical groups, would understand what they were supposed to do based on the materials provided and their arrangement. For the same reason, we used an “impossible action” as the incongruent prime (coins being taken out of the bank slot; Figure 2), so that participants could only perform the predetermined action of putting the coins in the toy-bank (rather than being able to imitate the action shown in the video) in response to the incongruent prime. Previous research has documented that motor priming, action mirroring and mirror neuron activation occur in response to both possible and impossible events in typical individuals (Borroni, Gorini, Riva, Bouchard, & Cerri, 2011; Costantini et al., 2005; Liepelt & Brass, 2010; Longo, Kosobud, & Bertenthal, 2008).

Participants were seated in a comfortable chair, 60 cm from the computer monitor in front of a small table, and their attention in response to each video was recorded using the eye-tracker system and analyzed using frame-by-frame defined areas of interest using Tobii Studio analysis software. Fixation criteria were set to Tobii Studio defaults of a 30-pixel dispersion threshold for 100 ms. The regions of interest encompassed the area where the demonstrator’s action was taking place. Eye-tracking calibration was controlled by the Tobii Studio software. A five-point calibration and validation procedure was used, with calibrations being signaled as “valid” by the software when all five points showed good fit in the computed mapping for both eyes. The procedure was repeated until the five points were properly calibrated for each eye.

Immediately after the presentation of each video, the toy bank and the coins shown in the videos were placed on the table in front of the child, according to the same position featured at the beginning of the congruent prime action video (with the five coins placed on the left of the toy bank). The experimenter encouraged the child to insert the coins into the slot, using the same instruction, “you can play” after each video. The instruction was repeated a second time if participants did not engage with the task. This instruction was preferred to “put the coins into the slot” as it placed fewer verbal processing demands on the child.

The current study only reports data on participants who inserted coins into the slot. Importantly, participants’ capability to execute the action was verified through the item “coins in the piggy bank” in the fine motor subscales of the MSEL.

The child’s behavior with the coins and the toy bank in response to observation of the video-stimuli was video-recorded, and the duration of time employed by the child to insert all the coins into the slot was later calculated by a research assistant blind to diagnostic group and study hypotheses. The

Figure 2. Incongruent Prime Action video. The same video shown in Figure 1 is shown in reverse motion so that the coins appear to be taken out of the slot.
duration of time taken by the child to execute the action following observation of the Incongruent versus the Congruent prime was used as an index of motor interference, based on the reasoning that participants would be slower when observing the reverse motion prime action, which was incongruent with the action of inserting coins into the toy bank, as compared to when they observed the forward motion video, in which the observed and intended movements were congruent.

Our analytic plan included two repeated measures ANOVAs to establish whether participants’ visual attention to the videos and their execution of the pre-determined action varied in response to the congruent versus incongruent condition and as a function of group, after controlling for cognitive and fine motor functioning. Follow-up pairwise comparisons using Bonferroni corrections were conducted when analyses revealed significant Group X Condition interactions. Correlational analyses were then conducted to test the association between motor interference and measures of social functioning across groups.

In addition to conventional null hypothesis testing, we calculated the magnitude of the evidence in favor of the alternative ($H_1$) over the null ($H_0$) hypothesis using Bayesian analysis (Quintana & Williams, 2018; Wetzels et al., 2011). Following Jarosz and Wiley (2014), we considered a Bayes ($BF_{10}$) value of 3 or more to provide significant evidence in support of the null hypothesis and a value less than 0.33 as support for the alternative hypothesis.

Results

We first analyzed eye-tracking data to test whether the groups differed in their visual attention to the video stimuli. Participants’ visual attention to the action displayed in the two videos was subjected to a 3 (Group) × 2 (Condition-Congruent versus Incongruent Action) repeated measures ANOVA, using total attention duration as the eye-tracking metric for attention to the stimuli. As illustrated in Figure 3, there was a main effect of Condition ($F(2, 51) = 4.22, p < .05, \eta^2 = .76$), no main effect of Group ($F(2, 51) = 1.37, p = .26, \eta^2 = .05$), and no significant Group × Condition interaction ($F(2, 51) = .40, p = .67, \eta^2 = .01$), indicating that all groups had increased attention in response to the incongruent action versus the congruent action.

