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ORIGINAL PAPER

Verbal *Peaks* and Visual *Valleys* in Theory of Mind Ability in Williams Syndrome

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Abstract Research on theory of mind (TOM) has provided a major contribution to the understanding of developmental disorders characterized by atypical social behaviour. Yet, there is still little consensus relative to TOM abilities in Williams syndrome (WS). This study used visual and verbal tasks to investigate attribution of intentions in individuals with WS relative to mental age-matched typically developing individuals. Results showed that individuals with WS perform as accurately as controls on the verbal but not on the visual task. Such modality differences did not affect WS group's performance on a control condition not requiring TOM neither were found for the control group. These results suggest the existence of a verbal *peak* and a visual *valley* in TOM ability in WS.

Keywords Williams syndrome · Theory of mind · Attribution of intentions · Hypersociability

Introduction

It is widely accepted nowadays that theory of mind (TOM)—the ability to attribute independent mental states to self and others in order to explain and predict behaviour (Premack and Woodruff 1978)—is a main ingredient for adapted social behaviour (for a review see Baron-Cohen et al. 2000). In the last decades, research on TOM has provided an important contribution to the understanding of atypical social behaviour in biologically based developmental disorders. The most prominent example comes from studies showing a link between TOM impairments and poor reciprocal social interactions (e.g. autism, for a review see Baron-Cohen et al. 2000; schizophrenia—Bora et al. 2006). Yet, the interest of studying TOM can go beyond the understanding of compromised social behaviour and extend to opposite cases of individuals unusually overfriendly, engaging and outgoing (i.e. "hypersociable" individuals), as it is generally observed in Williams syndrome (WS).

WS does present a major interest within this framework, as it is a rare neurodevelopmental disorder characterized by remarkable social skills (e.g. Jones et al. 2000). WS combines distinctive medical (e.g. supravalvular aortic stenosis) and genetic (hemideletion of approximately 28 genes on chromosome 7) features (e.g. Korenberg et al. 2000). Individuals with WS also show an unusual cognitive profile, with increased verbal relative to visuo-spatial abilities (Bellugi et al. 2000; for a review see Mervis and Becerra 2007) coexisting with mild to moderate mental retardation (e.g. Mervis et al. 2000). Yet, it is probably at the behavioural level that one can find the most puzzling feature of WS—hypersociability. From early development, individuals with WS are overfriendly, interact easily, and show no fear of strangers and a strong empathy for the others (e.g. Jones et al. 2000). They tend to be extremely outgoing to the point of being called "hypersociable" (e.g. Jones et al. 2000). Yet, the panorama is not always that positive and clear. In fact, social behaviour in WS may also be maladapted and characterized by overfriendliness, oversensitivity and poor-peer relations (e.g. Laing et al. 2002). Knowledge of the mechanisms implicated in this unusual social behaviour of WS suggests far more complexity than was originally envisioned. Indeed, to date the question of whether hypersociability in WS actually goes along with intact TOM remains an enigma.

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The first systematic study of TOM in individuals with WS was conducted by Karmiloff-Smith et al. (1995). These authors used a large battery of TOM tasks including first-order (understanding another's belief about the world) and second-order false-belief tasks (understanding of another's belief about yet another's person belief about the world), as well as higher-order tasks involving attribution of intentions to linguistic utterances. Interestingly, the majority of WS participants were found to perform at similar levels relative to typically developing controls and significantly better than mental age-matched individuals with autism in first-order and even some second-order false-belief tasks and higher-order tasks (involving attribution of intentions to linguistic utterances). This led the authors to conclude that TOM is an "islet of relatively preserved ability" in WS (Karmiloff et al. 1995, pp. 202). However, a methodological limitation of this study was that most of the TOM tasks were language-based (requiring the subjects to follow detailed narratives and to answer grammatically complex questions), raising doubt as to whether spared TOM or relatively spared verbal abilities accounted for good performance of WS participants (see Tager-Flusberg et al. 1998; Tager-Flusberg and Sullivan 2000).

