

Social reasoning skills in adults with Down syndrome: the role of language, executive functions and socio-emotional behaviour

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Abstract

Background Although the prevalence of mental illness and behaviour problems is lower in adults with Down syndrome (DS) than in other populations with intellectual disabilities, they do present emotional and relational problems, as well as social integration difficulties. However, studies reporting on specific competences known to be central in developing appropriate social relationships (e.g. social reasoning, emotion processing, theory of mind) remain rare in the adult DS population and the mechanisms underlying these people's emotional and relational difficulties are unclear.

Method The present study investigated the ability to understand the appropriateness of others' social behaviour in 34 adults with DS, using the Social Resolution Task (SRT). Their results were compared with those of 34 typically developing (TD) children matched for gender and receptive vocabulary. The relationships among the SRT experimental task, cognitive competences (receptive and productive vocabulary, non-verbal reasoning, inhibition, selective attention) and a caregiver-rated measure of socio-emotional behaviour were examined in the DS group.

Results The DS participants' global SRT scores did not differ from those of the controls. However,

analyses of the SRT subscores revealed that the DS group identified significantly fewer inappropriate situations than the control group. Nevertheless, when they correctly identified the behaviour as inappropriate, they were as well as the controls to explain the rules underlying their responses. Regression analyses showed that receptive vocabulary and selective attention and a specific dimension of the socio-emotional profile (social relating skills) constituted the best predictors of the DS adults' performance on the SRT.

Conclusions The main findings show that the DS participants demonstrate relatively good social reasoning skills in comparison with TD children matched for verbal age. However, the two groups present distinctions in their response patterns, and the influence of cognitive variables on success on the SRT also appears different. While selective attention skills are found to be significant predictors for both groups, the influence of receptive vocabulary level is much stronger in the DS group. The implications of particular cognitive and socio-emotional factors for success on the SRT in this group are considered in more detail.

Keywords down syndrome, language, executive functions, social behaviour, social cognition

Introduction

Research conducted on socio-emotional abilities in people with Down syndrome (DS), and specifically

in adults, remains surprisingly rare when one considers the number of people affected by this syndrome. DS is the most common genetic form of intellectual disability (ID), and the adult population is largely represented in sheltered workshops and specialised institutions. For a long time, people with DS have been characterised as presenting good socio-emotional skills and few social behavioural problems (Gunn & Cuskelly 1991; Dykens *et al.* 1994; Carr 1995). Furthermore, studies reporting on mental illness and behaviour problems in adults with ID show a lower prevalence in people with DS. Antisocial, aggressive or destructive behaviour remains relatively low in this population compared with other adults with ID (Mantry *et al.* 2008; Melville *et al.* 2008; Cooper *et al.* 2009).

Yet, studies in DS people have also emphasised emotional and relational problems such as oppositional behaviour, intrusive behaviour and stubbornness (Coe *et al.* 1999; Fidler *et al.* 2008). Social integration difficulties have been underscored in young DS adults, who have been found to show particular problems developing a social network and maintaining friendships (Soresi & Nota 2000). Furthermore, adults with DS present difficulties with specific competences known to be central to the development of appropriate social relationships, such as emotion processing (Hippolyte *et al.* 2008; Hippolyte *et al.* 2009a) and abilities related to theory of mind (Zelazo *et al.* 1996a; Abbeduto *et al.* 2001). To date, very little work has investigated these competences in DS adults and the mechanisms underlying these people's emotional and relational difficulties.

While social reasoning ability has been extensively investigated in typically developing (TD) children (e.g. Nucci & Turiel 1978; Turiel 1983; Zelazo *et al.* 1996b), few studies have been conducted in populations with neurodevelopmental disorders. We found only two studies exploring this ability in children with autism (Loveland *et al.* 2001; Grant *et al.* 2005), whereas, to the best of our knowledge, these skills have never been investigated in adults with DS. In the DS population, social understanding has essentially been considered through questionnaires (Loveland & Kelley 1988; Hawkins *et al.* 2003; Rosner *et al.* 2004), which might be explained by the difficulty of finding suitable tasks for this population. In our view, it would be interesting to

develop a task adapted to DS participants, in order to assess their competences by a direct measure.

Consequently, our main objective in the present study was to explore the social reasoning skills of DS adults by using the Social Resolution Task (SRT), which was specifically created for people with ID. This task assessed the ability to understand the appropriateness of other people's social behaviour based on the knowledge of conventional and moral rules. In this study, we were also interested in investigating potential competences involved in the success of the SRT, such as general cognitive abilities and socio-emotional behaviour.

