Face Processing and Facial Emotion Recognition in Adults With Down Syndrome

Hippolyte, Loyse Mahaut Miguela; Barisnikov, Koviljka; Van der Linden, Martial

Face Processing and Facial Emotion Recognition in Adults With Down Syndrome

Loyse Hippolyte, Koviljka Barisnikov, and Martial Van der Linden
University of Geneva (Geneva, Switzerland)

Abstract
Face processing and facial expression recognition was investigated in 17 adults with Down syndrome, and results were compared with those of a child control group matched for receptive vocabulary. On the tasks involving faces without emotional content, the adults with Down syndrome performed worse than did the controls. However, their performance was good on the tests with complete faces. On the facial expression tasks, participants with Down syndrome exhibited particular difficulties with the neutral and surprised expressions. Analysis of their error pattern suggests they had a tendency to judge faces more positively than did the controls. Finally, there were significant relationships among emotional processing, receptive vocabulary, and inhibition measures; nonverbal reasoning ability was not related to any of the tasks.

Identifying faces and recognizing facial emotional expressions are important skills for successful social interactions. Research conducted on emotional understanding in a population with mental retardation has highlighted particular deficits when compared with control participants matched for chronological age (CA) and mental age (MA) (Maurer & Newbrough, 1987a; Rojahn, Rabold, & Schneider, 1995). More recently researchers have investigated these competencies, taking into account the etiology of the mental retardation, and have focused on populations with autism or genetic disorders, such as Williams syndrome, fragile X syndrome, or Turner syndrome (Karmiloff-Smith et al., 2004; Lawrence, Kuntsi, Coleman, Campbell, & Skuse, 2003; Matheson & Jahoda, 2005; Robel et al., 2004; Rondan, Gepner, & Deruelle, 2003). Surprisingly, only a few researchers have investigated emotion processing in people with Down syndrome, and to the best of our knowledge, no research has been specifically conducted on face processing. In addition, previous research has been focused mainly on child populations.

In a series of three experiments, Kasari, Freeman, and Hughes (2001) examined the comprehension of four basic emotions (happiness, sadness, anger, and fear) in children with Down syndrome through administration of three tasks, including labeling, recognizing, and identifying facial emotions within a familiar context (e.g., being taken to the zoo by mother, being alone in the dark). They used a puppet made of felt that had an expressionless face. Four felt faces (representing the four emotions) completed the material. In the first experiment, the results of the Down syndrome group (CA = 6.5 years, MA = 3.6) were compared with those of typically developing children matched for CA and MA (mean IQ was measured using the Stanford-Binet Intelligence Scale [Thorndike, Hagen, & Sattler, 1986]). Kasari et al. did not find differences between the Down syndrome and MA groups on any of the three tasks, with both groups performing significantly worse than the CA group. In addition, the Down syndrome and MA groups showed a specific pattern of errors compared to the CA group, tending to mistake a negative emotion for a positive one.

In the second experiment, Kasari et al. (2001)

matched children with Down syndrome (CA = 8 years, MA = 4) on MA to typically developing children and children with mental retardation of unknown etiology (MA = 4). They did not observe any differences between groups in the emotion recognition task, but the children with Down syndrome were less accurate than those in the MA group in verbally labeling the negative emotions (anger and fear) and less accurate than both control groups in identifying these two emotions from a context-based story. As in the first experiment, children with Down syndrome showed a tendency to misidentify negative emotions as positive ones, but this tendency was not observed in the two control groups.

In the third experiment, Kasari et al. (2001) followed 16 children with Down syndrome who had participated in Experiments 1 and 2, tracking their progress over a 2-year period. The same three tasks were examined, but not the error pattern. The results indicated a significant improvement in the labeling task only. The authors proposed that children with Down syndrome have difficulty dealing with these emotional tasks due to a lack of exposure to varied emotional stimuli. Their interpretation was based on a study by Tingley, Gleason, and Hooshyar (1994), who reported that mothers of preschool children with Down syndrome used fewer words referring to feelings and cognitive states and a less elaborate emotional repertoire than did mothers of typically developing children. Kasari et al. suggested that the results might also be related to the particular personality (friendly, sociable, well disposed) that Down syndrome children tend to have. Negative expressions might be used less frequently by their families because of their pleasant dispositions. Thus, these personality traits might interfere with the acquisition of knowledge of negative expressions, which may explain the specific impairment affecting the recognition of anger and fear. In case of hesitation, children would have a specific set of responses (i.e., happy).

Kasari et al.'s (2001) interesting study has some methodological weaknesses. The lack of a control task raises doubts about whether children with Down syndrome have a specific impairment in processing emotional stimuli. In fact, they might have difficulties processing faces in general, which could hinder them in reacting to emotional facial stimuli. Moreover, the experimental tasks presented by Kasari et al. had very few items: one item per emotion for labeling and recognition tasks and two for the identification task.

Turk and Cornish (1998) conducted a study using the same four emotions employed by Kasari et al. (2001) (happiness, sadness, anger, and fear). Participants were children with fragile X syndrome (CA = 10 years, MA = 6). The British Picture Vocabulary Scale (Dunn, Dunn, Whetton, & Pintilie, 1982) was administered as a matching measure. Results of the children with fragile X syndrome were compared with those of MA-matched typically developing children and children with Down syndrome (CA = 10 years). Emotion recognition was studied under three conditions: facial expression (schematic drawings of faces showing the four emotions), vocalized emotions, and recognition of emotions in different social contexts (e.g., getting ice cream, being chased by a dog). Contrary to the Kasari et al. (2001) study, Turk and Cornish did not find differences among groups in the first two conditions, in which children had to identify the emotions. On the other hand, the children with Down syndrome obtained lower results than did those in the other two groups when matching expressions according to a social context. Turk and Cornish proposed that the poor performance of the children with Down syndrome on this task might be related to a reduction in working memory resources, although they did not elaborate on this hypothesis. Again, the small number of items used by these researchers (four items per task) considerably limited the interpretation of the results.

Recognition of emotional expressions (happiness, surprise, sadness, fear, anger, and disgust) by children with Down syndrome was also examined by Wishart and Pitcairn (2000) in two experiments. Stimuli were photographs taken from Ekman and Friesen's (1976) Facial Affect Slides. The authors compared the performance of children with Down syndrome 8 to 14 years of age with that of typically developing children (CA range = 3 to 5) and children with nonspecific mental retardation (CA range = 8 to 14) on the basis of performance on the Kaufman Facial Recognition subtest (Kaufman & Kaufman, 1983). These investigators administered three experimental tasks in the first experiment: matching faces according to identity, matching faces according to emotional expression, and matching facial emotions to a brief verbal story (e.g., receiving a present). The Down syndrome group scored lower on all tasks than did children in both control groups, but they differed significantly only in the emotion matching task and specifically for expressions of surprise and fear. In the second experiment, participants had to match emotions (happiness and anger) and faces according to identity under rotation (0°, 90°, 180°). Results for the Down syndrome group were significantly lower than those of the MA group on the emotion matching task. On the identity task, their performance was significantly poorer than that of either control group. Based on results of these two experiments, Wishart and Pitcairn suggested that children with Down syndrome had a global impairment in processing emotional expression, but these conclusions may be questionable due to the small number of items (only one per emotion) used in these experiments.