In order to address this methodological concern, Tager-Flusberg et al. (1998) examined the ability to interpret mental states through a visual task—the Eyes task—in adults with WS (Tager-Flusberg et al. 1998). Results revealed that individuals with WS outperformed adults with Prader-Willi syndrome. However, only around half of the WS individuals were found to perform at the level of age-matched typically developing controls (the other WS participants rather performed at the level of mental age-matched Prader-Willi participants), suggesting that TOM ability in adults with WS is not spared on the absolute sense, but only in comparison to other developmentally delayed individuals.

Furthermore, it is important to note that WS participants in both Karmiloff-Smith et al.'s (1995) and Tager-Flusberg et al.'s (1998) studies (adolescents and/or adults) were well beyond the age at which typically developing individuals generally pass first-order (around age 4) and second-order (between the ages of 4 and 6) TOM tasks (e.g. Perner 1991; Sullivan et al. 1994). Findings of studies on TOM in children with WS do contrast with those found for adults. Children with WS have been shown to perform no better than children with learning difficulty (Prader-Willi or non-specific etiology) in first- or second-order TOM tasks (Sullivan and Tager-Flusberg 1999; Tager-Flusberg and Sullivan 2000). These contradictory findings left open the debate of whether TOM is spared or impaired in individuals with WS, despite their hypersociability and unusual increased motivation towards social stimuli.

The present study aims at investigating attribution of intentions in individuals with WS relative to typically developing individuals. While most of the studies on TOM in WS have typically used verbal tasks (e.g. tapping the use of mental-state language; Sullivan and Tager-Flusberg 1999; Tager-Flusberg and Sullivan 2000), in the current study TOM will be assessed through both visual and verbal tasks, designed to be as equivalent as possible. Given that language is a strength relative to visuo-spatial skills for most individuals with WS (for a review see Mervis and Becerra 2007), using only visual (e.g. Tager-Flusberg et al. 1998) or only verbal TOM tasks (e.g. Sullivan and Tager-Flusberg 1999) putatively constitutes a methodological limitation (e.g. Shaked and Yirmiya 2004), which may have contributed to previous contradictory findings. Here we hypothesized that if the WS uneven cognitive profile impacts on TOM ability in this disorder, this should be evidenced by increased performance on verbal relative to visual TOM tasks.

Methods

Participants

Table 1 provides a description of participants included in this study. Nineteen individuals with WS (14 female and 5 male) aged 7–26 years ($M = 14.4$; SD = 4.8) participated in this study. WS diagnosis was based on both clinical evaluation and a FISH (fluorescent in situ hybridization) test for microdeletion on one copy of the elastin gene on chromosome 7. All participants fulfilled the Preus (1984) criteria for WS (e.g. characteristic facial appearance, musculoskeletal problems, etc.) and were positive to the FISH test. Mental age (MA), inferred from IQ standardized measures (WAIS-III or WISC-III (Wechsler 1997, 1996,

Table 1 Characteristics of the participants included in the WS and the control group

	Mean	Standard deviation
Williams syndrome group		
Chronological age (years)	14.4	4.8
Full-scale IQ	57.5	11.0
Verbal IQ	65.5	14.3
Performance IQ	55.4	9.0
Mental age (years)	8.3	3.5
Verbal mental age (years)	9.3	3.5
Performance mental age (years)	7.9	2.7
Control group		
Chronological age (years)	8.2	4.8

respectively), according to the subject's age), ranged from 4 to 17 years ($M = 8.3$; SD = 3.5). Note that CA and MA selection criteria were not restricted because previous studies suggest that imposing such restrictions may substantially influence results on TOM measures (e.g. Shaked and Yirmiya 2004). Full-scale IQ scores ranged from 40 to 81 ($M = 57.5$; SD = 11.0), with verbal IQ (VIQ) scores ranging from 46 to 91 ($M = 65.5$; SD = 14.3) and performance IQ (PIQ) scores ranging from 46 to 80 ($M = 55.4$; SD = 9.0). IQ profile was characterized by a significant dissociation between verbal and performance abilities (t (1,18) = 4.64, $p < 0.001$), consistent with several previous studies on WS (e.g. Mervis et al. 2000). Given this dissociation we opted to match WS participants to controls on the basis of MA. This procedure appeared as the most reliable because (1) this study included both visual and verbal tasks and (2) matching procedures based on VIQ or PIQ result in non-equivalent WS and control groups.