Regarding cognitive abilities, we first considered general cognitive processes reported to be related to socio-emotional competences and theory of mind skills in people with ID. The involvement of language skills has been emphasised in numerous studies (Frith *et al.* 1994; Abbeduto & Murphy 2004; Thirion-Marissiaux & Nader-Grosbois 2008a). In addition, executive functions such as inhibitory control, attentional processing and working memory have been shown to play a significant role in the success of these socio-emotional tasks in populations of TD children (Gordon & Olson 1998; Carlson *et al.* 2002; Flynn *et al.* 2004; Rhoades *et al.* 2009) as well as in clinical populations involving children with autism spectrum disorders (Joseph & Tager-Flusberg 2004; Ames & Jarrold 2007), fragile X (Grant *et al.* 2007) and traumatic brain injury (Henry *et al.* 2006).

In our experimental design, we proposed to the DS group measures of receptive and productive vocabulary and non-verbal reasoning to control the impact of language skills in the SRT task. The potential influence of inhibition processes, which are often reported to be impaired in DS people (Munir *et al.* 2000; Rowe *et al.* 2006), was also controlled for. The assessment was completed with measures of visual selective attention. These skills were also assessed in the control group, as they may play a critical role in the processing of the SRT drawings.

Regarding the measure of the socio-emotional behaviour, studies involving TD children generally found associations between poor social reasoning skills and aggressiveness (for a literature review, see Harvey *et al.* 2001). Basquill *et al.* (2004) also observed such associations in adult males with mild ID (aetiology non-specified). However, the studies

investigating these links in populations with ID remain rare, and there are no studies in DS people. In the present study, we were interested in exploring the potential relations between the SRT and the socio-emotional behaviour of the DS adults. We therefore introduced a caregiver-rated measure of the DS participants' behaviour and emotional problems which assesses difficulties such as aggressiveness, anxiety, social avoidance or communication disturbance.

The DS adults' results on the SRT were compared with those of TD children matched for their receptive vocabulary abilities. We chose this match to check for differences in verbal ability that might interfere with the SRT. Furthermore, it constitutes a measure frequently used in studies reporting on social reasoning skills in people with ID (e.g. Gomez & Hazeldine 1996; Bieberich & Morgan 2004; Grant *et al.* 2005).

Materials and methods

Participants

Thirty-four French-speaking participants with DS (12 of whom were women) who had a moderate ID took part in the study. They were employed by two sheltered workshops, and lived with their families (91%) or in congregate settings (9%). All participants had a medical diagnosis of Trisomy 21 and had attended special schools for people with ID. Participants with significant sensory or physical disabilities were excluded from participation, as these difficulties might impede them to fairly complete the assessment; participants with psychiatric disorders (e.g. pervasive developmental disorder, mood disorder) as well as clinical symptoms of dementia were also likewise excluded. The mean chronological age (CA) of the group was of 32.22 years (SD = 9.66; age range 18 to 52, of which 91% under 42.5). Adults were individually matched for gender and raw score on a receptive vocabulary task with a control group comprising TD children attending an elementary public school (mean CA = 5.69; age range 4 to 11, of which 97% under 8.5). The vocabulary task was the French adaptation of the Peabody Picture Vocabulary Test – Revised (Evip-R; Dunn *et al.* 1993). On this task, the DS group obtained a mean raw score of 65.85 (SD = 22.77) and the control group had a mean

score of 66.59 (SD = 20.01). This difference was not statistically significant.

Two selective attention subtests (Rabbits and Faces) taken from the Nepsy neuropsychological battery (Korkman *et al.* 2003) were administered to all participants (see Table 1). However, two children in the control group ages 4.2 and 4.3 could not be given the Faces subtest as they did not understand the task instructions (subtest intended for children from age 5). In the Rabbits subtest, participants were asked to search for target pictures (rabbits) among dissimilar distracters (e.g. apple, tree and dog). The Faces subtest was more complex as two targets (two specific faces) had to be found among similar distracters (other faces). The time was limited to 180 s for each subtest, and participants were instructed to proceed as quickly as possible. The DS group obtained a poorer precision score (number of hits minus false alarms) for the Faces subtest ($P = 0.001$), and took significantly more time to perform both subtests (Rabbits: $P < 0.001$, Faces: $P < 0.001$) than the TD children.

Additional cognitive tasks assessing non-verbal reasoning, productive vocabulary and inhibition skills were administered to the DS adults to check for their potential influence on the SRT. These tasks could not be proposed to the control participants as we had time constraints for their assessment.