In a more recent study, Williams, Wishart, Pitcairn, and Willis (2005) administered the same identity and emotion matching tasks used previously by Wishart and Pitcairn (2000) to children with Down syndrome 7 to 17 years of age (MA range = 3 to 6 years), typically developing children (CA range = 3 to 6 years), and children with nonspecific intellectual disabilities (CA range = 6 to 17 years). The groups were matched on the basis of scores on the Wechsler Preschool and Primary Scales of Intelligence–WPPSI-R (Wechsler, 1990) or Wechsler Intelligence Scale for Children–WISC-III (Wechsler, 1992) and the Benton Facial Recognition Test short-form (Benton, Sivan, Hamsher, Varney, & Spreen, 1983). Williams et al. assessed the same six emotions (happiness, surprise, sadness, fear, anger, and disgust) but increased the number of trials (18 trials for the identity task, 3 trials per emotion in the emotion task). On the identity matching task, results for the Down syndrome group were significantly poorer than those of both control groups. The authors explained these results by suggesting a decreased task engagement rather than impaired performance, given that the children with Down syndrome were able to process the first part of the task as well as the two control groups did. On the emotion matching task, the Down syndrome children obtained poorer overall performance compared with the typically developing children, but the difference was only relevant for the emotion of fear. The relationship between the emotion task and specific abilities (language, adaptive behavior) was also explored, as was the pattern of error in the emotion task. With regard to the Down syndrome error pattern, Williams et al. did not observe the confusion between positive and negative emotions found by Kasari et al. (2001). Indeed, the errors did not show any specific trend. Finally, no significant correlations appeared between performance on the experimental tasks and specific abilities or CA.

In the studies discussed above, researchers examined several emotional expressions under different conditions, and most of them found impairments in emotion recognition in children with Down syndrome. Negative expressions such as anger and fear seemed to be harder to recognize, although the results varied among studies. Kasari et al. (2001) found a tendency to mistake a negative emotion for a positive one; this error pattern was not confirmed by Williams et al. (2005). The large variety of stimuli (photographs, schematic drawings, vocalization) and task conditions (identification, labeling, emotion-to-story matching) as well as the limited number of items used by most of the researchers restricted the generalization of their results. Moreover, as emphasized by Williams et al., some of the emotional tasks administered might have made additional cognitive demands on verbal memory and expressive language, which tend to be weak in individuals with Down syndrome (Brock & Jarrold, 2005; Jarrold & Baddeley, 2001). Thus, the deficits observed might not be related to emotional impairments but, rather, be due to the difficulty of the task. Nevertheless, the studies done with Down syndrome children have shown that CA and developmental age do not seem to be related to a better understanding of emotions in this population. However, we do not have information about emotional recognition abilities in adults with Down syndrome as, to our knowledge, no studies have yet been published. One study of children with Down syndrome (Williams et al., 2005) included adolescents up to 17 years of age, and the results showed that they did not outperform their younger peers. This finding suggests that adults with Down syndrome probably do not process emotional stimuli better than do children. This hypothesis is supported by results found in Tingley et al.'s (1994) study, which indicated that children with Down syndrome grow up in environments with poorer exposure to emotions, hindering the development of their emotional skills. In addition, some authors have reported that personality influences (Kasari et al., 2001) and the deleterious effect of social stigmas and withdrawal often observed in people with mental retardation (Moore,

2001) might also have a negative influence on the acquisition of emotional knowledge. Moore stated that children with mental retardation might have preserved basic emotion recognition skills and that it is their particular subsequent development that will lead them to have impairment in adulthood. Despite the above observations, it may be possible for individuals with Down syndrome to develop social and emotional abilities in adulthood. In the last 3 decades, a major effort has been made to improve the quality of the social environment for people with mental retardation (e.g., workshops, cinemas, sports, holiday camps). These social stimulations could have a positive impact on the development of their emotional abilities. Therefore, it is of great interest to explore emotional processing in adults with Down syndrome, particularly how facial emotion recognition abilities manifest in adulthood. Social and behavioral difficulties, which are often reported by caregivers and families, may be related to specific emotional deficits (Clark & Wilson, 2003; Dykens, Shah, Sagun, Beck, & King, 2002). Investigating these competences is also important with a view to developing rehabilitation strategies in the future.

Thus, our aim in the present study was to investigate different aspects of emotion recognition and face processing in adults with Down syndrome. We presented tasks assessing facial stimuli with and without emotional content. This experimental design allowed us to clarify whether an impaired performance was specific to emotional stimuli or was related to face processing (Moore, 2001). Facial processing abilities were evaluated by an Identity Matching subtest showing faces with a neutral expression, which withdrew emotion processing demands. The capacity to process facially expressed emotions was examined through different modalities (identification, matching, and recognition) (Bruce et al., 2000; Rojahn, Rabold, & Schneider, 1995). To avoid additional information processing loads, we designed the experimental tasks to make minimal demands on verbal memory and expressive language. In all tasks, the stimuli were limited to facial information (no hairline or clothing) to avoid the influence of nonfacial features (Duchaine & Weidenfeld, 2003). Specific cognitive tasks assessing nonverbal reasoning and inhibition were given to the Down syndrome group in order to explore their relationship with facial emotional processing. Thus, some authors have claimed that emotion recognition is related to more general cognitive abilities in adults with mental retardation (Moore, 2001; Simon, Rosen, & Ponpipom, 1996), whereas others have asserted that there is a specific deficit (Rojahn, Rabold, & Schneider, 1995). The potential influence of inhibition processes, which are often reported to be impaired in Down syndrome people (Rowe, Lavender, & Turk, 2006), was controlled for. These competencies seem to be related to tasks involving emotional and social processing (Carlson & Moses, 2001; Grant, Apperly, & Oliver, 2007). The results of the adults with Down syndrome were compared with those of typical developing children matched on a receptive vocabulary task. We chose this match to check for differences in verbal ability that might interfere with the emotional tasks (Bieberich & Morgan, 2004; Turk & Cornish, 1998). This approach allowed us to identify whether the performance of adults with Down syndrome was impaired in terms of a quantitative score difference (e.g., presence of developmental delay). Moreover, if qualitative differences were observed between the groups, it would allow us to define the pattern of performance of the Down syndrome group (e.g., atypical processing).