The control group included 19 typically developing individuals (14 female and 5 male) aged 4–17 years ($M = 8.2$; SD = 4.8), individually matched to participants with WS subjects on MA (using a 6-months window), sex and handedness. They were recruited via local schools and day-care centres, all attending normal classes corresponding to their age level. Teachers were asked to select children on the average level of the class, thus avoiding the inclusion of children either particularly advanced or delayed relative to matching age.

Participants with WS were recruited via the Department of Pediatric Neurology at the local hospital (La Timone, Marseille) and via regional WS associations. At the time of testing all participants attended schools or specialized centres.

All participants were native French speakers, had normal or corrected-to-normal vision and had no overt-physical handicap or known-neurological deficit. Parental informed consent was obtained for all children and WS participants. The experimental procedure was approved by the local ethics committee.

Experimental Design

Participants were presented with two tasks—one visual and one verbal—focusing on the ability to attribute intentions to others. These tasks were inspired from previous studies investigating TOM abilities (e.g. Brunet et al. 2003). Preliminary findings using both the visual and the verbal tasks have shown that by age 5 typically developing children can understand the instructions and perform the task accurately (77 and 80% correct responses on attribution of intention (AI) and physical causality (PhC) conditions, respectively).

Both visual (see Figs. 1, 2) and verbal (see Appendix 1, 2) tasks were composed of scenarios depicting characters performing actions and comprised two conditions, one requiring attribution of intention to others (AI, see Fig. 1; Appendix 1) and one control condition relying on the comprehension of physical causality (PhC, see Fig. 2;

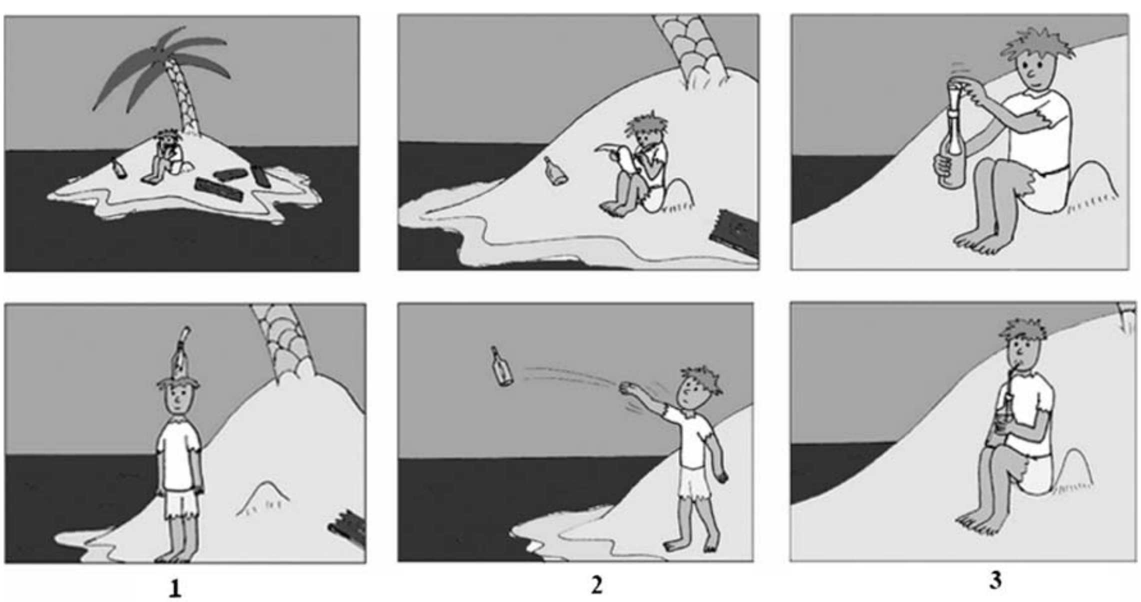


Fig. 1 Example of an attribution of intentions (*AI*) comic strip used on the visual task. The correct response corresponds to picture *2* on the *bottom*