Non-verbal reasoning ability was assessed using Raven's Coloured Progressive Matrices (CPM);

Table 1 Participants' main characteristics

	DS group Mean (SD)	Control group Mean (SD)
Chronological age (years)	32.22 ^a (9.66)	5.69 ^b (1.63)
Evip-R: developmental age (years)	6.12 (1.95)	6.14 (1.7)
Rabbits subtest precision score*	17.91 (2.43)	18.74 (1.64)
Rabbits subtest response time (seconds)	133.32 ^c (43.03)	79.97 ^d (40.57)
Faces subtest precision score*	1.38 ^e (5.88)	7.41 ^f (8.26)
Faces subtest response time (seconds)	179.5 ^g (2.58)	153.04 ^h (40.99)

* Maximum precision score = 20.

a > b, $P < 0.01$; c > d, $P < 0.01$; e < f, $P < 0.01$; g > h, $P < 0.01$.

Raven *et al.* 1998): mean raw score = 15.09, SD = 5.31 (corresponding approximately to an IQ of 57). Productive vocabulary abilities were assessed with a naming subtest taken from the Isadyle French language battery (Piérart *et al.* 2007): mean percentage score = 70.34, SD = 11.72. Two tasks requiring participants to inhibit a prepotent response were administered: the Sun-Moon task (verbal response) (computerised version; Hippolyte *et al.* 2009b), which is adapted from the Day-Night Stroop-like task (Gerstadt *et al.* 1994) and the tapping task (motor response) (Diamond & Taylor 1996; the number of items was increased from 16 to 24). The DS participants obtained a mean percentage score of 82.39 (SD = 30.99) in the Sun-Moon task and of 60.42 (SD = 35.67) in the tapping task.

Finally, the Developmental Behaviour Checklist (DBC-A adult version, Mohr *et al.* 2005) assessing the emotional and behavioural problems of adults with ID was completed by the DS adults' referent caregivers at the sheltered workshop. This checklist provided a global score as well as six sub-scale scores. We used the French version of the DBC-A and the internal consistency of its six sub-scales was satisfactory (Cronbach's α between 0.8 and 0.9 for sub-scales 1 to 4 and 6; Cronbach's α of 0.72 for sub-scale 5). The items are rated on a 3-point scale (0 = not true, 1 = somewhat or sometimes true, 2 = very true or often true) and mean scores can be calculated (continuum between 0 and 2). The DS group obtained a mean global score of 0.19 (SD = 0.16), and mean scores on the sub-scales were as follows: 0.25 (SD = 0.28) for sub-scale 1, Disruptive (e.g. tantrums, irritable); 0.08 (SD = 0.09) for sub-scale 2, Self-absorbed (e.g. bangs head, screams); 0.25 (SD = 0.22) for sub-scale 3, Communication disturbance (e.g. talks fast, hallucination); 0.08 (SD = 0.14) for sub-scale 4, Anxiety/Antisocial (e.g. hides things, steals); 0.42 (SD = 0.35) for sub-scale 5, Social relating (e.g. loner, shy); and 0.19 (SD = 0.25) for sub-scale 6, Depression (e.g. withdrawn, lost self-care).

Procedure

The assessment was conducted in French, and all participants were tested individually in a quiet room at their workplace or at school. The TD children in the control group completed the SRT and the cog-

nitive tests (Nepsy and Evip-R) in one session (25 to 35 min). Two to three sessions were necessary (25 to 35 min each) to administer all the tasks to the DS participants, depending on the participants' fatigue and motivation. Tasks were administered in a counterbalanced order and sessions took place over approximately 1 to 2 weeks. The research was approved by the Ethics Committee of the University of Geneva and authorisations from the institution, the legal guardians of the DS adults, and the school were obtained. Participants gave their oral consent to take part in the study, and were free to withdraw from the procedure at any time.

The Social Resolution Task

The SRT (Barisnikov *et al.* 2005) assesses the ability to judge the appropriateness of social behaviour based on knowledge of conventional and moral rules. This task was basically created for people with mild to moderate ID but its use also seems to be adapted for young TD children. Although the psychometric properties of the SRT have not been investigated, developmental norms for children ages 4 to 12 years (Barisnikov *et al.* unpublished data) shows that the SRT global success score progressively increases with age, without any floor or ceiling effects.