Method

Participants

The participants were 17 adults with Down syndrome (8 men, 9 women) with moderate mental retardation who were recruited from two sheltered workshops. All of them had a medical diagnosis of Trisomy 21 and had attended special schools for people with mental retardation. Sensory, psychiatric, or physical disabilities and clinical symptoms of dementia were exclusion criteria for participation. The mean age of this group was 33.3 years (SD = 10.5). The control group consisted of 17 typically developing children (8 boys, 9 girls) who attended an elementary public school (mean age = 5.9 years, SD = 0.7). The two groups were matched on a receptive vocabulary task, as reflected by the raw score on the French adaptation (Dunn, Thériault-Whalen, & Dunn, 1993) of the Peabody Picture Vocabulary Test-Rev. (Dunn & Dunn, 1981)—hereafter referred to as the PPVT-R-F. On this task, the Down syndrome group obtained a mean raw score of 70.41 (SD = 15.11) and the control group had a mean score of 70.23 (SD = 16.52). These scores corresponded to a developmental verbal age of 6.08 years (for the

Down syndrome group: *SD* = 1.29, range = 4.58 to 9; for the control group: *SD* = 1.17, range = 4.5 to 8.08). This difference was not statistically significant.

We administered additional cognitive tasks to the adults in the Down syndrome group to check for their potential influence on the experimental tasks. Nonverbal reasoning ability was assessed using Raven's Coloured Progressive Matrices (Raven, Court, & Raven, 1998), mean raw score = 20.17, *SD* = 4.15 (corresponding approximately to an IQ of 67). Inhibition measures were assessed by the day–night Stroop-like task (Gerstadt, Hong, & Diamond, 1994) and the tapping task (Diamond & Taylor, 1996). Both tasks require participants to remember two rules and to inhibit a strong response tendency (a verbal response for the day–night, a motor response for the tapping task). The adults with Down syndrome obtained a mean score (percentage) of 82.35 (*SD* = 30.79) in the day–night task and a mean score (percentage) of 64 (*SD* = 29.21) in the tapping task. Compared to norms established with typically developing children (Diamond & Taylor, 1996), the performance of the adults with Down syndrome was equivalent to an MA of 5.9 for the day–night task and 3.7 for the tapping task.

Materials and Procedure

In the present study we used tests taken from the Face Processing Tests (Bruce et al., 2000) to assess facial emotion identification and matching as well as face processing with the Identity Matching Test. The Facial Discrimination Task (Rojahn, Rabold, & Schneider, 1995) is used to assess facial emotion recognition and emotion intensity attribution. Participants were tested individually and three to five sessions (15 to 25 min each) were necessary to administer the various tasks, depending on the participant's fatigue and cooperativeness. An assessment adapted to the participant's pace and attention level was critical to prevent lack of motivation, which can be observed in this population. The various sessions took place over approximately 1 to 2 weeks, in accordance with the participants' availability and work schedule. The cognitive tasks were administered first, followed by the Face Processing Tests and Facial Discrimination Task. Assessments were conducted in a quiet room at the sheltered workshop for the Down syndrome group; the typically developing children were assessed in a room at their school.

Face Processing Tests

All stimuli used in the Face Processing Tests are images of children's and adults' faces (monochrome photographs, 5.5 cm × 4 cm) presented with a uniform grey background in order to exclude visible paraphernalia.

Identity matching. Five subtests are given using the same design: A child target face is shown at the top of the page and participants have to identify the target face (out of two faces) at the bottom of the page. Each subtest includes 16 items. The first two subtests, Face-Dis and Face-Sim, vary regarding the dissimilarity/similarity, respectively, of their distracters (same vs. different gender, age, and general appearance, like hair color or shape of the face). The following two subtests, Masked-Dis and Masked-Sim, present faces that are dissimilar/similar (same criterion), respectively, with the hair and ears concealed. The fifth subtest, Eyesmasked-Sim, presents similar faces with hair, ears, and eyes concealed. One trial item is offered for the first three subtests to ensure that participants understand. Rough difficulty levels established by Bruce et al. (2000) for the Identity Matching Test show that success rates for the last two subtests (Masked-Sim and Eyesmasked-Sim) are not above the chance level before the age of 7 or 8. Nevertheless, all subtests were presented in this study because we had no specific hypothesis concerning the participants with Down syndrome.

Emotion identification. In the Emotion Identification Test, participants are shown pairs of children's faces and have to point to the face in each pair that displays a particular emotion named orally by the experimenter. The emotions of happiness, sadness, anger, and surprise are assessed (3 items per emotion).

Emotion matching. In the two Emotion Match Tests, a target face is shown at the top of the page and the participants are asked to point to the face at the bottom (out of two) that displays the same expression as the top one. Two tests showing children's and adult's faces (12 items, respectively) are presented with the same expressions as in the Emotion-Identification Test (3 items per emotion). One trial item is administered in the first test.

Facial Discrimination Task

Emotion recognition and intensity attribution. In this task, 41 black and white photographs of faces (13 cm × 18.5 cm) with three different expressions (happy, sad, or neutral) are presented. The participants have to indicate whether a given item depicts a happy face, a sad face, or a face that is neither happy nor sad (neutral). If the response is happy (or sad), the participants are then asked to decide between two intensity levels for this emotion. Level 1 is for a face that is *a little* happy or sad and Level 2, for a face that is *a lot* happy or sad. Responses are given by pointing to a visual aid represented by short (Level 1) and long (Level 2) vertical columns. Participants have a training session with 6 items before performing a test with 35 items representing 12 happy faces (9 for the first level, 3 for the second), 12 neutral faces, and 11 sad faces (7 for the first level, 4 for the second) presented in a random order.

Results

Face Processing Tests

The assumption of normality of distribution using one-sample Kolmogorov-Smirnov tests was examined for all Face Processing Tests variables (separately for each group). Normality was found for the Identity Matching Test, allowing us to conduct parametric analyses. The two emotion tests (Emotion-Identification and Emotion-Match) did not follow a normal law, as some scores were close to ceiling. Therefore, we used a nonparametric approach for these two tests. Main descriptive data are summarized in Table 1.

Face Processing Tests

Identity Matching Test. We first analyzed the Identity Matching Test data using a 2 (group) × 3 (test) repeated-measure ANOVA. The last two subtests (Masked-Sim, Eyesmasked-Sim) were not included in the analysis because results from both groups were close to chance level (score near 8). Figure 1 illustrates percentage scores (per group) for the five subtests. Significant main effects of group, $F(1, 32) = 8.63$, $p = .006$, and test, $F(2, 64) = 125.66$, $p < .0001$, were observed, but the interaction between test and group was not

Table 1. Mean Raw Scores by Group on the Face Processing Tests (FPT) Identity and Emotion Subtests and the Facial Discrimination Task (FDT) Scores

		Down syndrome		Controls	
Measure	Maximum score	Mean	*SD*	Mean	*SD*
Face Processing Tests					
Identity Matching					
Face–Dis	16	15.17	1.38	15.88	.33
Face–Sim	16	13.76	2.61	15.11	.69
Maskedface–Dis	16	8.17	2.72	10.29	2.64
Maskedface–Sim	16	7.58	2.39	8.58	2.57
Eyesmasked–Sim	16	7.35	2.59	7.47	2.74
Emotion Identification					
Happiness	3	2.94	0.24	3.00	0.00
Sadness	3	2.58	0.50	2.88	0.33
Anger	3	2.76	0.56	2.94	0.24
Surprise	3	2.17	0.88	2.88	0.33
Emotion Matching					
Child's face	12	8.23	1.56	10.70	1.26
Adult's face	12	7.88	1.83	10.64	1.41
Facial Discrimination Task					
Emotion Recognition					
Happiness	12	10.94	0.55	11.11	0.48
Sadness	11	9.29	1.53	9.23	1.43
Neutral	12	7.35	4.58	11.11	0.78

