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Understanding goals and intentions in low-functioning autism☆

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ABSTRACT

We investigated ability to understand goals and attribute intentions in the context of two imitation studies in low-functioning, nonverbal children with autism (L-F CWA), a population that is rarely targeted by research in the domain. Down syndrome children (DSC) and typically developing children (TDC) were recruited to form matched comparison groups. In the two sets of simple action demonstrations only contextual indicators of the model's intentions were manipulated. In the Head touch experiment the model activated a button on a toy by pushing it with the forehead, whereas in the Hidden box experiment the model used a ball with a magnet to lift a box out of its container. Both actions were unusual and non-affordant with regards to the objects involved, none of the children in the baseline condition produced them. L-F CWA imitated the experimenter exactly, regardless of the model's intention. TDC showed appreciation of the model's intention by imitating her actions selectively. DSC reproduced only the intentional action as often as they imitated the experimenter exactly. It is concluded that L-F CWA attributed goals to the observed model, but did not show an appreciation of the model's intentions even in these simplified, nonverbal contexts.

Children interpret and predict others' actions on the basis of the mental states they attribute to the actor. Autism is associated with a specific cognitive deficit in inferring and representing mental states, as documented by seminal studies showing difficulties with false belief tasks (Baron-Cohen, 1995; Baron-Cohen, Leslie, & Frith, 1985; Leslie & Thaiss, 1992; Perner, Frith, Leslie, & Leekam, 1989; Sodian & Frith, 1994) and with pretend play (Wing, Gould, Yeates, & Brierley, 1977). Mental states, however, vary in nature; beliefs, desires, goals, intentions, emotions as well as perceptions have been proposed in literature (Frith, Morton, & Leslie, 1991; Luo, 2011; Premack & Woodruff, 1978; Saxe, Carey, & Kanwisher, 2004; Vivanti et al., 2011). Goals, for instance may be considered as mental states that are more 'transparent' or observable in behaviour than beliefs and desires, at least under a broad mentalising theory (Hamilton, 2009). Still, relatively few studies have investigated goal understanding in autism and most of these studies have involved high-functioning children with autism (H-F CWA). One of the aims of this study therefore was to assess goal understanding on the other end of the autistic spectrum, in low-functioning children with autism (L-F CWA). A further issue with existing reports is that they do not distinguish in all cases between an understanding of a goal as an internal state and the understanding of the visible outcome of a goal directed action, without inferring an intentional mental state. Therefore the other aim of our study was to better

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control this possibility by using imitation paradigms where the children's responses may indicate for us the different intentional mental states they attribute to the model across the experimental conditions.

1. Goal understanding in high-functioning autism

Studies that explored goal understanding in H-F CWA show that although understanding beliefs and desires is clearly impaired, the ability to read another person's intended goals is preserved. In fact, there are not many direct tests of whether individuals with autism understand action goals, but much information can be gathered from studies of imitation and experiments that explored how they interpret the actions of animated figures. We shall first review these two groups of studies.

Imitation research shows that CWA, high-functioning or with mild to moderate mental handicap for a few studies, can successfully imitate actions with clear goals, thus showing some understanding of goals. For instance, they reproduce object-use actions (Beadle-Brown, 2004; Charman & Baron-Cohen, 1994; Stone, Ousley, & Littleford, 1997), recognise and reproduce the goal of others' hand actions (Avikainen, Wohlschläger, Liuhanen, Hänninen, & Hari, 2003; Hamilton, Brindley, & Frith, 2007), and also perform well on nonverbal gesture recognition (Hamilton et al., 2007; Smith & Bryson, 1994) or gesture memory tasks (Rogers, Bennetto, McEvoy, & Pennington, 1996). Autistic children's imitation behaviour seems to be driven by goals' saliency, with more imitation in cases where the action has a clear and interesting outcome (a light or sound) compared to cases without an outcome (Ingersoll, Schreibman, & Tran, 2003). Hamilton et al. (2007) add to these results the finding that goal understanding is in fact an island of intact functioning in autism, in contrast to these children's poor performance on theory of mind tasks. In this study, three action tasks were proposed to CWA with moderate mental retardation, assessing goal-directed imitation, mirror imitation and grasp planning. Although CWA did not succeed as controls in the theory of mind tasks, there were no differences between the two groups in goal imitation.