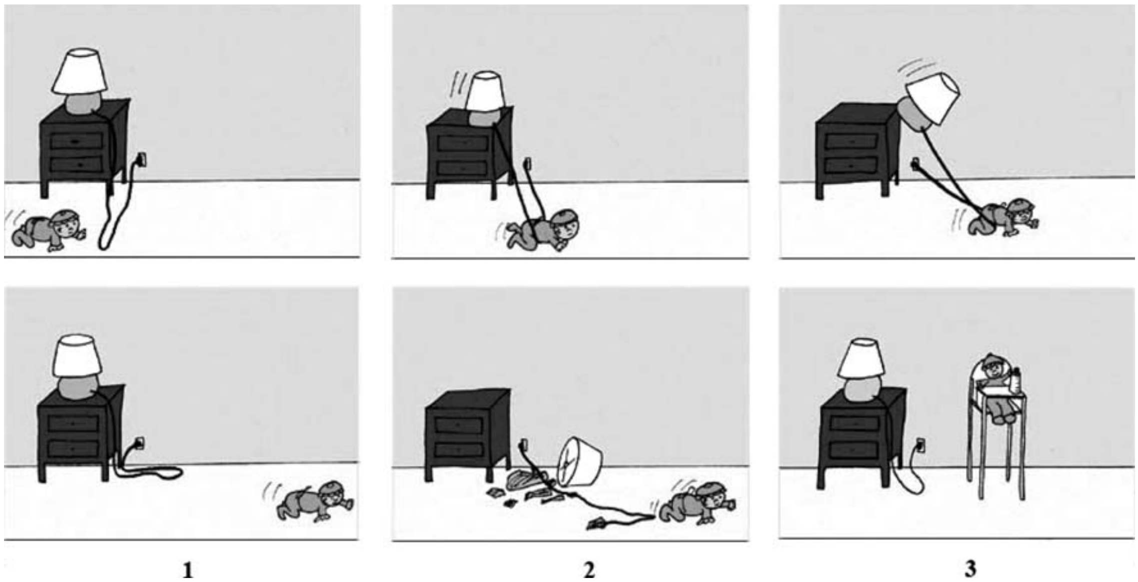


Fig. 2 Example of a physical causality (*PhC*) comic strip used on the visual task. The correct response corresponds to picture *2* on the *bottom*

Appendix 2). While in the AI condition the stories were designed to depict simple first-order intentional behaviour, in the PhC condition the subjects had to use their knowledge of the physical properties (e.g. weight, position etc.) of objects or human bodies. Both tasks comprised the same number of stories (12 AI and 12 PhC) of similar complexity. In the verbal task, PhC stories were in a propositional form to match the AI stories in terms of syntax.

Visual and verbal tasks were designed to be as equivalent as possible, differing only in terms of the modality of stimuli presentation. In both tasks, stories were composed of three scenes depicting a simple story. In the verbal task, stories were composed of three sentences each, presented orally by the experimenter. In the visual task, stories were composed of comic strips, presented on a computer screen in scenarios of three pictures. Participants were asked to pay attention to the scenarios presented (either orally or on the screen). In both tasks, participants were then asked orally by the experimenter "*What happens then*?". Following this, they were presented with three response-options (one correct and two distracters) and were asked to choose the correct response. In the verbal task, response-options were presented orally by the experimenter and were associated to one finger each in order to clearly indicate to participants that there were three distinctive options (first option = thumb; second option = index; third option = middle finger). In the visual task, response-options were added in the lower half of the screen and were associated to a number patched on the keyboard (1, 2 or 3, corresponding to the position of the option on the screen from left to right and to the "A", "Y" and "P" keys of a French keyboard, respectively). Subjects were not instructed that there were two conditions in each task and that their responses could be based on attribution of intentions or on physical causality.

Procedure

Participants were tested in a quiet room at the Institute of Cognitive Neuroscience of the Mediterranean (CNRS, Marseille, France) or at their home. In both cases, experimental conditions were carefully matched and controlled (e.g. the participant was alone with the experimenter, any possible distractions were minimized, use of exactly the same materials). For the visual task, participants were seated in front of a 17-in. computer screen (controlled by a Macintosh PC computer) at a viewing distance of 60 cm. They were told that they were going to be presented with comic strips depicting a brief story and that they were going to be asked by the experimenter one question about it. They were then told that they were to choose their response within three response-options and that they were to press the button corresponding to their choice. Response-options remained on the screen until the subject responded. For the verbal task, participants were told that they were going to hear some brief stories followed by one question and again that they were to choose one of three response-options proposed by the experimenter. To ensure these instructions were understood participants were presented with two training trials, which were followed by 24 test trials for each task. The order of presentation of the tasks (verbal and visual), trials, as well as the position of the correct response were all randomly assigned across subjects.