The duration of time taken by participants to insert all the coins in the bank after observing the prime action videos was subjected to a 3 (Group) × 2 (Condition- Congruent versus Incongruent Prime Action) repeated measures ANOVA. Additionally, the MSEL Total Developmental Quotient and Fine Motor

![Figure 3](image-url). Duration of attention to the prime action videos in the congruent and incongruent condition. X-axis represents Group Status, Y-axis represents seconds.
Developmental Quotient were entered as covariate terms given the potential confounding factors of overall cognitive and motor differences between the groups. There was a non-significant trend toward a main effect of Condition ($F(2, 49) = 2.57, p = .11, \eta^2_p = .05$), and no main effect of Group ($F(2, 49) = .61, p = .53, \eta^2_p = .02$). Neither covariate was significant: Total DQ ($F(2, 49) = 1.11, p = .73, \eta^2_p = .00$); Fine Motor DQ ($F(2, 49) = .07, p = .78, \eta^2_p = .00$). A significant Group X Condition interaction ($F(2, 50) = 4.81, p = .01, \eta^2_p = .16$) was found. As illustrated in Figure 4, follow-up pairwise comparisons showed that while participants in the TD took significantly longer to execute the action after observing the incongruent action compared to the congruent one (adjusted $p$ [Bonferroni] = .001, $\eta^2_p = .19$), this was not the case in the ASD group (adjusted $p$ = .53, $\eta^2_p = .00$) or in the WS group (adjusted $p$ = .20, $\eta^2_p = .03$). Using Bayesian statistics, a value of BF$_{01} = 3.020$ was found for the contrast between incongruent and congruent conditions for the ASD group (substantial support for the null hypothesis), and a value of BF$_{01} = 2.185$ for the WS group (evidence in favor of the null hypothesis).

To test the working hypotheses that the motor interference effect would be associated with measures of social functioning, correlations between the magnitude of the interference effect (computed as the duration of action execution after the incongruent prime action minus the time employed to execute the action after the congruent action) and measures of social skills were examined in each group. In the ASD group, the magnitude of the interference effect was negatively associated with severity of social symptoms as measured through the ADOS Social Affect score, $\rho = −.54, p < .05$, indicating that children with more severe social impairments showed less motor interference. Additionally, there was a non-significant trend between the magnitude of motor interference and parent-reported social communication skills (SCQ total score, $\rho = −.38, p = .12$). In the TD group, magnitude of the interference effect was negatively associated with parent-reported social communication skills (SCQ total score, $\rho = −.51, p < .05$), indicating that TD children with better social skills showed more motor interference. There were no significant associations between motor interference and social functioning in the WS group ($\rho = −.02, p = .95$).

**Discussion**

Recent theoretical frameworks have proposed a crucial link between motor interference and social cognitive functioning in both typical and atypical development (Becchio & Castiello, 2012; Casartelli et al., 2016; van Schaik et al., 2016). The current study investigated motor interference in...
preschoolers with ASD and WS and TD children using an eye tracking paradigm that enabled young children with social-communication deficits to be tested. We found that TD children, but not those with ASD and WS, experienced motor interference (slowing of motor performance) when completing an action after observing an incongruent (versus congruent) motor prime. Importantly, the differences in motor interference could not be attributed to visual attention to the motor prime actions, as gaze patterns in response to the prime actions were similar across groups. Additionally, the difference between the clinical groups and the typical controls could not be attributed to differences in cognitive or motor functioning, as developmental quotient and fine motor skills were taken into account in the analysis.

We also documented that the magnitude of the motor interference effect was negatively associated with social functioning in the TD and the ASD groups, although that was not the case in the WS group. These findings extend previous knowledge on motor interference in ASD relative to TD and provide novel insight on motor interference in young children with WS.

The current finding that preschoolers with ASD were less susceptible to motor interference compared to typically developing children is consistent with previous studies research showing that the behavior of individuals with ASD appear to be less affected by the observation of others’ behaviors, including motor actions, affective states, and communicative and referential cues (Vivanti et al., 2011; 2016a,b, Vivanti, Hocking, Fanning, & Dissanayake, 2017). Additionally, our data are consistent with theories of impaired ‘action-perception coupling’ in ASD (Vivanti & Hamilton, 2014; Williams, 2008), which predict that a reduced motor activation in response to the observation of others’ actions in ASD (possibly associated with abnormalities in the mirror neuron system) would affect both motor interference (as the observation of incongruent actions would fail to elicit a conflicting motor representation in those with ASD) and social cognition (as lack of motor activation in response to others’ actions would disrupt action understanding; see Catmur, Thompson, Bairaktari, Lind, & Bird, 2018, for a discussion on the different perspectives within this theoretical framework). While our paradigm did not allow for examination of neural activity during the task, our results support the notion of abnormalities in the mirror neuron system in this population (Hamilton, 2013; Williams, 2008). However, more research is needed to reconcile inconsistencies in brain activation data across studies (e.g., Wadsworth, Maximo, Donnelly, & Kana, 2018) and to clarify whether atypical mirror neuron activity in ASD reflects initial biological disruptions or downstream consequences of altered engagement with social stimuli (Vivanti & Rogers, 2014).