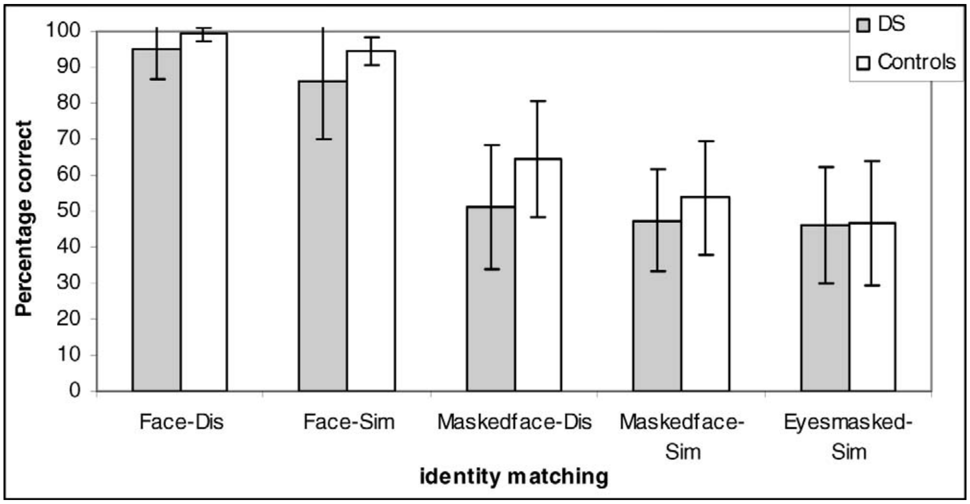

Figure 1. Face Processing Tests Identity Matching scores (%) in Down syndrome group compared with control group.

significant, $F(2, 64) = 1.22$, $p = .25$. We then investigated main effects of group and test, using Bonferroni post-hoc comparisons. These analyses were done in order to determine whether the difficulty levels established by Bruce et al. (2000) could also be found in this study. No significant differences appeared between the groups on the three subtests (Face-Dis, Face-Sim, Masked-Dis), but we note that the Down syndrome group performance on the Masked-Dis subtest was close to chance level. Both groups performed better on the first subtest, Face-Dis, followed by the Face-Sim and Masked-Dis subtests, which corresponded to the results in Bruce et al.'s developmental study. Finally, between-group comparison analyses (Student t tests) were used in the last two subtests, Maskedface-Sim and Eyesmasked-Sim, where no significant differences appeared.

Emotion tests. Figure 2 shows percentage scores (per group) for both emotion tests. For the Emotion Identification Test, we analyzed emotions separately, using Mann-Whitney U tests. There was a significant group difference for the emotion of surprise, $U = 73.5$, $p = .004$, which was better identified by the control group. On the Emotion Matching Tests, adults with Down syndrome scored significantly lower than did the control group on tests representing both children's faces,

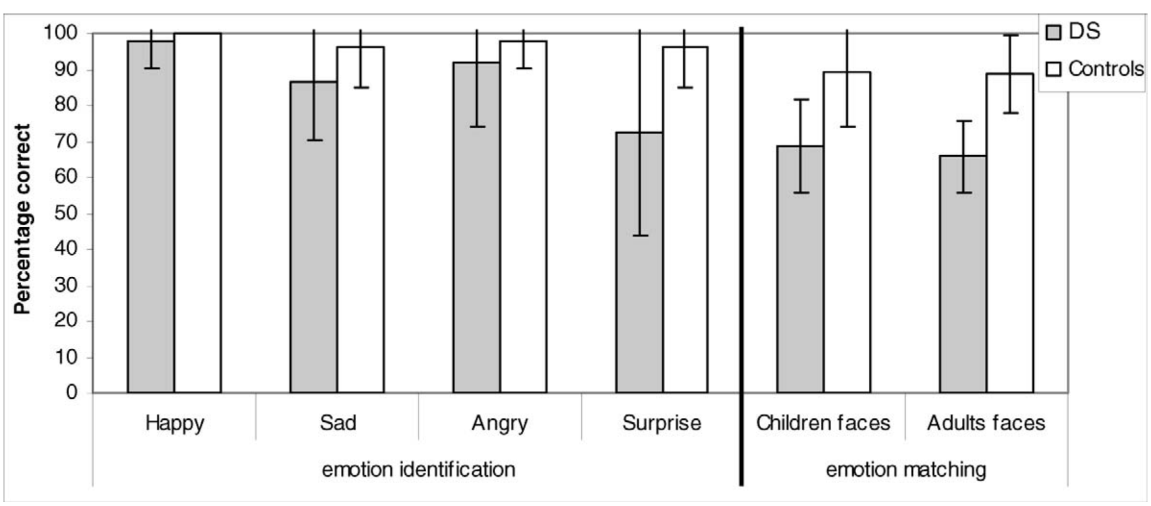

Figure 2. Scores (%) for the Face Processing Tests Emotion Identification and Emotion Matching for Down syndrome and control groups.

$U = 28$, $p < .0001$, and adults' faces, $U = 35$, $p < .0001$. Finally, no differences were observed within groups on these two tests.

Correlations Among Face Processing Tests, Cognitive Tasks, and CA

We employed Kendall's Tau-b nonparametric correlations to investigate the relationships among various Face Processing Tests, the cognitive measures, and CA for the Down syndrome group. Main correlations are presented in Table 2 for both groups. For face processing abilities (5 Identity Matching subtests), we did not observe any significant relationship between these subtests and cognitive measures or CA in the Down syndrome group. No relationship was found in the control group either.

Correlations among the emotion tests, the cognitive measures, and CA were then investigated. Significant positive relations were found in the Down syndrome group between receptive vocabulary score (PPVT-R-F) and identification of angry expressions, $\tau = .47$, $p = .024$, and surprise, $\tau = .46$, $p = .022$. A positive relation was also observed between the PPVT-R-F and the Emotion Matching Test (adults' faces), $\tau = .41$, $p = .033$. No significant correlations were found for the control group. Finally, in order to investigate the relations between face processing and facial emotion processing, we conducted correlations between the Face Processing Tests as a whole. However, the correlations were not significant in either group.

