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Research report

Covert processing of facial expressions by people with Williams syndrome

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ABSTRACT

Although individuals with Williams Syndrome (WS) are empathic and sociable and perform relatively well on face recognition tasks, they perform poorly on tasks of facial expression recognition. The current study sought to investigate this seeming inconsistency. Participants were tested on a Garner-type matching paradigm in which identities and expressions were manipulated simultaneously as the relevant or irrelevant dimensions. Performance of people with WS on the expression-matching task was poor and relied primarily on facilitation afforded by congruent identities. Performance on the identity matching task came close to the level of performance of matched controls and was significantly facilitated by congruent expressions. We discuss potential accounts for the discrepant processing of expressions in the task-relevant (overt) and task-irrelevant (covert) conditions, expanding on the inherently semantic-conceptual nature of overt expression matching and its dependence on general cognitive level.

1. Introduction

Williams syndrome (WS; Williams et al., 1961) is a rare autosomal genetic disorder (estimated 1:20–25,000 live births, e.g., Kaplan et al., 2001, but see Strømme et al., 2002 for a much higher rate of occurrence), characterized by typical facial dysmorphology, renal and cardiovascular anomalies, short stature, characteristic dental malformation and hypercalcemia (McKusick, 1988). Most cases of WS are sporadic resulting from a microdeletion on chromosome 7q11.23 (but see Osborne et al., 2001). The missing region typically includes the Elastin (ELN) gene, which is hypothesized to account for the vascular and connective tissue abnormalities (Ewart et al., 1993). The other phenotypic characteristics are presumably linked to the adjacent 24 or so genes that are part of the standard deletion resulting in WS (Frangiskakis et al., 1996; Mervis et al., 1999).

IQ scores of individuals with WS are generally within the 50–70 range with a verbal IQ that is typically higher than performance IQ (Mervis et al., 1999; for a recent review and meta-analysis see Martens et al., 2008). Although children with WS are late talkers their vocabulary is relatively well developed and grammar seems to be an area of relative strength (but see Karmiloff-Smith et al., 1997 and Volterra et al., 1996 for a different view). Deficits are nevertheless seen in semantic and pragmatic aspects of language. In contrast to

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language, severe deficits in the spatial domain, particularly in visual–spatial construction tasks, are characteristic of this syndrome (Bihrle, 1990; Mervis et al., 1999).

Individuals with WS are often described as ‘‘people-oriented’’. They are hyper-sociable, exhibiting high sensitivity, empathy, and quick and spontaneous reactions to changes in the mood of other people (for a review see Doyle et al., 2004). As babies they have a tendency to stare at people's faces and to approach strangers indiscriminately (e.g., Bellugi et al., 1999; Klein-Tasman and Mervis, 2003). Yet, individuals with WS also experience high anxiety levels in social contexts along with poor performance on Theory of Mind tasks (Einfeld et al., 1997; Laws and Bishop, 2004; Tager-Flusberg and Sullivan, 2000). They have difficulties in understanding social cues and in maintaining long-term friendships.

Individuals with WS perform poorly on tasks of facial expression recognition. They are at the level of mental age controls on the Animated Full Facial Expression Comprehension Test (AFFECT; Gagliardi et al., 2003), on the Diagnostic Analysis of Nonverbal Accuracy Scale (DANVA-2; Nowicki and Duke, 1994) and on the Revised Eye Test (Baron-Cohen et al., 2001; Plesa-Skwerer et al., 2006a, 2006b). Interestingly, the deficits of individuals with WS in reading facial expressions stand in intriguing contrast to their relatively preserved face recognition ability as evident in standardized tests such as the Benton Face Recognition Test (BFRT; Benton et al., 1983, 1994), where they perform at, or close to age-appropriate level (e.g., Bellugi et al., 1994; Rose et al., 2007).

The current study sought to further investigate the perception of facial expressions in people with WS with a special focus on comparing direct and indirect processing. Of particular interest was the performance of participants with WS when processing facial expressions was indirect and did not require overt categorization. Studying covert processing would allow us to begin to tease apart the semantic-conceptual demands inherent in explicit categorization of facial expressions, from the relevant perceptual processing. To address this question a Garner-type paradigm (1976) was adopted in which facial expressions and face identity were manipulated simultaneously as the task-relevant and task-irrelevant dimensions (Levy and Bentin, 2008). In that study of healthy adults, we showed that matching expressions of same identity faces was faster and more accurate than matching expressions of different identity faces. Similarly, matching identity of faces that bore the same expressions was facilitated relative to matching identities that bore different facial expressions. Since expression was irrelevant in the identity matching task, and identity was irrelevant in the expression matching task, interaction between the task-relevant and task-irrelevant dimensions was considered evidence for indirect (perhaps covert) processing of the irrelevant dimensions. Incidentally, these results are in accord with the growing body of evidence suggesting interactions between identity and expression processing (Campbell et al., 1996; Ganel and Goshen-Gottstein, 2004; Ganel et al., 2005; Jackson et al., 2009; Schweinberger and Soukup, 1998; Schweinberger et al., 1999). Will people with WS process the task-irrelevant expressions and exhibit a similar pattern of facilitation?

2. Method

2.1. Participants

2.1.1. Individuals with WS

Sixteen individuals with a confirmed genetic diagnosis of WS [positive Fluorescent In Situ Hybridization (FISH) test], mean chronological age 17.6 (range: 12;0–26;5 years) participated in the study. Their mean verbal mental age (VMA) based on the vocabulary sub-test of the WISC-R (Hebrew version, Cahan, 1998) was 8 (range: 5–13 years; Standard Deviation – SD 2.2). Participants were recruited with the help of the Israeli WS Association. Participants or their guardians signed an informed consent as required by the Hebrew University ethical committee.