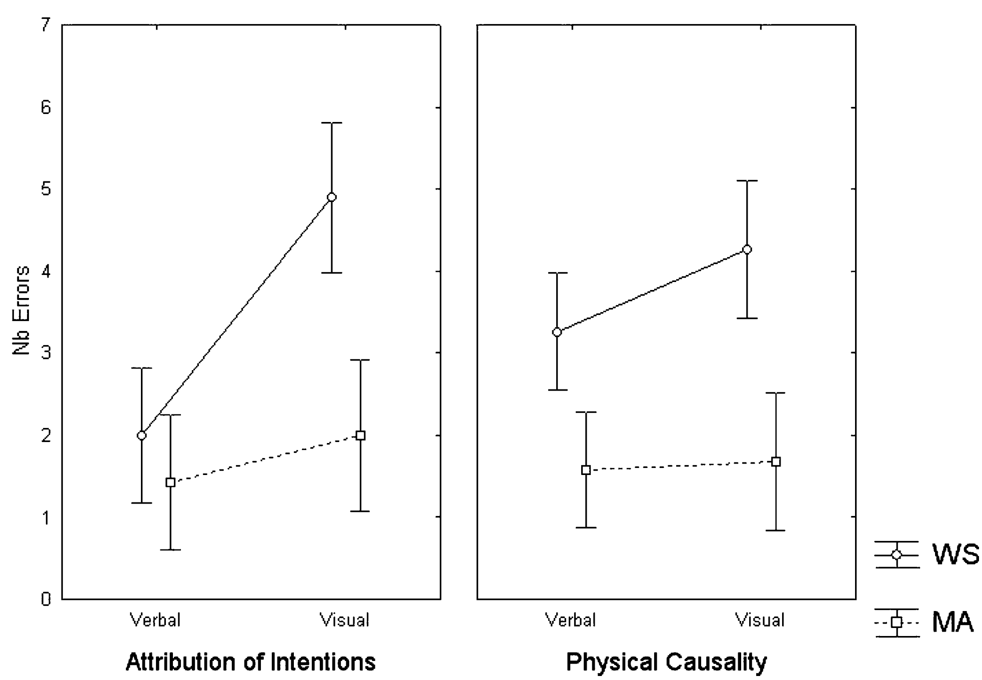
Results

The number of errors was analyzed using a three-way ANOVA including Group (WS vs. MA controls) as between-subjects factor, and Modality (Visual vs. Verbal) and Condition (AI vs. PhC) as within-subjects factors (Fig. 3). Results revealed a significant main effect of Group (F (1,38) = 15.31, $p < 0.001$) and Modality (F (1,38) = 26.26, $p < 0.001$), with overall more errors for the WS ($M = 3.58$; SD = 0.31) than the control group ($M = 1.82$; SD = 0.32), as well as for the visual ($M = 3.37$; SD = 0.40) than the verbal modality ($M = 2.02$; SD = 0.32). However, the Group × Modality interaction was also significant (F (1,38) = 7.06, $p = 0.01$). Results of post-hoc analyses using Tukey tests showed that while individuals with WS produced more errors on the visual than on the verbal modality (4.60 vs. 2.55; $p < 0.001$), no such modality-related differences were found for MA controls ($p = 0.31$). Most importantly, results revealed a significant Group × Modality × Condition interaction (F (1,38) = 5.07, $p = 0.03$). Results of post-hoc analyses demonstrated that WS group only differed from MA controls in the AI condition on the visual modality (5.05 vs. 2.25, $p = 0.05$). Moreover, significant Modality × Condition interactions were found for the WS group only. While no modality-related differences were found in the PhC condition, in the AI condition participants with WS were significantly less accurate on the visual ($M = 5.05$; SD = 0.45) than on the verbal modality ($M = 1.90$; SD = 0.38, $p < 0.001$). In addition, on the verbal modality, performance of WS group was significantly higher on AI (M = 1.90; SD = 0.38) than on PhC ($M = 3.2$; SD = 0.35, $p = 0.01$). Note that such differences were not found for MA controls.