Facial Discrimination Task

We performed statistical parametric analyses for the Facial Discrimination Task because all variables followed a normal law, except the score for the happy expression, for which the data were close to ceiling effect. However, nonparametric analyses of the data produced fundamentally the same results. We first conducted a 2 (group) × 3 (expression) repeated-measure ANOVA to investigate whether the two groups differed significantly on the recognition of happy, sad, and neutral expressions (scores in percentages). Figure 3 provides scores for each group for these expressions (Table 1 shows main raw scores). The analysis revealed main effects of group, $F(1, 32) = 11.51$, $p = .002$, and expression, $F(2, 64) = 5.38$, $p = .006$. A significant interaction between expression and group, $F(2, 64) = 7.83$, $p = .001$, was also observed. Bonferroni post-hoc comparisons revealed that the adults with Down syndrome recognized

Table 2. Correlations Between Face Processing Tests (FPT) Main Scores and Facial Discrimination Task (FDT) Main Score, CA, and Cognitive Measures by Group

	FPT tasks (Tau-B)							FDT (Pearson)			
	Identity matching	Emotion identification[a]				Emotion matching		Emotion recognition			
Group/ Variable	Total score	H	Sa	A	Su	Child	Adult	H	N[b]	Sa	Bias
Down syndrome											
CA	−.20	−.08	−.06	−.36	−.31	−.25	−.03	.01	−.12	.11	.27
PPVT-R-F	.16	.21	−.08	.47*	.46*	.08	.40*	−.68*	.68*	.04	−.43
Raven	−.06	−.13	.21	−.05	−.02	.21	−.01	−.34	.34	−.43	−.01
Inhibition											
Day–night	.09	.24	.24	.29	.16	−.09	.37	−.16	.14	.08	−.77**
Tapping	.23	−.15	−.09	.26	.39	.18	.13	.05	.43	−.12	−.03
Control											
CA	.26	—	.42	−.15	−.37	.00	.15	.28	.04	.44	−.20
PPVT-R-F	.31	—	.09	.08	.00	.33	.03	.25	.12	.39	−.21

[a]H = happiness, Sa = sadness, A = anger, Su = Surprise. [b]Neutral.
*$p < .05$. **$p < .01$.

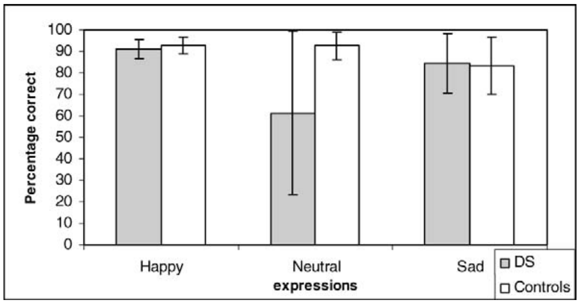

Figure 3. Emotion recognition in Down syndrome group compared with control group for the Facial Discrimination Task (%).

significantly fewer neutral faces than did their controls, $p < .0001$. The Down syndrome group identified both sad, $p = .009$, and happy, $p < .0001$, expressions more easily than the neutral ones; no significant differences were found among the three expressions for the control group.

A 2 (group) × 4 (intensity) repeated-measure ANOVA was then performed to determine whether groups differed significantly when rating emotion intensity (Happy 1, Happy 2, Sad 1, and Sad 2). The ANOVA revealed significant main effects of group, $F(1, 32) = 14.71$, $p < .0001$, and intensity, $F(3, 96) = 23.89$, $p < .0001$, as well as a significant interaction effect, $F(3, 96) = 2.64$, $p = .05$. Subsequent Bonferroni post-hoc comparisons showed that the adults with Down syndrome differed from the controls only on the recognition of very sad faces, where they identified significantly fewer items, $p < .0001$. We observed that the Down syndrome group identified the very happy faces significantly better than all the other expressions, whereas no significant difference appeared for recognition of other expressions (Happy 1, Sad 1, and Sad 2). On the other hand, the control group obtained high results for both very happy and very sad faces, which were significantly better identified than the low emotion intensities.

In order to investigate the results obtained on the Facial Discrimination Task more precisely, we analyzed all responses for the two groups. Table 3 presents the percentages of responses (correct and incorrect) for each emotion according to intensity. In general, we observed that the participants rarely selected an emotion in the opposite hedonic tone (e.g., happy for sad) when they gave an incorrect answer.

The errors made by the two groups in the Facial Discrimination Task were computed as an emotional bias score, reflecting the error size and trend (overly positive vs. negative responses). This Facial Discrimination Task bias score was obtained by calculating an error ranking for each response (plus one point per degree in the positive trend and minus one point per degree in the negative trend). For example, a 2-point positive score was assigned when the participant said *a little happy* instead of *a little sad.* Adults with Down syndrome (M score = 7.35, SD = 8.44) responded more positively than did the controls (M = 4.64, SD = 4.37), although this difference was not statistically significant. However, effect size, as measured by Cohen's d, relative to controls was between medium and large, $d = .63$. This finding suggests an outcome that would probably be significant and of practical importance if the sample size were increased.

Correlations Among Facial Discrimination Task, Cognitive Tasks, and CA

Pearson correlations were undertaken to investigate associations among the Facial Discrimi-

Table 3. Facial Expressions Given by Groups for Photographs in Facial Discrimination Task (%)

	Expected answer									
	Happy 1		Happy 2		Sad 1		Sad 2		Neutral	
Response[a]	DS adult	Child[b]	DS adult	Child	DS adult	Child	DS adult	Child	DS adult	Child
Happy 1	**29**	**33**	14	4	4	3	1	0	15	3
Happy 2	59	58	**86**	**94**	0	2	1	0	7	1
Sad 1	3	0	0	0	**51**	**52**	49	6	14	4
Sad 2	0	0	0	2	27	26	**47**	**91**	2	1
Neutral	9	9	0	0	18	19	1	3	**61**	**93**

Note. Boldface type indicates correct responses; Roman type indicates incorrect responses.
[a]1 = *a little*, 2 = *very*. [b]Typically developing children.

nation Task main scores, the cognitive measures, and CA in the Down syndrome group. As can be seen in Table 2, the vocabulary score (PPVT-R-F) correlated significantly and positively with the recognition of the neutral expression, $r = .68$, $p = .003$, and negatively with the happy expression, $r = -.68$, $p = .002$. A significant negative correlation was observed between the mean score on the verbal inhibition task (day–night) and the Facial Discrimination Task bias score, $r = -.77$, $p < .0001$. General nonverbal reasoning ability (Raven Coloured Progressive Matrices) and CA were not significantly related to any Facial Discrimination Task scores. In the control group, no significant correlations were observed between Facial Discrimination Task scores, PPVT-R-F, and CA.

Correlations Between Face Processing Tests and Facial Discrimination Task

Finally, we analyzed the relationships between Face Processing Tests and the Facial Discrimination Task, using nonparametric correlations. In the Down syndrome group, we observed a significant relationship between the recognition of surprise (Face Processing Tests) and the neutral expression (Facial Discrimination Task), $\tau = .74$, $p < .0001$. A significant positive relation also appeared between the recognition of the neutral expression and the Face-Sim Identity Matching subtest (face complete and similar), $\tau = .48$, $p = .015$. No significant relationship was found for the control group.