2.1.2. Controls matched on the BFRT

Sixteen children were individually matched to the participants with WS according to BFRT age-equivalence, as derived from the raw scores achieved by the participants with WS (Benton et al., 1983; see Gagliardi et al., 2003 and Karmiloff-Smith et al., 2004 for a similar procedure). The adequacy of this matching was assessed as described in Section 3.1 below. We shall refer to this group as Benton Raw Scores (BRS). Participants were typically-developing (TD), had no known cognitive, learning or developmental problems. Mean chronological age of the BRS group was 13;5, range: 6;5–27;0. The wide age range reflected the variability in performance on the BFRT seen in participants with WS.

2.1.3. VMA controls

Since expression recognition tasks may have a semantic component, VMA controls were chosen. Sixteen TD children, mean age 8 (6;0–12;3; SD: 1;9) with no known cognitive, learning or developmental problems were individually matched to the WS group. Participants and controls were matched on raw scores of the verbal sub-test of the Hebrew version of the WISC-R (Cahan, 1998). We shall refer to this group as VMA.

One-way analysis of variance (ANOVA) showed significant chronological age differences between the groups [$F(2,45) = 19.601$, $MSe = 359.1$, $p < .0001$]. Post hoc analysis revealed that both the WS and the BRS groups were older than the VMA group (WS-VMA: $p < .0001$; VMA-BRS: $p < .005$, respectively), and the WS group was somewhat older than the BRS group [WS-BRS: $p < .05$]. Along with the experimental tasks, participants and controls were tested on the short version of the BFRT and the DANVA-2 (Nowicki and Duke, 1994) to establish their level of performance on these normative tests.

2.2. Testing materials

2.2.1. BFRT (Benton et al., 1983)

The BFRT was selected as a dimension for matching face identity because, notwithstanding its questionable validity in the diagnosis of prosopagnosia (Duchaine and Nakayama, 2004), it is a well standardized test of face recognition. In this test black and white portraits of unfamiliar people with neutral expressions serve as stimuli. The short version of this test including 27 trials has been used. In the first part six front view faces are shown beneath a target face and participants have to match one of the portraits to the target. In the second part stimuli are presented at various view points. In the third part, direction of lighting is manipulated. In our version of the test, the stimuli were presented on a 15″ laptop screen with resolution 1024×1280 pixels. This mode of presentation is different from the traditional way of presenting paper pictures to the subjects. The experimenter rehearsed the task with each participant and made sure that the instructions were well understood. Target remained on the screen until the participant pressed the keypad.

2.2.2. *DANVA-2 (Nowicki and Duke, 1994)*

The sub-test 'Child Faces 2' was administered. Twenty-four colorful front portraits of children (12 boys) are shown, one at a time. The faces bear the following expressions: happy, sad, angry or fearful. Participants are asked to select the name of the expression on the target face. The alternative choices are spelt below the pictures. Each expression is repeated six times on different faces.

In our version of the test, labels, with the words 'happy', 'sad', 'angry' or 'fearful' in Hebrew, were attached to the keyboard to serve as reminders of the available choices. The experimenter rehearsed the labels with the participants in a training session and made sure that the instructions were well understood and that participants could read the labels. Stimuli were presented on a 15″ laptop screen with resolution 1024×1280 pixels. Targets were shown on screen for 3 sec. After the target disappeared the participant pressed the keypad for her answer and the experimenter pressed the mouse for the next stimulus.

2.2.3. *Identity and expression-matching tasks*

2.2.3.1. Stimuli. Seventy Hebrew University students were asked to mimic the following expressions: neutral, happiness, disgust, surprise and anger. They were photographed mimicking each expression in two different ways. Pictures were taken from 5 different orientations. All portraits had a uniform, blue background. None of the students wore glasses and none had facial hair. Portraits were edited to remove earrings or other facial accessories, as well as distinctive scars and bruises, and to equate size and luminosity.

The typicality of the posed expressions was determined by a group of 40 Hebrew University students (24 males; 16 females; age 21;6–25;0 M = 25;0) who were asked to label the expression on each face. Portraits of 44 individuals were selected (17 males and 27 females) for whom all five expressions were correctly identified by at least 34 out of the 40 judges (85%).

Since each expression was mimicked twice by the same person, albeit in different ways, portraits were rated for semblance at the image level, so as to assure that pictorial similarity will not be greater between two portraits of the same person mimicking the same expression and two portraits of the same person mimicking different expressions. Twenty-four undergraduates (12 males; 12 females; age 21;0–26;2 M = 24;2) rated the portraits. Each photographed person contributed six different front images: Two images expressed happiness, two expressed disgust and two were neutral. Two same-gender portraits were presented in each trial in one of four conditions: In the Same Person Same Identity (SPSE) condition the two front portraits were of the same person mimicking the same expression twice, in what the photographed person believed to be a different manner. In the Same Person Different Identity (SPDE) the two front portraits were of the same person mimicking different expressions. In the Different Person Same Expression (DPSE) the two front portraits were of different persons, both mimicking the same expression. In the Different Person Different Expression (DPDE) the two front portraits were of different persons each mimicking a different expression. Each photographed model was presented once in each condition yielding 88 trials (22 per condition), presented in random order. Participants were instructed to rate the similarity of the portraits within each pair on a 1–7 scale. No reference was made to either identity or expression.

Out of the 44 models, we selected 15 for whom *t*-test showed no significant difference in image similarity between same and different expression conditions (i.e., SPSE ≈ SPDE and DFSE ≈ DFDE). The stimuli used in the following experiments were portraits of these 15 models. Note that the ratings guided our selection of *individuals*, and portraits of these individuals served as stimuli.

The stimuli were presented on a 15″ laptop monitor with a resolution of 1280×1024 pixels and a refresh rate of 60 Hz. seen from a distance of 70 cm, each face occupied $4.1^\circ \times 4.9^\circ$ of the visual field.

2.3. *Tasks and design*

2.3.1. *Identity matching of expressive faces*

Participants were requested to match the identity of an expressive, front view, target face to one of four expressive test faces, presented in either front or angular views. In the congruent condition the expression on the target face was the same as the expression on all four test faces, and in the incongruent condition the expression on the target face was different than the expression shared by all four test faces. Thus, the most interesting comparison was between identity matching when target and matched face shared the same expression (albeit mimicked in a different way) and when target and matched face bore different expressions.