The SRT consists of 14 coloured drawings illustrating daily social situations. Five items depict an appropriate situation (e.g. helping an elderly lady to cross the street, cooperating in washing dishes) and nine items depict an inappropriate situation (e.g. failing to share cookies with a friend, destroying property). For each item, participants are asked by the experimenter whether the situation is appropriate or not. This first question assesses the ability to judge the situation from a general point of view. Then participants have to point to the element on which their judgement is based. This question considers the ability to identify the relevant constituent of the social situation. Finally, participants who answer that the situation is inappropriate (even if it is actually appropriate) are asked to explain why. This last question assesses the understanding of the situation in detail. One trial item depicting an appropriate situation is first presented to ensure that the participants understand the task.

	DS group Mean (SD)	Control group Mean (SD)	Mann–Whitney <i>U</i>
Judgement			
Appropriate situation	84.1 (20.2)	89.7 (18.3)	485.5
Inappropriate situation	77.5 (22.6)	87.9 (14.6)	419*
Identification			
Appropriate situation	68.8 (30.4)	82.4 (22.9)	434
Inappropriate situation	68.6 (26)	83 (18.4)	388*

* $P < 0.05$.

DS, Down syndrome; SRT, Social Resolution Task.

A global SRT score (maximum = 105 points) and three subscores – one for each question asked by the experimenter – were calculated. In addition, separate scores could be calculated for the appropriate and inappropriate situations.

Question 1: 2 points were awarded if the answer was correct and 0 if it was wrong (judgement subscore; maximum = 28 points).

Question 2: 1 point was awarded for a correct answer and 0 for a wrong one (identification subscore; maximum = 14 points).

Question 3: this question was coded into four categories according to the participants' level of social understanding and cognitive reasoning. 0 to 7 points were given for the explanation of each inappropriate situation (understanding subscore; maximum = 63 points). 0 point (level 0 response) for an incorrect or inappropriate answer (e.g. when seeing a girl pulling another girl's hair: 'it is wrong, they should be in class by now'). 2 points (level 1 response) for a description of the scene without social awareness (e.g. 'it is wrong, she is pulling her hair'). 5 points (level 2 response) for an answer based on causality relations with social awareness (e.g. 'it is not nice, she is going to cry'); 7 points (level 3 response) for an answer based on conceptual knowledge of conventional or moral rules (e.g. 'it is wrong to hurt someone').

Results

Comparison between groups on the SRT global score and subscores

The SRT data were investigated using four types of analysis: (1) a Student *t*-test analysis to compare the

global SRT score between the groups; (2) non-parametric¹ analyses (Mann–Whitney *U*-tests) to compare the subscores between the groups; (3) multilevel models (mixed effects models with crossed random effects) to control for the impact of the two SRT dimensions (conventional and moral); and (4) multiple regression analyses to investigate the impact of the different predictors on the SRT scores (for the inappropriate situations and for the global score) in interaction with the group variable and in the DS group alone.

The mean SRT global score (percentage) was 46.72 (SD = 15.46) for the DS group and 50.84 (SD = 10.63) for the control group. The Student *t*-test analysis showed that these two scores were not statistically different, $t(66) = -1.28$, $P = 0.21$. The two groups' mean SRT subscores related to the questions of judgement and identification (differentiating appropriate and inappropriate situations) are reported in Table 2 with their Mann–Whitney *U*-values. For the appropriate situations, the two groups' performance did not differ. For the inappropriate situations, we observed that the DS group obtained significantly lower scores than the controls for both judgement ($P = 0.044$) and identification ($P = 0.018$) subscores. However, no differences were observed within groups between judgement and identification subscores according to the appropriateness of the situation.

We then analysed the SRT understanding subscore for the two groups (inappropriate situations only). No differences appeared between the DS

¹ While the SRT global score was normally distributed, the distribution of the SRT subscores was continuous but asymmetric. Non-parametric analyses were therefore conducted on these subscores.

Table 2 Scores (percentage) of the DS and control groups for the judgement and identification questions of the SRT

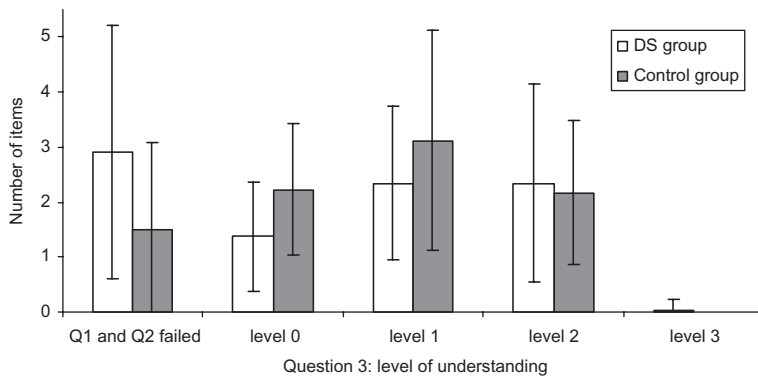


Figure 1 Number of items (inappropriate situations) obtained for each level of representation in the understanding subscore for both groups. DS, Down syndrome.