Discussion

Our purpose in this study was to investigate face and emotion processing ability of adults with Down syndrome. We administered various tasks presenting facial stimuli with and without emotional content, and compared the results with those of a control group matched on a receptive vocabulary task. In the Face Processing Tests, no significant differences were found between the two groups on the Identity Matching Test. On the emotional tasks, the adults with Down syndrome had more problems matching faces according to emotional expressions, particularly with the recognition of the neutral and surprised expressions. In attributing emotional intensity, they performed very well when identifying the very happy faces, whereas the control group was easily able to identify the very happy faces, but also the very sad ones.

The Down syndrome group performed relatively well on the first two subtests (Complete Faces Dissimilar/Similar), and their results on the Identity Matching Test did not differ from those of the control group. This seems to suggest that these adults do not have difficulties when processing faces that are presented in their entirety, which is consistent with the findings of studies of children with Down syndrome (Williams et al., 2005; Wishart & Pitcairn, 2000). On the other hand, the Down syndrome group's performance dropped to chance in the last three subtests, in which some features (ears, hair, eyes) were concealed. The children in the control group were also unable to execute the last two subtests, suggesting that the difficulties encountered by the Down syndrome group might be related to MA. According to Bruce et al. (2000), the various subtests from the Identity Matching Test are designed to favor a particular face processing strategy (featural vs. configural), depending on the stimuli presented. When faces have similar features, or when certain features are masked, this impairs the featural processing strategy (analysis of the individual features of the face) because it disrupts analysis focusing on the main features (e.g., eyes, mouth) (Carey & Diamond, 1977; Freire & Lee, 2001; Tanaka & Farah, 1993). In this case, a configural processing strategy (analysis of the relations between facial features) is required. These results suggest that the adults with Down syndrome favored a featural processing strategy as did the children in the control group, who failed the last subtests. Results for the children in the control group were similar to those found by Bruce et al. and consistent with the developmental literature. Indeed, researchers have reported that young children favor a featural over a configural strategy when processing facial stimuli. During the course of childhood, the use of the featural strategy will decrease and a configural strategy will be employed more frequently (Itier & Taylor, 2004; Taylor, Batty, & Itier, 2004). Concerning the processing strategy used by adults with Down syndrome, it remains unclear whether they present a simple developmental delay or use atypical processing strategies. Indeed, the last two Identity Matching subtests may have required additional cognitive demands (such as attentional skills), which may have compromised the success of participants with Down syndrome. It would, therefore, be very interesting to further investigate face processing in this population by administering adapted tasks in order to reduce the additional cognitive demands. To clarify face processing strategies by individuals with Down syndrome, it would also be important to present stimuli in different conditions, such as modified faces or inverted faces as well as to study these abilities along a developmental trajectory.

On the Emotion Identification Test, we observed that adults with Down syndrome showed a significant impairment in processing the expression of surprise, whereas their identification of happiness, sadness, and anger did not differ from that of children in the control group. Wishart and Pitcairn (2000) reported a deficit in processing the expression of surprise for children with Down syndrome (age range 8 to 14 years), which suggests that identification of this expression does not improve with increasing age. In our study, the Down syndrome group showed particular difficulties in the emotion matching conditions, although the reason remains unclear. We observed that both the adults with Down syndrome and the younger children tended to match the faces according to their identity rather than their emotional expression. They seemed to find it difficult to inhibit facial identity and focus on the facial expression. It is also possible that the task instructions might have been more difficult to understand with the concept of "feeling the same way," leading to a misinterpretation of the task. This hypothesis may be corroborated by the significant positive relationship found in the Down syndrome group between this emotion matching condition and the passive vocabulary measure.

Regarding the results of the Facial Discrimination Task, we observed that the proportion of neutral faces correctly rated by the Down syndrome group was significantly lower than that of the control group. On the other hand, their recognition of faces expressing happiness and sadness did not differ statistically from that of the controls. When rating emotional intensity, the Down syndrome group showed a propensity to maximize positive emotions and minimize negative ones. The response pattern of the control group was dissimilar: They tended to intensify both happy and sad emotions. Moreover, analysis of the adults' error pattern suggests a tendency to judge faces more positively than did children in the control group. In light of these observations, we suggest that the Down syndrome group presents a positive bias in assessing emotional facial stimuli. High performance in rating happy emotions was also observed by Kasari et al. (2001) in children with Down syndrome, but the children had a strong tendency to substitute a positive emotion for a negative one. Investigations of developmental trajectory, including a measure of emotion intensity attribution, could be of great interest in providing a more qualified response pattern in the Down syndrome population.

As seen previously with children (Williams et al., 2005; Wishart & Pitcairn, 2000), the adults with Down syndrome in our study did not show particular difficulties when processing complete faces without emotional expressions (Identity Matching subtests 1 and 2). This supports the hypothesis that they have a specific emotional deficit, because they performed successfully on facial tasks of comparable complexity and abstraction (Rojahn, Rabold, & Schneider, 1995). These data did not support the theoretical position that sustains preserved basic emotion-perception skill in people with mental retardation (Moore, 2001; Moore, Hobson, & Lee, 1997), at least in people with Down syndrome. The Moore (2001) literature review, in which Moore examined in detail the issue of a specific emotion deficit versus preserved basic skills in people with mental retardation, included participants whose mental retardation etiology was unknown (e.g., Maurer & Newbrough, 1987; McAlpine, Kendall, & Singh, 1991) or not examined (e.g., Simon et al., 1996). Nevertheless, in the majority of recent studies conducted in the population with mental retardation, researchers have reported a substantial variability in emotional abilities depending on the etiology. The emotion specificity hypothesis could be further considered in this new context.

Several hypotheses may now be considered in order to better understand the emotional impairments showed by the Down syndrome group. First, we might question the relationship between general cognitive abilities and emotional processing. Even though this issue has been examined by many authors, opinions still remain diverse (Dawson, Webb, & McPartland, 2005; Gagliardi et al., 2003; Moore, 2001; Rojahn, Lederer, & Tassé, 1995). In our study, results on the various emotional tasks did not correlate significantly with the Raven Coloured Progressive Matrices raw score. Therefore, these results show that the recognition of facial emotional expressions is not directly related to a general nonverbal reasoning capacity. These findings contradict the assumption that emotion recognition is related to MA in adults with mental retardation (Moore, 2001; Simon et al., 1996) and suggest that it would be appropriate to offer emotion-based programs to people with Down syndrome.