Portraits of 12 out of the 15 individuals (seven females), selected as described above, were used in the experimental trials, while portraits of the remaining three individuals were used in the practice trials. Trials consisted of a front-face target with a happy or a disgusted expression, and four test faces placed underneath. Test faces were either front, or 45°R, i.e., face turned 45° to the left, or 45°L, i.e., faces turned 45° to the right. To reiterate, all four test faces in a trial shared orientation and expression – happy or disgust – which could be either the expression of the target face (congruent condition), or a different expression (incongruent condition). The angular views were used to reduce the residual impact of putatively higher pictorial similarity between the target and test faces in the congruent than the incongruent conditions. Fig. 1 is an example of a trial set.

Altogether 144 trials were presented in the experimental phase, equally distributed between congruent and

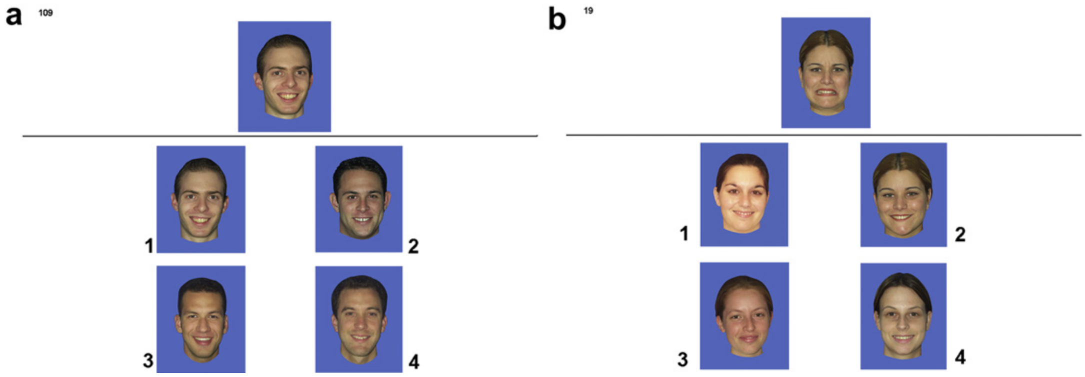

Fig. 1 – Trial set for the Identity task. (a) Congruent condition and (b) incongruent condition.

incongruent conditions. Each photographed individual appeared in 12 trials, six times in each condition. Among the six repeated presentations, three were of a disgusted face and three of a happy face (in front, left or right views). Matching test faces were quasi-randomly placed in one of the four corners of the display, varying equally among all four corners.

2.3.2. *Expression matching of same or different identities*

Portraits of 10 out of the 15 individuals (five females) whose portraits have been validated were used in the experimental trials, while portraits of three other individuals were used in the practice trials. For each individual there were eight different images, two bearing each of the four expressions: happy, disgust, anger and surprise. All the pictures were colored front portraits. Each trial consisted of five faces. The target face was placed above four test faces, arranged at the four corners of a square. The four test images were pictures of the same person, each with a different expression. The position of the test face with the matched expression varied equally among the four corners. Fig. 2 is an example of a trial set.

There were 80 experimental trials. In 40 trials the face of the same person was presented as target and as test stimuli (congruent condition). In the remaining 40 trials the face used as target was of a different person than the one used for the four test faces (incongruent condition). All four expressions were equally represented in the congruent and the incongruent conditions, with ten trials per expression. Each person appeared as target eight times, once with each of four expressions in the congruent condition, and once with each of the four expressions in the incongruent condition. The trials were ordered in a pseudo-random way so that each expression appeared first in the congruent condition for half of the participants, and first in the incongruent conditions for the other half.

2.4. *Testing procedures*

Most participants were tested in a quiet room in their homes. Ten participants with WS were tested in a quiet playroom of a summer camp they attended.

Prior to each task there were three training trials. For the identity matching task, participants were requested to press the button as soon as they found 'the photograph that has the same person as the one on top'. No reference was made to the fact that faces varied in their expressions. For the expression-matching task, participants were instructed to find the face 'that had the same expression as the face shown on top' and to reply as fast as they could. Expressions were not labeled by the experimenter, nor were the participants requested to label them. No reference was made to the fact that identity varied between trials. Speed and accuracy were equally emphasized. Following training, the experimental trials were presented in a random order.

The order of presentation of the tasks was counter-balanced such that half the participants received the Identity task first, while the other half received the expression task first. The buttons used to collect the responses were 7, 9, 1 and 3 on the keypad, corresponding to the four corners on the display where the faces appeared. Displays were removed from the screen as soon as a response was recorded. Between trials intervals were manually controlled by the experimenter and consequently allowed for rest time as needed. RTs were

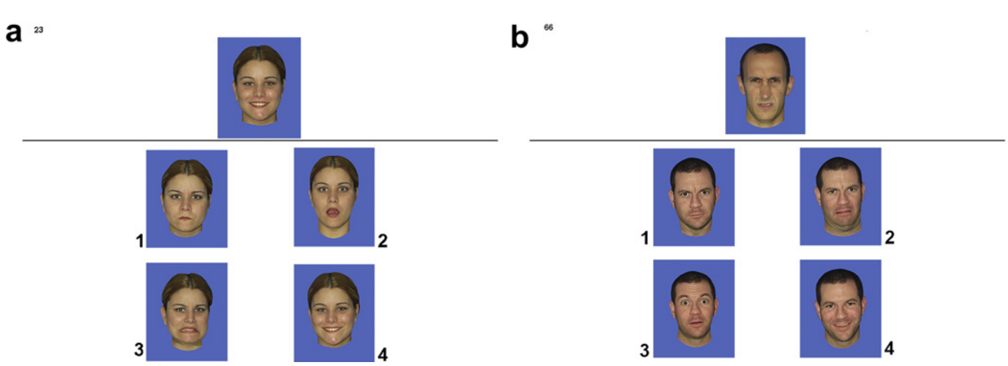

Fig. 2 – Trial set for the expression task. (a) Congruent condition and (b) incongruent condition.