group (mean percentage score = 27, SD = 14.6) and the control group (mean percentage score = 27.1, SD = 10.2) when we considered the global subscore, $U = 552$, $P = 0.75$. Finally, the levels of social understanding (number of items for each level) reached by the two groups were investigated (see Fig. 1). As expected, the DS adults failed significantly more of these items than the controls ($U = 387.5$, $P = 0.017$). However, it was observed that, when they correctly judged and identified the situations, they gave fewer incorrect or inappropriate answers (level 0) than the control group ($U = 384$, $P = 0.015$). The two groups' subscores did not differ for the explanation of the situations at levels 1, 2 and 3.

The SRT assesses the ability to judge the appropriateness of social behaviour based on knowledge of conventional (3 items) and moral rules (6 items) and we tested for a difference between these two dimensions on the SRT score. We ran a mixed effects model with subject and item as crossed random effects on the SRT and with the group and type of item as factors. No differences were found between the items testing moral versus conventional rules for the two groups.

Analyses of the SRT subscores revealed that the DS adults had more difficulties judging and identifying inappropriate social situations than the controls. In order to examine the potential variables that might explain this inter-group difference, we conducted a multiple regression analysis on a compound score related to the inappropriate situations (judgement and identification subscores together). As predictors for this analysis, we used the cognitive scores on the Evip-R (receptive vocabulary task),

Rabbits and Faces (selective attention subtests) and CA and the interaction of these variables with group. The best model found explained almost 40% of the variance in the dependent variable ($R^2 = 0.39$ and R^2 adjusted = 0.35). We observed a main negative effect of the Rabbits subtest (response time) ($\beta = -0.42$; $t(63) = -3.35$, $P = 0.001$) and a positive main effect of the Evip-R ($\beta = 0.25$; $t(63) = 2.35$; $P = 0.022$), while the main effect of group in the complete model was not significant ($P = 0.67$). There was a significant interaction between group and the Evip-R ($\beta = 0.22$; $t(63) = 2.18$; $P = 0.033$). The analysis of the interaction revealed that the Evip-R had a greater impact on the DS group's score ($\beta = 0.45$), than on the control group's score ($\beta = 0.03$). Regarding to the appropriate situations, we did not conduct regression analyses as no differences were found across the groups for these situations.

A multiple linear regression analysis was then conducted on the SRT global score using the same predictors (Evip-R, Rabbits and Faces, CA, group). The best model explained nearly 45% of the SRT global score's variance ($R^2 = 0.49$ and R^2 adjusted = 0.45). There was a main negative effect of the Rabbits subtest (response time) ($\beta = -0.38$; $t(60) = -3.09$, $P = 0.003$), a marginal positive effect of the Evip-R ($\beta = 0.20$; $t(60) = 1.86$; $P = 0.068$) and a positive effect of the Faces subtest (precision score) ($\beta = 0.33$; $t(60) = 2.71$; $P = 0.009$). The main effect of group was not significant ($P = 0.154$). Finally, we found a significant interaction between group and the Evip-R ($\beta = 0.30$; $t(60) = 2.98$; $P = 0.004$). The analysis of the interaction again showed a greater impact of the Evip-R variable on

the DS group's score ($\beta = 0.50$) than for the control group's score ($\beta = -0.09$).

Analysis of the SRT global score for the DS group

A multiple linear regression analysis was conducted on the DS group's SRT global score introducing whole cognitive variables (i.e. non-verbal reasoning, productive and receptive vocabulary, attention, inhibition), CA and the DBC-A checklist. To explore the data, we first looked at the correlations between the SRT and the explanatory variables. As expected, significant relations were found with the Evip-R task ($r = 0.058$, $P < 0.001$), and the two selective attention subtests (Rabbits response time: $r = -0.43$, $P = 0.012$; Faces precision score: $r = 0.41$, $P = 0.015$). Positive relations were found with two additional cognitive measures: the Isadyle productive vocabulary task ($r = 0.53$, $P = 0.001$) and the tapping inhibition task ($r = 0.35$, $P = 0.048$). Finally, a negative relation appeared with sub-scale 5, 'social relating' from the DBC-A checklist ($r = -0.42$, $P = 0.014$).