This experiment puts forward several interesting results. The WS group performed more accurately when tasks were presented in the verbal than in the visual modality. Based on the hallmark cognitive feature of WS—increased verbal relative to visuo-spatial skills (e.g. Mervis et al. 2000)—it is somehow not surprising to find poor performance in visual tasks for the WS group but not for controls. However, it is striking to notice that modality differences did not affect WS performance across all experimental conditions, but only that requiring TOM. In fact, individuals with WS performed lower than MA-matched controls only when they were to attribute intentions to others based on visual cues. By contrast, they exhibited the performance level expected for their MA in the AI verbal condition, as well as in both visual and verbal PhC conditions. These findings suggest that the task modality impacts specifically on TOM ability in WS, as it interferes with attribution of intentions but not with the ability to infer physical causality. Furthermore, controls showed similar levels of performance in AI and PhC conditions in both verbal and visual modalities, excluding task-complexity differences as an underlying bias. By contrast, individuals with WS presented more ability performing AI than PhC on the verbal modality only.

Importantly, this experiment investigated whether individuals with WS show a primary TOM deficit, or a deficit that was a consequence of impairment in more general resources such as working memory or executive functioning. Firstly, both tasks used here included comparison trials

Fig. 3 Mean number of errors found on the attribution of intentions (graph on the *left*) and the physical causality (graph on the *right*) conditions for each group (WS and MA-matched controls) in each modality (verbal and visual)



that did not require TOM abilities, but that made similar cognitive demands (corresponding to specific incidental demands of the TOM trials). If individuals with WS showed poor performance because they struggled to meet the incidental processing demands of the task, then similar levels of performance should have been observed in AI and PhC trials within each modality. This would have suggested that an overall cognitive deficit accounted for at least some of their TOM difficulties. Another possibility could be that the same cognitive resources that were necessary for handling the incidental processing demands of the task were also necessary for AI itself. If this was the case, we would have observed greater impairment on AI than on PhC trials, but this impairment should be in proportion to the level of impairment on PhC trials. Finally, if individuals with WS had performed better when the trials did not require TOM abilities (i.e. more accuracy on PhC than AI trials) in both visual and verbal modalities then this would have been evidence of a primary deficit in TOM that was not merely related to the task modality itself nor to a cognitive impairment. Rather, findings of the present experiment suggest that individuals with WS are impaired in TOM visual processing. These findings also suggest an unusual link between verbal and TOM abilities in individuals with WS, with verbal cues favouring comprehension of other's mental states in this population in particular.

There remains, however, the question of whether important factors such as CA and overall verbal skills influenced WS pattern of performance. It is also important to note that a dissociation between (relatively spared) verbal and (impaired) visual abilities is a consistent characteristic of WS cognitive profile. Therefore, to show a selective preservation of TOM verbal abilities, it is not enough to demonstrate that individuals with WS perform higher on TOM verbal relative to TOM visual tasks. Rather, it must be shown that their performance in TOM verbal tasks is unrelated to their overall level of verbal skills.

In order to investigate these issues we first performed a series of correlation analyses (Pearson's r test) between performance and age for each participant in each condition (AI_{visual} and AI_{verbal}). Results revealed that WS performance on the verbal ($r = 0.61$, $p < 0.01$), but not on the visual modality ($r = -0.05$, $p > 0.05$), was significantly correlated with age. Interestingly, this decrease of the number of errors on the verbal modality with increasing age was consistent to that found for the MA group ($r = -0.48$, $p < 0.05$), which unlike the WS group also showed a significant correlation between age and performance on the visual modality ($r = 0.66$, $p > 0.01$). These results suggest that TOM verbal (but not TOM visual) ability develops typically in WS as, like for controls, the ability to accurately attribute intentions to others was found to increase with age. The lack of correlation between increasing age and performance on the visual task for the WS group may be the result of an atypical development of the ability to extract mental state meaning out of visual cues. By contrast, the finding of a significant correlation between age and performance on the verbal task for this group may be interpreted as an index of an emerging specialization for TOM verbal processing in individuals with WS.

Similar correlation analyses were also conducted to determine whether WS group's performance was related to general factors such as low intellectual ability or increased VIQ relative to PIQ. Interestingly, results revealed that full-scale IQ was unrelated to performance in both modalities (AI_{visual}: $r = 0.41$, $p > 0.05$; AI_{verbal}: $r = 0.04$, $p > 0.05$). Finally, performance on the verbal modality was found to be unrelated to VIQ ($r = 0.13$, $p > 0.05$), as performance in the visual modality was found to be unrelated to PIQ ($r = -0.46$, $p > 0.05$).