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Table 1 – Percent correct (SD) and percent of labels used in error in the DANVA-2.

	WS		VMA		BRS	
	% correct	% use in error	% correct	% use in error	% correct	% use in error
Happy	93.7 (10.3)	30.7 (6.2)	95.2 (7.3)	30.5 (5.6)	97.8 (5.7)	30.8 (5.9)
Sad	75 (18.3)	27.6 (7.2)	86.9 (18.4)	31.7 (10.3)	93.3 (10.2)	28.9 (5.4)
Angry	40.6 (22.7)	12.8 (6.5)	37.9 (16.5)	10.3 (7.8)	68.8 (16.8)	16.1 (6.1)
Fear	92.7 (8.5)	28.9 (5.6)	92.9 (8)	27.5 (7.8)	93.3 (10.2)	24.2 (4.9)
Overall	75.5 (8.5)		78.2 (8)		88.3 (6)	

recorded from the trial onset. There was a 1–1.5 h interval between the Identity and the expression tasks for the BRS and the older children from the VMA group, and a 1–2 days' interval between tasks for the participants with WS and the younger children in the VMA group.

3. Results

3.1. *Performance on the BFRT*

Accuracy in the WS and BRS groups was 78% (SD in both groups, 8.8). Accuracy in the VMA group was 73% (SD 9.4). The BRS group and participants with WS were thus well matched. One-way ANOVA did not reveal significant differences between the three groups [$F(2,45) = 1.602$, MSe = 80.892, $p = .213$].

3.2. *Performance on the DANVA-2*

A mixed-model ANOVA with group (WS, VMA, BRS) as a between-subjects variable and Facial expression (happy, sad, angry, fearful) as a within-subjects variable, showed that both main effects and the interaction between them were significant [$F(2,45) = 13.8$, MSe = 725.1, $p < .0001$; $F(3,135) = 121.1$, MSe = 183.1, $p < .0001$ and $F(6,135) = 5.8$, MSe = 183.1, $p < .001$ for group, facial expression and interaction, respectively].

Post hoc examination of group effects (corrected $\alpha = 1.67\%$) showed that expression recognition was significantly more accurate in the BRS group than in either the WS group [$p < .0001$] or the VMA group [$p < .001$], whereas the difference between the WS and VMA groups was not significant [$p = .882$]. Table 1 gives the percent correct and percent misuse of the different expression labels. Note that participants and controls were the least successful in labeling angry faces and anger was erroneously used fewer times than any other label.[1] We return to these results in the Discussion. Correlation between accuracies on the DANVA-2 and on the BFRT was significant for participants with WS but not for the controls [WS $r = .518^*$; VMA $r = .439$; BRS $r = -.172$].

3.3. *Identity matching task*

Group performance was analyzed using a mixed-model ANOVA with repeated measures. The between-subjects variable was group (WS, VMA, BRS) and the within-subject factors were congruence (congruent, incongruent), view (front, right, left) and (target's) expression (happy, disgust). The dependent variables were accuracy and reaction time (RT). Post hoc comparisons were conducted using contrasts and *t*-tests with Bonferroni correction, where necessary.

3.3.1. *Accuracy*

Results for the different views and for the different expressions are presented in Table 2. Accuracy was higher in the congruent condition than in the incongruent condition [$F(1,45) = 18.3$, MSe = 61.4, $p < .0001$] for all three groups. The main effect of view was also significant [$F(2,90) = 36.3$, MSe = 80.5, $p < .0001$], and there was no main effect of expression [$F(1,45) = 2.3$, MSe = 42.0, $p = .135$]. The main effect of group approached significance [$F(2,45) = 3.1$, MSe = 893.5, $p = .059$], but interacted significantly with the effect of expression [$F(2,45) = 4.8$, MSe = 42.0, $p < .05$] and with expression x congruence as a second-order interaction [$F(2,45) = 6.5$, MSe = 52.1, $p < .01$]. Importantly, there was no group × congruence interaction suggesting that the advantage of shared expression between the target and test faces (i.e., the congruence effect) was similar across groups. No other interactions were significant.[2]

For participants with WS, post hoc examination of the group × expression interaction ($\alpha = 1.67\%$) revealed a significant congruence effect for disgust [$t(15) = 2.264$, $p < .05$] and no congruence effect for happy faces [$t(15) = .703$, ns]. In the VMA group there was a significant congruence effect for both happy and disgusted faces [happy: $t(15) = 3.709$, $p < .005$; disgust: $t(15) = 2.272$, $p < .05$]. In the BRS group there was a significant

[1] Post hoc examination did not reveal significant differences in accuracy level between the groups in the happy and fearful expressions, but there were significant differences in the sad and angry expressions [$F(2,45) = 5.345$, MSe = 258.989, $p < .01$; $F(2,45) = 13.042$, MSe = 357.236, $p < .0001$, respectively]. While the interaction between group and expression was not significant [$F(6,90) = .769$, MSe = 1.515, ns], the main effect of expression was significant [$F(3,135) = 14.998$, MSe = 1.515, $p < .0001$]. Examination of the expression effect using post hoc contrasts ($\alpha = .83\%$) revealed that anger was the label least misused by all the groups [angry-happy: $F(1,45) = 34.883$, MSe = 1027.966, $p < .0001$; angry-sad: $F(1,45) = 48.544$, MSe = 1067.917, $p < .0001$; angry-fearful: $F(1,45) = 8.509$, MSe = 893.944, $p = .005$].

[2] Interaction between group × congruence [$F(2,45) = .46$, MSe = 61.372, ns]; group × view [$F(4,90) = .138$, MSe = 80.497, ns]; congruence × expression [$F(1,45) = .622$, MSe = 52.139, ns]; congruence × view [$F(2,90) = .325$, MSe = 50.032, ns]; view × expression [$F(2,90) = .36$, MSe = 48.584, ns]. Group × view × congruency [$F(4,90) = .286$, MSe = 50.032, ns]; group × view × expression [$F(4,90) = .616$, MSe = 48.584, ns]; view × expression × congruency [$F(2,90) = .702$, MSe = 86.975, ns]; group × expression × view × congruency [$F(4,90) = .978$, MSe = 86.975, ns].