Two studies, also using imitation as a measure, have asked whether H-F CWA expect agents to use the most efficient or rational means possible to reach their goals. Evaluating the effectiveness of an observed means is an important step towards reading others' intentions. Although these investigations are not conclusive regarding the rationality principle (Gergely, Bekkering, & Király, 2002; Gergely & Csibra, 2003), they provide further evidence showing that H-F CWA understand goals. For instance, Rogers, Young, Cook, Giolzetti, and Ozonoff (2010) compared the imitation of functional and non-functional acts on objects (to shake a maraca or to shake a potato masher) and found that CWA imitated the functional acts. They imitated less in the non-functional conditions; however, this does not necessarily mean that they did not understand these goals. Perhaps the children were simply less inclined to imitate in these conditions for two reasons, which we explain here in more detail because they are both relevant regarding the choice of tasks for our present study. Firstly, non-functional acts are less rational in the sense that they do not correspond to the common use of objects (and are therefore more social in nature – as shaking a potato masher may be an invitation to play or to share a pleasant moment). The absence of imitation in these tasks may simply reflect a preference for the imitation of functional actions with objects that highlight means–end relations (shaking a maraca corresponds to the object's function and brings about a salient effect). Secondly, in this particular case, in order to imitate a non-functional action, children need to suppress the action scheme that is activated by the object's affordances and common usage (which, in the case of the potato masher would be to make mashing movements). Perhaps a failure to imitate in these situations also reflects a failure to inhibit the usual action scheme. Studies that similarly report enhanced performance on meaningful imitation compared to meaningless imitation or the imitation of an action's style used pantomime or gestural imitation as measures where again the goal of the action was less manifest in the sense that it did not bring about a salient change in the environment (Hobson & Hobson, 2008; Rogers et al., 1996; Stone et al., 1997). The lack of imitation in the non-functional or meaningless conditions in these studies therefore does not necessarily reflect a failure to interpret actions being that are non-rational with reference to their goals. However, they provide clues regarding autistic children's imitative behaviour and show their preference for imitating goal-directed, functional actions with objects that stress means–end relations.

The second group of studies on goal understanding in H-F CWA examined how they interpret the actions of animated geometric shapes. The results show that they derive the goals of an action from the situation's physical parameters or the agent's kinematic properties just like controls (Abell, Happe, & Frith, 2000; Castelli, 2006; see also Castelli, Frith, Happe, & Frith, 2001 for a neuroimaging study with adults). In Abell et al.'s (2000) study the animations showed two triangles moving around the screen according to one of three conditions, where the different types of motions could be described either in terms of mental states, goal-directed actions or non-deliberate actions (such as random movement). Before each presentation, subjects were cued with character roles; for example, the two triangles were a mother and a child. In this study, H-F CWA gave descriptions of the goal-directed animations (e.g. fighting, chasing) and the random animations (e.g. floating, drifting) that were as accurate as the controls. They used mentalistic descriptions (e.g. tricking, being jealous) less than typical controls, frequently referring to mental states that were inappropriate to the animation. In a similar study by Castelli (2006), children saw a circle at the bottom of a U-shaped valley rolling up and down the slopes and getting closer to (but failing to actually reach) a target (another circle resting at the top of either side of the valley). The task was to decide about the final goal of the moving circle by clicking (with the computer mouse) on one of the five marked locations along the slopes. H-F CWA were as able as controls to infer the agent's intended goal, even though the target was never reached.

All the above studies indicate that goal understanding is indeed an island of intact functioning in H-F CWA. We can see, however, that further investigations involving L-F CWA are needed in order to confirm that ability is generally preserved in ASD. Only one study, by Nadel et al. (2011), explored observational learning in L-F CWA. Results show that they are able form long-term representations of actions involving several sub-goals and can also reproduce these actions if they have an opportunity to practice. Another issue with these studies is that they mostly show that autistic children understand and infer the visible outcome of a goal-directed action, but do not indicate whether they also infer an intentional mental state underlying the goal. In everyday life, the observable outcome of a motor act is most often not sufficient to understand the action; the actor's intention also needs to be inferred, based on the referential and communicative cues conveyed by the agent's behaviour and the broader context in which the action occurs (Gergely & Csibra, 2003; Gómez, 2009).

2. Intention understanding in high-functioning autism

Only few studies have explored specifically intention understanding in autism and again, these have mostly been done with children on the higher end of the autistic spectrum. In fact, only one study examined whether L-F CWA recognize the imitative intention of another person (Nadel et al., 2000). In this experiment, using a revisited version of the still face paradigm, it was found that, although children do not react to a first still face episode, they react to a second one as a violation of intentional exchanges. Studies involving H-F CWA tested intention inference in situations where the observable outcome did not match the original intention (own intention or another person's intention), as in the case of accidents or experimental situations where the outcome of an action is manipulated.