Discussion

This study aimed at investigating TOM abilities in WS using both visual and verbal tasks. Results revealed that when the task was presented in the verbal modality, the WS group performed as accurately as controls, while being impaired on the visual task. This finding suggests that individuals with WS do have relatively spared (MA-appropriate) abilities for attributing intentions to others dependent on the presence of verbal cues, although we cannot conclude about sparing in an absolute sense (because CA-matched comparisons were not conducted). Interestingly, this assumption is supported by results of correlation showing that WS performance on TOM verbal (but not TOM visual) increases with age and thus possibly stems from a typical developmental trajectory.

Focusing on performance on the visual task, findings of this study indicate that individuals with WS have a selective impairment when infering mental states such as intentions based on visual cues. These findings are, to some extent, in line with those of a recent study using a TOM visual task and showing impaired understanding of false-beliefs, but MA-appropriate performance on social script and mechanical stories, in a subgroup of individuals with WS (Porter et al. 2008). However, findings of this study contrast with those of previous studies showing that adults with WS are relatively proficient at reading mental state information from the eyes region, i.e. at attributing mental states to others based on visual cues (Tager-Flusberg et al. 1998; Karmiloff-Smith et al. 1995, Experiment 1). Several methodological reasons may underlie this discrepancy. In the present study the WS sample included younger participants (mean age: 14 years, ranging from 7 to 26 years) than that of Tager-Flusberg et al.

(1998; mean age: 27 years, ranging from 17 to 37 years). In this study, the WS group was also compared to MA-matched typically developing individuals and not to MA-matched individuals with mental retardation, as it was the case in previous studies. Finally, the discrepancy may be task-related. Indeed, Tager-Flusberg and Sullivan (2000) have proposed that a distinction should be made between social perceptual skills (such as reading facial expressions that involve immediate online judgements of mental states) and social cognitive skills that involve social reasoning (such as attributing false beliefs and intentions). Based on this, it may be that individuals with WS are able to use visual cues for reading facial expressions but not for attributing intentions.

The finding of relatively spared TOM verbal abilities in WS is in agreement with previous studies using verbal materials to assess TOM. Such studies show that adults with WS succeed false-belief attribution (verbal) tasks and some are even able to perform higher-order TOM tasks requiring attribution of intentions to linguistic utterances (Karmiloff-Smith et al. 1995, Experiment 6). Yet, given the cognitive demand of the verbal task used here, this finding (increased verbal relative to visual TOM ability in WS) is somehow surprising. On the visual task the attention and memory demands were kept as low as possible by presenting participants with the whole comic strip (simultaneous presentation) until he/she answered (see Brunet et al. 2003 for similar procedure). By contrast, the verbal task was presented orally by the experimenter (sequential presentation) and participants had thus to keep track of and integrate a narrative sequence of events in order to provide the correct response. Given WS difficulties in attention, short concentration span and distractibility (e.g. Greer et al. 1997), one might rather expect WS participants to perform poorly on the verbal rather than on the visual task. Alternatively, it might be argued that, unwillingly, presenting stories the experimenter exerted some influence on performance on the verbal task. However, it is important to note that, despite AI and PhC conditions being closely matched, the impact of modality on WS performance was found to affect the AI condition only, while sparing the ability to infer PhC. Furthermore, when based on verbal (but not on visual) cues individuals with WS showed higher performance on attribution of intentions than physical causality trials. Interestingly, this finding provides support to the idea put forward by Tager-Flusberg and Sullivan (2000, pp. 76) of a “potential difference between psychological and physical reasoning in WS”. This idea was based on the finding that children with WS tend to perform better (although not reaching statistical significance) on verbal TOM than verbal control (non-mentalistic) stories, contrary to children with other causes of mental retardation (children with Prader-Willi and with non-specific mental retardation). It might be that this difference becomes more salient with increasing age, becoming significant in older individuals with WS (as those included in the present study). Interestingly, previous studies have found the opposite for individuals with autism, as they show impaired intuitive psychology (reasoning about mental states), whilst superior understanding of intuitive physics (reasoning about physical phenomena; see Baron-Cohen et al. 2000 for a review; see also Binnie and Williams 2003 for data on children with autism). This dissociation, and TOM deficits in particular, is thought to be related to impairments in social and communicative development in autism (e.g. Baron-Cohen et al. 2000).