Table 2 – Percent accuracy (SD) in the Identity task for group, expression, congruency and view.

	WS				VMA				BRS			
	Happy		Disgust		Happy		Disgust		Happy		Disgust	
	Con.	Incon.	Con.	Incon.	Con.	Incon.	Con.	Incon.	Con.	Incon.	Con.	Incon.
Front	91.7 (8.6)	91.1 (10.3)	93.2 (6.25)	89.1 (14.2)	90.5 (10.03)	86.9 (11.7)	94.05 (10.3)	87.5 (13.5)	98.9 (2.8)	95.6 (9.1)	96.7 (5.9)	96.1 (6)
45° L[a]	86.5 (11.7)	83.9 (12.7)	86.5 (11.7)	84.4 (12.5)	82.1 (10.03)	78 (13.5)	85.1 (11.05)	85.1 (9.7)	92.2 (7.7)	87.8 (8.5)	88.9 (7.9)	89.4 (10.7)
45° R[b]	85.4 (14.1)	85.9 (14.2)	88 (13.3)	80.2 (17.2)	82.7 (14.4)	79.8 (13.2)	85.7 (13.1)	81.5 (18.6)	93.9 (10.7)	85.6 (13.1)	88.9 (9.5)	92.8 (9.6)
All views	87.9 (9.4)	87 (9.4)	89.2 (8.2)	84.6 (12.6)	85.12 (9.1)	81.55 (10.8)	88.29 (9.2)	84.72 (11.6)	95 (6.3)	89.63 (6.9)	91.48 (5.9)	92.78 (6.3)
Overall	87.4 (9.3)		86.9 (10.2)		83.3 (10.2)		86.5 (10.4)		92.3 (5.9)		92.1 (5.6)	

Con. = congruent.
Incon. = incongruent.
a Subject saw the left side of the face.
b Subject saw the right side of the face.

congruence effect for happy faces and no congruence effect for disgust [happy: $t(15) = 3.14$, $p < .01$; disgust: $t(15) = .906$, ns].

3.3.2. Reaction time

RTs to correct responses across groups, views and expressions were analyzed. They are presented in Table 3. Across all conditions RTs were faster in the congruent than in the incongruent conditions. The VMA group was the slowest to respond, while the BRS group was the fastest.

A mixed-model ANOVA using the same design as for accuracy showed that the main effects of group, congruence and view were significant [$F(2,45) = 6.0$, MSe = 19,806,454, $p < .01$; $F(1,45) = 29.5$, MSe = 1,443,529, $p < .0001$; $F(2,90) = 40.9$, MSe = 832,906, $p < .0001$ respectively]. The main effect of expression was not significant [$F(1,45) < 1.0$]. None of the first, second or third order interactions were significant, with one exception [view × expression × congruency $F(2,90) = 5.8$, MSe = 466,687, $p < .01$].[3] Post hoc comparisons showed that RTs for the VMA group were longer than for the BRS group [$\alpha = 1.67\%$, $p < .005$] and there were no significant differences between the WS and VMA, and between the WS and BRS.[4]

3.4. Expression-matching task

The data were analyzed using a mixed-model ANOVA with repeated measures. The between-subjects factor was group (WS, VMA, BRS) and the within-subjects factors were congruence (congruent, incongruent) and expression (happy, sad, disgusted and angry). The dependent variables were accuracy and reaction time. Post hoc comparisons were conducted using contrasts and t-tests with Bonferroni correction.

3.4.1. Accuracy

Table 4 presents the accuracy results. All three main effects were significant [$F(2,45) = 14.3$, MSe = 490.4, $p < .0001$; $F(1,45) = 123.7$, MSe = 165.0, $p < .0001$ and $F(3,135) = 34.8$, MSe = 127.0, $p < .0001$, for group, congruence, and expression, respectively]. Expression-matching accuracy was higher across groups in the congruent condition than in the incongruent condition. Importantly, as evident in Table 4, both congruence and expression had a different effect in different groups, as revealed by congruence × group and

[3] Group × congruency $F(2,45) = 2.847$, MSe = 1,443,529, $p = .069$; group × expression $F(2,45) = .345$, MSe = 818,541; group × view $F(4,90) = 1.537$, MSe = 832,906; congruency × expression $F(1,45) = 2.930$, MSe = 653,333; congruency × view $F(2,90) = 2.886$, MSe = 704,265, $p = .061$; view × expression $F(2,90) = .408$, MSe = 610,220; group × expression × congruency $F(2,45) = 1.949$, MSe = 653,333, $p = .154$; group × view × congruency $F(4,90) = .115$, MSe = 704,265; group × view × expression $F(4,90) = 1.898$, MSe = 610,221, $p = .118$; group × expression × view × congruency $F(4,90) = .63$, MSe = 466,687.

[4] Reaction times in response to front views were shorter than in response to right [$F(1,45) = 79.784$, MSe = 1,549,316, $p < .0001$] or left views [$F(1,45) = 36.19$, MSe = 2,059,164, $p < .0001$], and left was faster then right [$F(1,45) = 4.448$, MSe = 1,388,956, $p = .041$]. Post hoc analysis between view, expression and congruence revealed significant congruence effects for disgust in all views [front: $t = 3.786$, $p = .002$, right: $t = 5.971$, $p < .0001$, left: $t = 2.892$, $p = .011$] and for happiness in the front view [$t = 6.915$, $p < .0001$].

Table 3 – Reaction time (SD) in the Identity task for group, expression, congruency and view.