It seems that more specific abilities may be involved, such as receptive vocabulary. Indeed, we did observe a significant positive correlation between the receptive vocabulary task (PPVT-R-F) and the surprised and neutral expressions, which were less well-recognized by the adults with Down syndrome. Consequently, one can assume that recognition of these two expressions might require more complex semantic representation (e.g., surprise can be associated with a positive or a negative event) than joy, sadness, or anger. Nevertheless, the absence of any relationship between the PPVT-R-F score and the recognition of neutral or surprise stimuli in the control group might invalidate this hypothesis and suggest instead a particular emotional deficit inherent in individuals with Down syndrome. Indeed, these two expressions were easily recognized by the child control group. A significant negative correlation was also observed in the Down syndrome group between the PPVT-R-F score and the recognition of happy expressions (Facial Discrimination Task), showing that, paradoxically, adults with Down syndrome, who were better at recognizing the happy faces, had a poorer receptive vocabulary score. This result may be related to the positive bias: Participants who had difficulty recognizing neutral expressions might have had the tendency to respond *happy* more often during the test, which resulted in a very high score for this emotion. Moreover, we observed that adults with Down syndrome often confused the expression of surprise with the expression of happiness (probably because of the wide-open mouth in both expressions), which also supports the hypothesis of the positive bias. The poorer recognition of the neutral expression by the Down syndrome group may be related to structural specificity. Indeed, in neutral faces, the features (e.g., mouth, eyes, and eyebrows) are less prominent than in other expressions (Guizatdinova & Surakka, 2005). This hypothesis is supported by the significant positive relationship between the neutral expression score and the Identity Matching subtest Face-Sim (face complete and similar) in the Down syndrome group, indicating that the participants who were better at recognizing the neutral stimuli were also more accurate in matching similar faces. The Facial Discrimination Task design (a choice among three options) also offers the possibility of succeeding by deduction (if the face is neither happy nor sad, it must be neutral). Because the adults with Down syndrome performed well on the recognition of happy and sad expressions, one might expect them to use the exclusion strategy when neutral faces were presented. Instead, they showed a tendency to propose the happy expression and demonstrated a positive bias throughout the task. The preference for more positive emotions exhibited by people with Down syndrome may be difficult to inhibit, particularly when they face new or puzzling situations, a hypothesis that seems to be supported by the strong correlation between the bias score and the verbal inhibition measure (day–night task). In order to further investigate the processing of this expression by adults with Down syndrome, we are planning additional research in which we will use some tasks involving neutral faces under different conditions (identification, matching). An experimental design should be used to allow the counterbalancing of the administration of emotional tasks, in order to control for the potential influence of task presentation on participants' performances. In this study we decided to present the emotional tasks according to their level of difficulty: The tasks with the easiest instructions were administered first in order to encourage the participants. However, we paid careful attention to the motivation and attentional level of all participants, which allowed us to control this drawback as much as possible. Because our results show that some specific competences were involved in the emotional tasks (inhibition and receptive vocabulary), it will be of great interest to add other cognitive measures, such as productive vocabulary or attentional abilities to our experimental design.

Finally, these findings lead us to reflect on the possible implications of this emotional impairment for other aspects related to the social sphere. Soresi and Nota (2000) observed that young adults with Down syndrome present deficits in interpersonal relationships, with problems maintaining appropriate interactions. Their difficulty in recognizing neutral expressions and their tendency to interpret other people's emotional states as too positive may be linked to socially inappropriate behavior. Indeed, when faced with a partner who is expressing no particular emotion, a person with Down syndrome may not correctly understand the other's emotional state and, thus, his or her reaction may be maladjusted. More detailed investigations in this area are required. Moreover, it would be very interesting to determine the facial emotional recognition pattern in children and adolescents with Down syndrome, as well as adults, in order to study the developmental trajectory of their emotional processing. The comparison of the emotional pattern in individuals with Down syndrome with that of people who have other genetic disorders associated with mental retardation will also be important in the future, in order to verify whether the atypical pattern observed in our population is specific to Down syndrome. Our findings emphasize the relevance of a more qualitative approach, analyzing a complete response pattern for facial emotional recognition and using the emotion intensity rating. The experimental design provides a more accurate emotional processing profile of people with Down syndrome and opens up the possibility of designing an early rehabilitation program to improve their social behavioral skills.

References

Benton, A. L., Sivan, A. B., Hamsher, K., Varney, N. R., & Spreen, O. (1983). *Benton Facial Recognition Test.* New York: Oxford University Press.

Bieberich, A. A., & Morgan, S. B. (2004). Self-regulation and affective expression during play in children with autism or Down syndrome: A short-term longitudinal study. *Journal of Autism and Developmental Disorders, 34,* 439–448.

Brock, J., & Jarrold, C. (2005). Serial order reconstruction in Down syndrome: Evidence for a selective deficit in verbal short-term memory. *Journal of Child Psychology and Psychiatry, 46,* 304–316.

Bruce, V., Campbell, R. N., Doherty-Sneddon, G., Import, A., Langton, S., McAuley, S., & Wright, R. (2000). Testing face processing skills in children. *British Journal of Developmental Psychology, 18,* 319–333.

Carey, S., & Diamond, R. (1977). From piecemeal to configurational representation of faces. *Science, 195*(4275), 312–314.

Carlson, S. M., & Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development, 72,* 1032–1053.

Clark, D., & Wilson, G. N. (2003). Behavioral assessment of children with Down syndrome using the Reiss Psychopathology Scale. *American Journal of Medical Genetics, 188,* 210–216.

Dawson, G., Webb, S. J., & McPartland, J. (2005). Understanding the nature of face processing impairment in autism: Insights from behavioral and electrophysiological studies. *Developmental Neuropsychology, 27,* 403–424.

Diamond, A., & Taylor, C. (1996). Development of an aspect of executive control: Development of the abilities to remember what I said and to "Do as I say, not as I do." *Developmental Psychobiology, 29,* 315–334.

Duchaine, B. C., & Weidenfeld, A. (2003). An evaluation of two commonly used tests of unfamiliar face recognition. *Neuropsychologia, 41,* 713–720.

Dunn, L., & Dunn, L. (1981). *Peabody Picture Vocabulary Test–revised: Manual for Forms L and M.* Circle Pines, MN: American Guidance Service.

Dunn, L., Dunn, L., Whetton, C., & Pintilie, D. (1982). *British Picture Vocabulary Scale.* Windsor: NFER–Nelson.

Dunn, L., Thériault-Whalen, C. M., & Dunn, L. M. (1993). *Peabody Picture Vocabulary Test–Revised.* Toronto, ON: Psycan.

Dykens, E., Shah, B., Sagun, J., Beck, T., & King, B. H. (2002). Maladaptive behaviour in children and adolescents with Down's syndrome. *Journal of Intellectual Disability Research, 46,* 484–492.

Ekman, P., & Friesen, W. V. (1976). *Facial affect slides.* Palo Alto, CA: Consulting Psychologists Press.

Freire, A., & Lee, K. (2001). Face recognition in 4- to 7-year-olds: Processing of configural, featural, and paraphernalia information. *Journal of Experimental Child Psychology, 80,* 347–371.

Gagliardi, C., Frigerio, E., Burt, D. M., Cazzaniga, I., Perrett, D. I., & Borgatti, R. (2003). Facial expression recognition in Williams syndrome. *Neuropsychologia, 41,* 733–738.

Gerstadt, C. L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: Performance of children 3 1/2–7 years old on a Stroop-like day-night test. *Cognition, 53,* 129–153.