The findings from the current study are consistent with those of Cook et al. (2014), but inconsistent with other studies in the area, which reported intact or exaggerated motor interference in individuals with ASD (Bird et al., 2007; Deschrijver et al., 2017; Gowen et al., 2008; Grecucci et al., 2013; Press et al., 2010; Sowden et al., 2016; Spengler et al., 2010). This inconsistency might be explained by differences in sample composition, as previous research focused on adults or school-age children with ASD in the high functioning end of the autism spectrum. It is possible that our inclusion of younger children with varying levels of cognitive ability allowed us to capture fundamental differences that might be “masked” in older, high functioning individuals due to their learning history and use of compensatory strategies (Rutherford & Troje, 2012).

One other possible explanation for inconsistencies with previous studies is that our paradigm involved a transitive (i.e., goal-directed) action, while most previous studies focused on intransitive movements (e.g., lifting fingers, or emotional facial expressions). Previous research has shown that action execution in imitative tasks is more susceptible to bottom-up influences for paradigms involving intransitive compared to transitive actions (Gowen et al., 2008), perhaps as a result of increased reliance on visual input demanded by execution of intransitive movements compared to transitive actions. As suggested by Tessari and Rumiati (2004), imitation of transitive actions can be achieved via a top-down “semantic route” which relies on knowledge of the action goal and meaning, whereas imitation of intransitive movements is supported by a bottom-up “direct visuospatial route” in which motor execution is driven by a direct mapping of the visual input on the motor output, making it more vulnerable to the interference of incongruent visual inputs. While it is possible that
the transitive nature of the action involved in the current study caused children with ASD (and WS) to be unaffected by the motor interference effect, it remains unclear why this was not the case for TD children. Future research should systematically manipulate the transitive versus intransitive nature of primed actions to identify whether this has differential effects on motor interference in preschoolers with ASD (and WS) when compared to TD children of the same age.

The current findings are the first to document reduced motor interference in preschool aged children with WS. This is consistent with the notion of atypical ‘action-perception coupling’ in WS, which is supported by previous studies showing atypical understanding of others’ motor actions (Sparaci, Stefanini, Marotta, Vicari, & Rizzolatti, 2012). Additionally, our data support the notion of reduced structural integrity of the mirror neuron system in individuals with WS (Ng et al., 2016), although research in this area is still at its infancy. Despite the historical portrayal of ASD and WS as the opposite sides of the spectrum (Bellugi, Wang, & Jernigan, 1994), our findings are consistent with previous research showing commonalities across selective social-cognitive processes that involve a motor response (Ng et al., 2016; Vivanti et al., 2017c; Vivanti, Hamner, & Lee, in press). Conversely, dimensions of sociability that differ between ASD and WS, such as opposing propensities for social affiliation might be unrelated to the ‘action-perception coupling’ processes tapped by motor interference tasks and related social cognitive tasks (see Vivanti et al., 2016a for further evidence of a dissociation between social cognition and social affiliation in this population).

However, unlike in the TD and ASD group, we did not find an association between the magnitude of motor interference and social functioning in children with WS. These findings suggest that abnormalities in motor interference might not be related to social cognitive skills in young children with WS; however, it will be important for future studies to examine the mechanisms of aberrant motor interference at a more fine grained level in this population, and using larger samples.

The current study has some limitations that should be acknowledged. First, our experiment involved a relatively simple task when compared to previous studies involving multiple target-actions and stimuli. In particular, the use of a single trial points to the need for additional research in order to substantiate the findings reported here. Nevertheless, the experimental paradigm was designed to be feasible for the understudied population of young children with ASD and WS, and to facilitate engagement with the task while avoiding fatigue and attrition due to inattention and lack of cooperation. Additionally, the sample size was relatively small, in particular for the WS group, although it was still sizeable given the narrow age range and the rarity of this condition.

Despite these limitations, our experimental paradigm allowed us to address gaps and limitations of previous research in the area, including examining motor interference for the first time in children with WS and in a matched sample of preschoolers with ASD, as well as controlling for or minimizing potential confounding factors such as reduced attention to the stimuli, and the social and verbal processing demands related to the stimuli.

In conclusion, the current study provides the first cross-syndrome comparison of motor interference in preschoolers with ASD and WS, two disorders that share motor and social cognitive impairments. Challenges that have hampered previous research were addressed through the inclusion of developmentally matched samples of preschoolers with ASD and WS, the use of a TD age-matched comparison group, and by using an eye-tracking paradigm that allowed us to rule out the possibility that group differences in motor interference were due to altered attention to the motor prime actions. The results showed that TD children were slower in executing actions after observing a movement that was incongruent with their intended movement, while this was not the case in young children with ASD and WS.

The pattern of findings lend support to theoretical perspectives linking atypical motor interference to social cognitive functioning in both typical development and neurodevelopmental disorders. Further research is needed to uncover the neurodevelopmental mechanisms underlying motor interference and its links to social cognition in young children with ASD and WS. Understanding early emerging challenges in this area, in turn, will be critical to the development of research-informed treatments targeting disrupted mechanisms of social cognition in young people with ASD and WS.
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