Since the mid-1990s, autism and WS are often contrasted, even to the extent of proposing an impaired social module in autism and a selectively intact one in WS (e.g. Karmiloff-Smith et al. 1995). There is little doubt that the most striking difference between autistic and WS individuals is their social behaviour, with the former being socially avoidant, whereas the latter are rather gregarious, strongly interested in people and affective on their communicative style (e.g. Lincoln et al. 2007). “Side-by-side, these syndromes appear to be mirror images of one another, suggesting that what is impaired in autism may be specifically spared in WS” (Tager-Flusberg et al. 2006, pp. 1). Although we are sceptical about such a sharp contrast between the two syndromes, it might be that stark differences in social skills between autistic and WS individuals account for opposite patterns of performance found in these two populations. In other words, it might be that TOM strengths (relative to reasoning about physical causality) are related to *hypersociability* in WS, as TOM impairments are related to *hyposociabiliy* in autism (for a review see Baron-Cohen et al. 2000). Indeed, fluent mentalising has far-reaching consequences for social insight and is a core mechanism underlying a balanced social life. Though this hypothesis is tempting, it is important to bear in mind that, despite social behaviour that is warm, engaging, empathic and friendly (e.g. Jones et al. 2000), individuals with WS also have some social difficulties. For instance, they have difficulties in triadic social interaction (Laing et al. 2002) and in making and sustaining friendships particularly with their peers (Gosch and Pankau 1994). Moreover, they have poor social judgement (Gosch and Pankau 1994) and often lack of social inhibition (Jones et al. 2000). Together, this evidence indicates that WS social phenotype is certainly not as clear-cut as it appears to be in contrast to autism and as it was initially thought. Furthermore, the finding of distinctive TOM abilities in WS as a function of the modality is difficult to interpret in terms of a link between TOM and social behaviour only.

At this point, is worth noting that results for controls revealed no modality nor condition differences, allowing us to rule out possible task-related bias as responsible for the performance dissociation found between verbal and visual tasks in the WS group. Rather, findings of this study converge to suggest that verbal cues help WS individuals interpret other's mental states.

Another tempting explanation of our findings may be the fact that language is a relative strength for most individuals with WS (for a review see Mervis and Becerra 2007). Indeed, previous studies suggested that success in TOM tasks is causally dependent on verbal ability (e.g. Frith and Happé 1994; Happé 1995). However, in the present study TOM performance for the WS group was found to be unrelated to overall verbal ability (VIQ scores). Putatively, the verbal measures used (standard IQ verbal subtests from Wechsler Intelligence Scales) did not capture verbal skills closely connected to the development of TOM (e.g. knowledge of sentential complements, for a review see de Villiers 2000 and Tager-Flusberg 2000). Despite findings of this study having limited interpretation in light of the so-widely debated link between language and TOM, they do nonetheless show a verbal *peak* (relative to a visual *valley*) in TOM abilities for WS. Importantly, these may contribute to tailoring specific clinical and educational interventions on social cognition and behaviour in WS. For instance, the finding that the understanding of others' mental states in WS is dependent on the modality through which the situation is presented has important implications for the development of TOM-intervention programs targeting areas of specific strengths and weaknesses. Finally, the role of verbal cues on the acquisition of cognitive competences needs further investigation, as it may extend from TOM to other cognitive domains. If demonstrated, it will certainly contribute to the design of new educational environments adapted to the needs of individuals with WS and provide them with greater opportunities for reaching their full potential.

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Appendix

Appendix 1. Attribution of Intention

The baby is crying.
His mum goes to the kitchen.
She heats up some milk.
And what happens then?

1. She drinks a cup of milk
2. She prepares a feeding-bottle*
3. She washes the dishes

Appendix 2. Physical causality

Jenny puts her books in her schoolbag.
She forgets to close it.
She runs to get to school on time.
And what happens then?

1. The books fall out of the bag*
2. Jenny arrives late to school
3. The books get damaged

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