	WS				VMA				BRS			
	Happy		Disgust		Happy		Disgust		Happy		Disgust	
	Con.	Incon.	Con.	Incon.	Con.	Incon.	Con.	Incon.	Con.	Incon.	Con.	Incon.
Front	3588 (906)	4150 (1407)	3149 (672)	4119 (1278)	3600 (1050)	4980 (1807)	3792 (1378)	4623 (1855)	2681 (1147)	3162 (1296)	2854 (1520)	3299 (1190)
45° L[a]	4223 (1086)	4586 (2001)	4447(1699)	4699 (1746)	4681 (1482)	5598 (1522)	4577 (1166)	5293 (1991)	3353 (1590)	3492 (1397)	3076 (1095)	3449 (1289)
45° R[b]	4796 (1504)	4722 (2269)	4128 (1150)	4892 (1296)	4832 (1730)	5344 (1670)	4985 (1623)	5820 (2425)	3676 (1490)	3251 (1410)	3217 (1421)	3964 (1815)
Overall	4344 (1328)		4239 (1097)		4839 (1313)		4848 (1566)		3269 (1242)		3310 (1275)	

Con. = congruent.
Incon. = incongruent.
a Subject saw the left side of the face.
b Subject saw the right side of the face.

expression × group interactions [$F(2,45) = 9.6$, $MSe = 165.0$, $p < .0001$ and $F(6,135) = 5.0$, $MSe = 127.0$, $p < .0001$, respectively]. The interaction between congruence and expression was likewise significant [$F(3,135) = 21.2$, $MSe = 101.7$, $p < .0001$], while the second-order interaction between group, congruence and expression was not [$F(6,135) = 1.767$, $MSe = 101.727$, $p = .11$].

As evident in Table 4, the overall differences between the groups were mainly due to the low performance of participants with WS in the incongruent condition, which was nevertheless significantly different than performance by chance ($Z = 5.158$, $p < .001$). Moreover, the facilitation afforded through matching facial expressions of the same individual as opposed to different individuals (congruence effect) was twice as large in participants with WS (22.6%) than in either the VMA group (11.4%), or the BRS group (9.7%). However, investigating the congruence × group interaction by separate ANOVAs in each condition revealed that even in the congruent condition there was a significant difference between the groups [$F(2,45) = 9.1$, $MSe = 27.2$, $p < .0001$], and post hoc *t*-tests ($\alpha = 1.67\%$) showed that participants with WS performed worse than both the VMA and BRS groups ($t = 3.086$, $p < .005$ and $t = 3.562$, $p < .001$, respectively). The two control groups did not differ ($t = .838$, ns).

The expression × group interaction was investigated by separate ANOVAs within each group, followed by planned *t*-tests. In the WS group the response to happy faces was the most accurate ($t = 6.470$, $p < .0001$, $t = 2.440$, $p < .05$ and $t < 3.525$, $p < .005$, for happiness compared to disgust, anger and surprise, respectively), and the response to disgust was the least accurate ($t = 4.443$, $p < .0001$ and $t = 4.291$, $p < .001$, for disgust compared to anger and surprise, respectively). In the VMA group the response to happy faces was the most accurate as well ($t = 3.701$, $p < .005$, $t = 4.457$, $p < .0001$ and $t = 3.303$, $p < .01$, for happiness compared to disgust, anger and surprise, respectively), whereas accuracy in response to anger was lower than in response to surprise ($t = 2.606$, $p < .05$). Similar to the other groups, in the BRS group too, the response to happy faces was the most accurate ($t = 6.414$, $p < .0001$, $t = 3.951$, $p < .001$ and $t = 5.333$, $p < .0001$, for happiness compared to disgust, anger and surprise, respectively) and the accuracy in response to anger was higher than in response to disgust ($t = 3.309$, $p < .005$).

Finally, the congruency × expression interaction was assessed for each expression separately (*t*-test, $\alpha = 1.25\%$). The congruence effect was significant for all four expressions: happy [$t = 7.611$, $p < .0001$], disgust [$t = 9.914$, $p < .0001$], anger [$t = 3.731$, $p < .001$] and surprise [$t = 2.652$, $p < .025$].

3.4.2. *Reaction time*

RTs to correct response were analyzed. They are presented in Table 5. All three main effects were significant [$F(2,45) = 3.9$, $MSe = 4{,}500{,}998$, $p < .05$; $F(1,45) = 96.2$, $MSe = 3{,}419{,}404$, $p < .0001$; $F(3,135) = 23.6$, $MSe = 1{,}529{,}901$, $p < .0001$, for group, congruence, and expression, respectively]. However, unlike accuracy, there were no interactions between group and the other two main effects. The interaction between congruence and expression was significant [$F(3,135) = 9.4$, $MSe = 1{,}040{,}327$, $p < .0001$] while the second-order interaction was not significant [$F(6,135) = 1.7$, $MSe = 1{,}040{,}327$, $p = .13$].

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Table 4 – Percent accuracy (SD) in the expressions task for group, expression and congruency.

	WS			VMA			BRS		
	Con.	Incon.	Overall	Con.	Incon.	Overall	Con.	Incon.	Overall
Happy	94 (7.3)	83 (25.5)	88 (15.2)	98 (7.5)	94 (9.4)	96 (5.4)	99.3 (2.5)	98 (4)	99 (2.2)
Disgust	83 (17.4)	43 (19.2)	63 (15.7)	94 (5.9)	73 (20.5)	83 (11.8)	96.7 (4.7)	76.7 (12.5)	87 (7.7)
Anger	87 (11.4)	77 (17.8)	82 (11)	88 (9.8)	79 (17.5)	83 (11.6)	95.3 (7.2)	88.7 (10.2)	92 (6.8)
Surprise	92 (11.1)	63 (20.9)	78 (14.5)	96 (4.6)	85 (12)	91 (6.8)	96 (6.1)	85.3 (9.6)	91 (6.3)
Overall	89 (7.5)	66 (17.3)	78 (11.5)	94 (4.2)	83 (8.1)	88 (5.7)	97 (2.8)	87 (6.8)	92 (4.3)

Con. = congruent.
Incon. = incongruent.