Grant, C. M., Apperly, I., & Oliver, C. (2007). Is theory of mind understanding impaired in males with fragile X syndrome? *Journal of Abnormal Child Psychology, 35,* 17–28.

Guizatdinova, I., & Surakka, V. (2005). Detection of facial landmarks from neutral, happy and disgust facial images. *Journal of WSCG, 13,* 55–62.

Itier, R. J., & Taylor, M. J. (2004). Face recognition memory and configural processing: A developmental ERP study using upright, inverted, and contrast-reversed faces. *Journal of Cognitive Neuroscience, 16,* 487–502.

Jarrold, C., & Baddeley, A. D. (2001). Short-term memory in Down syndrome: Applying the working memory model. *Down Syndrome: Research & Practice, 7,* 17–23.

Karmiloff-Smith, A., Thomas, M., Annaz, D., Humphreys, K., Ewing, S., Brace, N., van Duuren, M., Pike, G., Grice, S., & Campbell, R. (2004). Exploring the Williams syndrome face-processing debate: The importance of building developmental trajectories. *Journal of Child Psychology and Psychiatry, 45,* 1258–1274.

Kasari, C., Freeman, S. F. N., & Hughes, M. A. (2001). Emotion recognition by children with Down syndrome. *American Journal on Mental Retardation, 106,* 59–72.

Kaufman, A. S., & Kaufman, N. L. (1983). *Kaufman Assessment Battery for Children.* Circle Pines, MN: American Guidance Service.

Lawrence, K., Kuntsi, J., Coleman, M., Campbell, R., & Skuse, D. (2003). Face and emotion recognition deficits in Turner syndrome: A possible role for X-linked genes in amygdala development. *Neuropsychology, 17,* 39–49.

Matheson, E., & Jahoda, A. (2005). Emotional understanding in aggressive and nonaggressive individuals with mild or moderate mental retardation. *American Journal on Mental Retardation, 110,* 57–67.

Maurer, H., & Newbrough, J. R. (1987a). Facial expressions of mentally retarded and nonretarded children: I. Recognition by mentally retarded and nonretarded adults. *American Journal of Mental Deficiency, 91,* 505–510.

Maurer, H., & Newbrough, J. R. (1987b). Facial expressions of mentally retarded and nonretarded children: II. Recognition by nonretarded adults with varying experience with mental retardation. *American Journal of Mental Deficiency, 91,* 511–515.

McAlpine, C., Kendall, K. A., & Singh, N. N. (1991). Recognition of facial expressions of emotion by persons with mental retardation. *American Journal on Mental Retardation, 96,* 29–36.

Moore, D. G. (2001). Reassessing emotion recognition performance in people with mental retardation: A review. *American Journal on Mental Retardation, 106,* 481–502.

Moore, D. G., Hobson, R. P., & Lee, A. (1997). Components of person perception: An investigation with autistic, non-autistic retarded and typically developing children and adolescents. *British Journal of Developmental Psychology, 15,* 401–423.

Raven, J. C., Court, J. H., & Raven, J. (1998). *Progressive matrices—Colour.* Oxford, UK: Psychologist Press.

Robel, L., Ennouri, K., Piana, H., Vaivre-Douret, L., Perier, A., Flament, M. F., et al. (2004). Discrimination of face identities and expressions in children with autism: Same or different? *European Child and Adolescent Psychiatry, 13,* 227–233.

Rojahn, J., Lederer, M., & Tassé, M. J. (1995). Facial emotion recognition by persons with mental retardation: A review of the experimental literature. *Research in Developmental Disabilities, 16,* 393–414.

Rojahn, J., Rabold, D. E., & Schneider, F. (1995). Emotion specificity in mental retardation. *American Journal on Mental Retardation, 99,* 477–486.

Rondan, C., Gepner, B., & Deruelle, C. (2003). Inner and outer face perception in children with autism. *Child Neuropsychology, 9,* 289–297.

Rowe, J., Lavender, A., & Turk, V. (2006). Cognitive executive function in Down's syndrome. *British Journal of Clinical Psychology, 45,* 5–17.

Simon, E. W., Rosen, M., & Ponpipom, A. (1996). Age and IQ as predictors of emotion identification in adults with mental retardation. *Research in Developmental Disabilities, 17,* 383–389.

Soresi, S., & Nota, L. (2000). A social skill training for persons with Down's syndrome. *European Psychologist, 5,* 34–43.

Tanaka, W. T., & Farah, M. J. (1993). Parts and wholes in face recognition. *Quarterly Journal of Experimental Psychology, 46A,* 225–245.

Taylor, M. J., Batty, M., & Itier, R. J. (2004). The faces of development: A review of early face processing over childhood. *Journal of Cognitive Neuroscience, 16,* 1426–1442.

Thorndike, R. L., Hagen, E. P., & Sattler, J. M. (1986). *The Stanford Binet Intelligence Scale.* Chicago: Riverside.

Tingley, E. C., Gleason, J. B., & Hooshyar, N. (1994). Mothers' lexicon of internal state words in speech to children with Down syndrome and to nonhandicapped children at mealtime. *Journal of Communication Disorders, 27,* 135–155.

Turk, J., & Cornish, K. (1998). Face recognition and emotion perception in boys with fragile-X syndrome. *Journal of Intellectual Disability Research, 42,* 490–499.

Wechsler, D. (1990). *Wechsler Pre–School and Primary Scales of Intelligence* (Rev. UK ed.). London: Psychological Corp.

Wechsler, D. (1992). *Wechsler Intelligence Scales for Children* (3rd UK ed.). London: Psychological Corp.

Williams, K. R., Wishart, J. G., Pitcairn, T. K., & Willis, D. S. (2005). Emotion recognition by children with Down syndrome: Investigation of specific impairments and error patterns *American Journal on Mental Retardation, 110,* 378–392.

Wishart, J. G., & Pitcairn, T. K. (2000). Recognition of identity and expression in faces by children with Down syndrome. *American Journal on Mental Retardation, 105,* 466–479.

Received 10/18/06, accepted 12/18/07.
Editor-in-charge: William E. MacLean, Jr.

We thank J. Rojahn and his colleagues for permission to use the Facial Discrimination Task, which was supported by the John D. and Catherine T. MacArthur Foundation. Correspondence regarding this article should be sent to Koviljka Barisnikov, University of Geneva, Child Clinical Neuropsychology Unit, Geneva, 1211, Switzerland. E-mail: Koviljka.Barisnikov@pse.unige.ch

Erratum

DOI: 10.1352/2008.113:ii

The order of authors of "Face Processing and Facial Emotion Recognition in Adults With Down Syndrome," which appeared in the July 2008 issue of the *American Journal on Mental Retardation* is incorrect. The correct order is:

Loyse Hippolyte, Koviljka Barisnikov, and Martial Van der Linden

There were several errors in the paper that were not the fault of the authors. We apologize for these errors. The on-line version has been corrected.