The best regression model found explained over 50% of the variance in the SRT global score ($R^2 = 0.56$ and R^2 adjusted = 0.51). It included three predictors: the Evip-R ($\beta = 0.52$; $t(30) = 4.23$; $P < 0.001$), sub-scale 5, 'social relating' from the DBC-A ($\beta = -0.35$; $t(30) = -2.84$; $P = 0.008$) and the Faces precision score ($\beta = 0.26$; $t(30) = 2.01$; $P = 0.049$).

Discussion

The main objective of this study was to investigate social reasoning skills in adults with DS by using a new task specifically created for people with ID. Indeed, no previous studies had examined these competences in DS adults by means of an experimental design. The SRT assesses the judgement of appropriateness of social behaviour. We administered it to a group of 34 participants with DS whose results were compared with those of a control group matched on a receptive vocabulary task. We also wanted to examine the role that general cognitive abilities might play in success on this task. We focused particularly on factors that had already been identified as critical in studies

reporting on socio-emotional skills such as language and executive functions. The potential differences which might appear between the two groups were explored using the cognitive measures available to all participants. In addition, we were interested in investigating the relations between social reasoning skills, as measured by the SRT experimental task, and a caregiver-rated measure of the DS adults' emotional and behavioural problems (DBC-A checklist).

The DS participants' global SRT scores did not differ from those of the control group. However, analyses of the SRT subscores revealed differences between the two groups depending on the appropriateness of the situations. For the appropriate situations, the DS adults judged and identified the pertinent element of the items similarly to controls. On the other hand, they obtained lower judgement and identification subscores for the inappropriate situations, showing that they found these situations more difficult to process than the controls. Interestingly, although the DS adults on the whole processed fewer inappropriate situations correctly than the control group, the two groups performed similarly for understanding. The analysis of the levels of social understanding achieved by the two groups explained this result. In fact, we noticed that the DS group gave fewer inappropriate answers (level 0 responses) to the social scenes than the controls did (e.g. when seeing a man destroying a street lamp with a baseball bat: 'this is wrong as he may hurt himself with the glass fragments'). Regarding the level 1 and 2 responses, it was found that both groups provided as many factual responses (e.g. 'it is bad to break the street lamp') as responses showing social awareness (e.g. 'then it is all dark in the street, and this is dangerous for the other people'). With the exception of one adult with DS, none of the participants made a response based on conceptual knowledge (level 3 responses). The lack of level 3 responses observed in the control group is consistent with the results found in TD children using the SRT (Barisnikov *et al.* unpublished data), as this level of response does not emerge before the age of 10. Furthermore, several developmental studies report that a more mature social reasoning appears quite late in development, around the adolescence (Piaget 1932/2000; Selman 1980; Colby *et al.* 1983).

To our knowledge, social reasoning skills have never been explored in DS participants through an experimental task, and we did not have specific hypotheses about the DS adults' results. According to studies of socio-emotional competences in the DS population (Soresi & Nota 2000; Fidler *et al.* 2008), we might have, however, expected a poorer understanding of inappropriate situations than in the control group. Yet the DS adults' results could be related to their own life experience; they might be familiar with the social situations presented in the SRT and even be regularly confronted with some of them (e.g. queuing politely at the post office). In addition, these situations might be frequently discussed with caregivers and families (respecting other people's private life, being careful with other people's equipment). On the other hand, it may be argued that life experience in special education environments where other people with ID reside can turn to the DS adults disadvantage to identify the SRT inappropriate social interactions. In comparison with TD children, the DS participants are more likely to have observed more extreme socially maladaptive behaviours and might therefore be inured to less serious inappropriate interactions. Our experimental design does not allow for this hypothesis, although this point might be somewhat negated by the subset of DS participants who were able to identify these behaviours as well as the control group. This last observation underlines the fact that there is some variability within the DS adults' competences to identify and explain inappropriate situations.

It is also essential to emphasise that the DS adults' results were compared with those of much younger participants. Although the SRT presents common social situations, the DS participants still have greater amounts of practice in these kinds of situations than the TD children, which might explain the general equivalence in the results of the two groups. In order to control the impact of life experience in the SRT performance, it would be necessary to examine other adult populations with ID and see whether they perform similarly on the SRT. Moreover, people with DS are frequently reported to demonstrate empathy and care for others (Buckley *et al.* 2002; Kasari *et al.* 2003). This trait might have a positive impact on their understanding of social interactions. In order to investi-

gate this issue, it would be interesting to compare their results to those of other populations presenting a similar general level of ID but showing different cognitive and socio-emotional profiles (e.g. people with autism or fragile X).