Post hoc investigation of the main effect of expression ($\alpha = .83\%$) revealed shorter RT in response to happy than in response to either disgust [$F(1,45) = 48.8$, MSe = 2,268,970, $p < .0001$], anger [$F(1,45) = 74.3$, MSe = 2,370,402, $p < .0001$] or surprise [$F(1,45) = 22.3$, MSe = 2,422,282, $p < .0001$]; RT to surprise were shorter than to both anger [$F(1,45) = 8.6$, MSe = 4,113,299, $p < .02$] and disgust [$F(1,45) = 7.3$, MSe = 3,002,972, $p < .01$].

4. Discussion

The goal of the present study was to explore the processing of facial expressions in individuals with WS, comparing explicit processing of expressions with the ability to use facial expressions to facilitate recognition of personal identity. This comparison was motivated by the seeming inconsistency of the documented impairment of people with WS on tasks of explicit categorization and matching of facial expressions and their close to normal performance on face recognition tasks (Gagliardi et al., 2003; Plesa-Skwerer et al., 2006a, 2006b). Participants with WS were compared to VMA controls, as well as to controls matched on BFRT age, derived from BFRT raw scores (BRS). Both groups were younger than the WS group. Thus, based on chronological age, participants with WS had adequate, if not richer, social exposure to faces when compared to the controls.

Using the BFRT as a measure of explicit face recognition, and DANVA-2 as a measure of explicit recognition of facial expressions, the present results replicated earlier work with people with WS. Participants were close to, yet not quite at their chronological age level on the BFRT, whereas they were at the level of the younger VMA control group on the DANVA-2.

Covert processing of facial identity and facial expressions was tested in a Garner-type paradigm (Garner, 1976), in which facial expressions and identity were simultaneously manipulated as the task-relevant and task-irrelevant dimensions. Accuracy levels and RT patterns of participants with WS in the identity matching task did not differ overall from the performance of either the VMA or the BRS groups. Crucially, expression congruence, which was the task irrelevant dimension, benefited to a similar extent the performance of people with WS and that of the control groups, as suggested by the lack of interaction between congruence and group. In other words, although they were relatively poor at matching expressions in the overt task (see below) participants with WS took advantage of sameness of expression to facilitate matching identities to the same extent that the control subjects did.

Since there was no explicit mention of facial expressions in this task, this might have increased the likelihood that subjects were using feature similarity rather than expressions to facilitate identity matching. Note, however, that similar expressions were mimicked in different ways by the same individual, as described above, and portraits were presented in different angles. Both measures considerably reduce the option of feature matching. The role of an abstract notion of expression as facilitator of identity matching, is thus much more likely.

In contrast to their performance on the identity matching task, the overall accuracy of the participants with WS on the expression-matching task did not reach the level of the performance of either the BRS or the VMA control groups.

Table 5 – Reaction time (SD) in the expressions task for group, expression and congruency.

	WS			VMA			BRS		
	Con.	Incon.	Overall	Con.	Incon.	Overall	Con.	Incon.	Overall
Happy	3935 (1268)	5472 (2077)	4703 (1555)	4508 (1214)	5237 (1653)	4994 (1412)	3253 (1058)	4220 (1556)	3950 (1527)
Disgust	4711 (1784)	7464 (3723)	6087 (2438)	4898 (1195)	7606 (2316)	6368 (1835)	3657 (879)	5657 (2092)	4831 (1557)
Anger	4840 (1716)	7183 (2839)	6011 (1961)	5132 (1576)	7964 (2598)	6584 (2011)	4032 (1401)	5599 (1660)	5016 (1535)
Surprise	4877 (2058)	6450 (2599)	5664 (2171)	4768 (1146)	6056 (1588)	5830 (1838)	3528 (922)	5437 (2025)	4696 (1561)
Overall	4590 (1479)	6642 (2515)	5616 (1878)	4974 (1151)	6915 (1911)	5771 (1328)	3814 (1172)	5432 (1861)	4423 (1209)

Con. = congruent.
Incon. = incongruent.

Performance differed for the different expressions, replicating previous work with healthy people.

Importantly, however, the facilitation afforded by congruent identities in matching expressions was double or more in participants with WS relative to controls, suggesting that their difficulty in overt matching of facial expressions drove them to rely more heavily on the (task-irrelevant) identity cues. Note also that the reliance of the VMA group on congruence of identity in the expression-matching task was likewise larger than that of the older BRS group (though not significantly so), and closer to the facilitation effect observed for the participants with WS, suggesting an overall developmental trend (for a review of developmental aspects of recognition of facial expressions see Herba and Phillips, 2004). Moreover, across groups, congruence of identity affected least of all the matching of happy faces, and had the largest effect on matching disgust. This pattern is in line with developmental data showing that positive expressions are recognized earlier and more accurately by children than negative expressions (Boyatzis et al., 1993; Camras and Allison, 1985; Widen and Russell, 2003; see also Gao and Maurer, 2009).

Further evidence of the interdependence of identity and expression recognition in participants with WS was seen in the significant correlations between performance on the BFRT and on the DANVA-2. Significant correlations were seen neither in the BRS group nor in the VMA group, although for the latter, the correlation was not negligible ($r = .439$). Thus, performance of the WS group resembled that of the younger VMA group in that both groups were less proficient in matching expressions than in matching identities and showed over reliance on congruence of identity.

The results of the current study point to an apparent dissociation between the impaired ability of participants with WS to overtly categorize or match facial expressions, and their normal use of facial expressions to facilitate identity recognition/matching. While we could not directly assess whether participants with WS were using facial expressions intentionally to facilitate face identification, there is some evidence in the pattern of performance that suggests they were not. Thus, the effect of expression congruency differed among the different expressions and was significant for disgust but not for happy expressions. Had facial expressions been resorted to explicitly, we would have observed a larger congruency effect for happy faces than for disgusted faces, mirroring the pattern seen in the overt expression-matching task as well as in all previous work so far.

Numerous similar dissociations between explicit and implicit manifestations of knowledge have been documented in many neuropsychological syndromes, such as amnesia, agnosia and neglect (see Reder et al., 2009; Aviezer et al., 2007; Van Vleet and Robertson, 2009 and many more). The converging evidence suggests a general principle in brain function, dissociating performance based on perceptual input and explicit awareness of such input. Interestingly, our current results are in line with similar dissociations between explicit recognition and implicit use of facial expressions reported recently for Huntington Disease Gene Carriers (Aviezer et al., 2009).

Although not directly relevant to the goals of this study, it is interesting to note that the results on the DANVA-2 showed a uniform pattern of performance among the participant groups, with performance being the highest for happy and fearful faces, and lowest for angry faces (see Table 1). The distribution of errors was also similar across groups. Interestingly, although recognition of angry faces was the poorest across the three groups, still anger was the most infrequently misused label. It is as if participants were 'reluctant' to attribute anger to faces, avoiding this label as much as they could. Such a pattern of performance might be related to the social/emotional consequences that may be associated with attributing anger to the face one is looking at. A recent study examining expression-identity interaction in visual short-term memory (VSTM) highlights the special status of angry faces (Jackson et al., 2009). Having ruled out other potential explanations, the fact that significantly more angry face identities were retained in VSTM than either happy or neutral faces was interpreted by Jackson and colleagues as a consequence of the unique inter-personal relevance of angry faces. Note that this pattern of performance in participants with WS is in line with the abnormal amygdala activation to positive and negative facial expressions reported in this population (Haas et al., 2009; see also Bellugi et al., 1999).

The results of the current study are relevant to the debate concerning the nature of the visual–spatial deficits in people with WS. While holistic processing seems intact (Karmiloff-Smith et al., 2004; Tager-Flusberg et al., 2003), Karmiloff-Smith et al. argued that second-order configural processing, such as is involved in computing the spatial relations between face components (Maurer et al., 2002) is impaired in this populations, resulting in lack of an inversion effect for faces. However, recent work by Deruelle et al. (2006) suggested that configural processing in visual closure tasks was preserved in people with WS, while Rose et al. (2007) reported normal performance of people with WS on identity recognition of neutral and expressive faces, as well as on a strong inversion effect, arguing against a deficit in configural processing in this population.

While abnormal development of the right hemisphere is a documented characteristic of WS (e.g., Eckert et al., 2006; Mills et al., 2000; Van Essen et al., 2006) which might affect certain aspects of face processing, the apparent processing of facial expressions when attention to such information is not required may also mean that the impairment is a function of attentional or strategic biases. It is, likewise, possible that the fairly normal holistic (as opposed to configural) face processing in WS (Karmiloff-Smith et al., 2004; Tager-Flusberg et al., 2003) is sufficient for covert processing of facial expressions (cf., Calder et al., 2000), or that different expressions are covertly recognized on the basis of featural processing, rather than on the basis of configural processing (e.g., Smith et al., 2005).

Alternatively, poor performance of people with WS on explicit recognition of expression, may concern the nature of this task, specifically, its semantic-conceptual demands and its context dependency. This has been recognized in previous work on expression recognition in healthy adults. Thus, Elfenbein and Ambady (2002) reported a universal characterization for happy faces, but cross-cultural differences in recognition of the other basic expressions (Ekman and Friesen, 1971). Le-Gal and Bruce (2002) found that surprise is more readily recognized on faces of women, whereas anger is more readily recognized on men. Reluctance to attribute anger to faces was seen in the current study, suggesting interference of social-emotional factors. Fernandez-Dols et al. (2008) have recently shown the importance of semantic processes in the detection and categorization of prototypical emotional expressions. Finally, several studies demonstrated that the perceptual and/or situational context in which a face is presented can bias its categorization (Aviezer et al., 2008; Fernandez-Dols et al., 2008).

All of the above suggest that, unlike identity matching of unfamiliar faces, overt matching of facial expressions has a strong semantic-conceptual component, requiring categorization and entailing attribution of affective states. Performance is likely to draw upon an interpretation of the specific context in which the face is seen, along with an appreciation of the social hierarchy and the expectations that it raises. The affective state of the perceiver may have an impact as well.

Bearing in mind the cognitive deficits that characterize people with WS, their impaired recognition of expressions may be a consequence of the semantic-conceptual and interpretative nature of the task. The latter, rather than the perceptual demands per se, are likely accountable for the fact that performance typically correlates with IQ, whereas identity matching correlates with age (Gagliardi et al., 2003; Karmiloff-Smith et al., 2004). A reflection of this is seen in the current study, in that the pattern of performance of participants with WS paralleled that of the younger, VMA controls. Further support for this analysis comes from the fact that the deficit in expression recognition seen in people with WS was reported for auditory affective expressions as well (Plesa-Skwerer et al., 2006a). The fact that the deficit extends beyond the specific perceptual characteristics of a given modality strengthens the hypothesis that general cognition plays a major role in this process. Of relevance is also the fact that poor performance on expression recognition tasks is not unique to WS, and has been reported for other populations with cognitive impairments. In addition to reports of deficits in individuals with autistic spectrum disorders, deficits in this domain have been reported for individuals with Down syndrome (Kasari et al., 2001; Williams et al., 2005) as well as for people with mental retardation of unspecified etiology (Adams and Markham, 1991; Maurer and Newbrough, 1987; McAlpine et al., 1991; Rojahn et al., 1995).

How do the deficits in explicit expression recognition impact in the personalities of people with WS? The strength and weaknesses of the WS social profile – their hypersociability, their sensitivity to people's moods along with their social anxiety and failure to maintain friendships – seem consistent with a preserved perceptual-emotional component of empathy, for which covert perception of facial expressions may suffice (Tager-Flusberg and Sullivan, 2000). Those will not suffice, however, for adequate assessment of social contexts, understanding others and interpreting and reacting to affective situations, for those depend on an age-appropriate cognitive level and explicit mentation (Hoffman, 1982; Feshbach, 1978) which, unfortunately, exceed the mental resources of people with WS.

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