In the present study, we were interested in investigating the relationships between general cognitive competences (receptive vocabulary and selective attention) and success on the SRT for all participants. For this purpose, multiple regression analyses were run on the SRT global score, as well as on the compound score including judgement and identification of the inappropriate situations, as the DS adults processed them worse than the controls. These two analyses gave similar results. The selective attention competences (Rabbits subtest response time and Faces subtest precision score) were significant predictors of the SRT global and compound scores for all DS and control participants. These results showed that participants with better selective attention skills were more successful in performing the SRT task. This relationship can be explained by the demands of the SRT, as participants have to focus their attention on the pertinent elements of the drawings linked to social interactions. The role of attentional skills had already been highlighted by the successful performance of socio-emotional and theory of mind-related tasks by TD children and people with ID (Hughes 1998; Thirion-Marissiaux & Nader-Grosbois 2008b).

The influence of receptive vocabulary skills also stood out, but the interaction between group and the Evip-R revealed that the impact of this variable differed according to group; the Evip-R variable appeared to be a critical predictor for the DS group, while its influence was much weaker in the control group. In relation to the DS participants, these results were similar to previous findings reporting positive relations between receptive language and socio-emotional competences such as emotion processing (Hippolyte *et al.* 2008, 2009a) and abilities related to theory of mind (Yirmiya *et al.* 1998). This significant relationship between the Evip-R and the SRT task found in the DS group might yet question the comprehension of this task by the DS participants. Indeed, the SRT can be considered as linguistically demanding, and some adults may have not fully understood its instructions. Nevertheless, the DS group succeeded

in the appropriate situations of the SRT, similarly to their controls, suggesting that their understanding of the task was satisfactory. We might also add that even if the participants did not correctly identify or understand an inappropriate situation, their answer always corresponded to task instruction.

In relation to the control group, we might suggest that this language measure is less pertinent for TD children. Indeed, the developmental literature shows that receptive vocabulary has a weaker relationship than general language measures with tasks related to theory of mind (Milligan *et al.* 2007), even when these tasks (e.g. false belief) are strongly related to receptive language. Moreover, the SRT makes considerable demands on expressive language, which was not measured in this group. It is thus possible that other language measures (e.g. narrative skills, syntax) would be related to SRT performance in TD children.

The focus of the present study was the DS population, and additional cognitive variables (non-verbal reasoning, productive vocabulary, inhibition of a predominant response) along with a measure of emotional and behavioural problems (DBC-A checklist) were assessed, allowing for a more in-depth investigation of the competences potentially involved in the SRT success. The best regression model, which accounted for more than 50% of the variance in the SRT global score, included three predictors: the receptive vocabulary task Evip-R, the ‘social relating’ sub-scale of the DBC-A and the precision score of the Faces subtest. These results confirmed the impact of receptive language and selective attention on successful performance on the SRT.

With regard to receptive vocabulary, the analyses showed that this measure was more central than productive vocabulary (Isadyle) to success on the SRT. This result is important, as the SRT, which requires a verbal response, is strongly related to productive language. Moreover, people with DS generally present an asynchrony between receptive and expressive language, with the latter being weaker (Chapman & Hesketh 2000).

Considering these elements, a methodological artefact could have been inferred in the DS group if the Isadyle measure had been more strongly related to the SRT than the Evip-R; in this case, the DS participants’ performance might mainly depend on

their linguistic impairments. Based on our results, we can consider that the conceptual representation of social objects is decisive in the DS adults’ performance. Participants with a poorer receptive vocabulary level might have difficulties understanding these concepts, which are central to figuring out social situations. It is also important to underline that there is considerable variation in language skills within the DS population (Rondal & Comblain 1996; Miller 1999). Nevertheless, the Evip-R comes out as a significant predictor of the SRT despite its variability in the DS group. This result supports the crucial role of the receptive vocabulary in the SRT success. As it has been emphasised in the control group, it would also be of interest to assess in the DS participants other aspects of language such as syntax comprehension and production with regard to the linguistic demand of the SRT.

Interestingly, a sub-scale of the DBC-A checklist proved to be significant in the model, showing an association between the caregiver-rated measure of social behaviour and social reasoning skills measured by an experimental task. The ‘social relating’ sub-scale mainly refers to social avoidance behaviour (remains aloof, prefers to do things on his or her own, resists being cuddled by close friends or family). The DS participants who were rated as more ‘socially avoidant’ by their referent caregivers performed poorly on the SRT. To our knowledge, such a relationship has never been pointed out in the literature looking into the links between social reasoning skills and behaviour in adults with ID or in TD children. Indeed, the factor that has always been found to be related to poor social reasoning skills is aggressiveness (Crane-Ross *et al.* 1998; Harvey *et al.* 2001; Basquill *et al.* 2004; van Nieuwenhuizen *et al.* 2009). Yet in our study no relations appeared with this factor, which can be referred to the DBC-A ‘disruptive’ sub-scale (describes abusive, provocative or irritable behaviour). We might explain this absence of relationship by the fact that very few difficulties were reported on the ‘disruptive’ sub-scale; the aggressiveness factor therefore appeared to be of little relevance in our DS population. In addition, previous studies conducted on people with ID separated them into groups according to their aggressiveness level (not aggressive versus very aggressive). We suggest that studies including a more representative population

could observe relations with other components of socio-emotional behaviour.

Regarding the results found in the DS group concerning the SRT's relation to the 'social relating' sub-scale, it can be hypothesised that the adults who understand social interactions poorly tend to stay in the background. They may prefer to avoid situations that they do not understand as these episodes could be stressful or unpleasant (e.g. sharing something reluctantly, having to be nice to people one dislikes). By implication, a vicious circle is created, as such people will miss out on opportunities to learn these skills because of their withdrawal. It is difficult to discern the main causes of a poorer understanding of social interactions, but personality factors could be an avenue worth exploring. For instance, we might hypothesise that DS participants with less empathetic sensitivity would be at a disadvantage in understanding interactions. It would be interesting to clarify these issues in further studies. In addition, we must underline the difficulty to assume the linearity of the relation between social aloofness and poor social understanding. A longitudinal study of these constructs could be of great interest to better understand the origin of the DS population's social withdrawal.

To conclude, as no ceiling or floor effects were reached with the SRT, this measure seems to be well-adapted to assess people with mild and moderate ID. It therefore constitutes a promising tool for studying social reasoning skills in this population. Indeed, the SRT would also be useful for other clinical populations with a particular socio-emotional profile, such as Williams syndrome, fragile X or autism and ID. The DS adults' ability to understand the appropriateness of others' social behaviour appears to be related to specific cognitive and socio-emotional skills, which opens up prospects for rehabilitation programmes. It would be important to work on selective attention and receptive language abilities, as they proved to be central to success on the SRT. Moreover, improving the social reasoning skills of socially withdrawn participants might have a positive impact on their integration. The SRT methodology might also be of great interest to study other kinds of social interactions in people with ID. Forensic issues concerning appropriate sexual behaviour could be one as these

people frequently have difficulties to understand what is right or wrong in relation to sexual issues (Balderian 1991; Furey 1994).

As this is the first study reporting on social reasoning skills in DS adults, further studies are now required to see if the present findings can be confirmed. The psychometric properties of the SRT which have not been evaluated in this study should also be explored. In addition, we need to conduct comparative studies assessing populations who present ID with another origin to find out whether the pattern observed for our adult group is specific to DS or not. Furthermore, it would be important to examine other executive skills domains which could be involved in the success on the SRT. The shifting abilities might be particularly interesting as Zelazo *et al.* (1996a) found significant relationships between these shifting skills and theory of mind in DS adults. Regarding the demands of the SRT task (processing the drawing, pointing out its most pertinent elements, elaborating an answer), introducing a measure of planification abilities might be also of great interest. By adding the shifting and the planification abilities to the SRT predictive model, we will furthermore improve our comprehension of the executive processes implied in the social reasoning abilities. Regarding the impact of the cognitive measures on the SRT performances, it would also be interesting to propose all cognitive measures to the TD participants in further studies. This could enable us to compare the way in which these variables influence the SRT performance with regards to TD children and clinical populations.

In relation to the measure of the DS adults' emotional and behavioural problems, the DBC-A checklist was completed by the sheltered workshop referents who provided information about participants' behaviour at their workplace. As adults may behave differently outside the work setting, it would be interesting to assess their profiles in their typical living environment and see if the 'social relating' sub-scale is still a significant predictor. Finally, it should be noted that the SRT assesses social reasoning skills through static stimuli. It would therefore be interesting to compare the SRT's results with those of a task that provides dynamic stimuli (e.g. staged social scenes presented on a video).

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