Two such studies investigated whether individuals with autism have difficulty recalling and processing their own intentions, but results are not consistent. A study by Phillips, Baron-Cohen, and Rutter (1998) examined whether H-F CWA children could recognise when the outcome of their own action was caused intentionally or not in a series of tasks where the outcome was controlled. They found that CWA were more likely than typical children to say they did mean to hit an unintended target (reporting intention to hit a target when the outcome was successful, but not when it was unsuccessful), suggesting a difficulty in monitoring and remembering their own intentions. Russell and Hill (2001) reported no difference between CWA who had mild to moderate intellectual disability and controls in both the shooting game task and a novel 'drawing' task where children were asked to report their own intended action when the final outcome was unexpected. However, it is possible that subjects' response in the drawing task was prompted by the direct question of whether they thought or meant to draw what turned out to be unexpected ('Did you think you were drawing an X or a Y?'/'Did you mean to draw an X or a Y?').

Two other studies used the unfulfilled intentions paradigm (Meltzoff, 1985), where children witness an incomplete or failed act involving an object and are later asked to act on the same objects. For example, in one of these tasks, the model holds a dumbbell shaped pull-apart toy and attempts to pull it apart, but does not succeed because her hand slips off the object. In the first study, reported by Aldridge, Stone, Sweeney, and Bower (2000), 2–4 year-old CWA were found to imitate intended actions on the objects, even though they never saw the completed the intended act. Similar results were found in a better controlled study by Carpenter, Pennington, and Rogers (2001) who showed that 2.5–5 year-old CWA produced as many target acts as controls after observing the model demonstrate the failed action. Both studies concluded that CWA were able to guess the model's intentions by observing failed attempts. The difficulty with the unfulfilled actions paradigm, however, is that the reproduction of a model's intended behaviour after observing the model's failed attempts may reflect affordance learning alone, without any actual understanding of the adult's intentions (Huang, Heyes, & Charman, 2002; Huang, Heyes, & Charman, 2006). In fact, one of the control conditions Carpenter et al. (2001) included in their study addresses this issue. In a manipulation condition, the experimenter modelled a set of similar actions that were different from the target action but were performed in the same general area of the object. In this condition CWA produced as many target acts as in the unfulfilled condition, an effect that was not found for children with developmental delays. Thus, it is possible that any random manipulation of the object was enough to make CWA produce the target action through stimulus enhancement.

D'Entremont and Yazbek (2007) avoided this problem with an experimental setting where the manipulated objects' constraints did not provide cues on the target action since the same action was presented as intentional (therefore target action) in some conditions and accidental in others. Only verbal cues marked the experimenter's intention: 'There' for intentional actions and 'Whoops' for accidental ones. The authors found that, unlike typically developing controls, H-F CWA did not respond on the basis of the experimenter's intentions. They tended to imitate the intentional acts as well as the irrelevant 'accidental' acts performed by the demonstrator, thus failing to select the intended or effective, rational acts in the stream of the demonstrator's behaviour. The authors conclude that, consistently with the findings in Carpenter et al.'s (2001) study, CWA were guided by stimulus enhancement, that is, the model's actions highlighted affordances of the objects and the children subsequently performed the actions that the objects afforded. It should be noted that the mean CARS scores of the participants (29 points) in this study did not reach clinical cut-off for autism; therefore a replication of this pattern is needed with children who clearly have autism.

We can observe that the last three studies (Aldridge et al., 2000; Carpenter et al., 2001; D'Entremont & Yazbek, 2007) all proposed actions that could be derived from the affordances of the objects involved, such as: grasping knobs to pull a toy apart (Meltzoff task) or using accessories like switches, buttons, handles and loops (D'Entremont & Yazbek, 2007). The issue with these objects and parts is that they are all used in everyday life and are therefore loaded with associated action schemes that, given their preference for functional actions, may be difficult to inhibit for CWA. For instance, having seen a dial turned, CWA may have more difficulties inhibiting this highly functional action, independently of whether it was presented intentionally or by accident. All three studies (Aldridge et al., 2000; Carpenter et al., 2001; D'Entremont & Yazbek, 2007) report that CWA, unlike controls, did not take into account the model's intention when imitating her actions, instead, they often showed exact copying behaviour. If this is a learning strategy specific to CWA, then exact copying should appear in tasks where the presented object-directed actions are not common everyday actions and could only have been acquired from the demonstration in the laboratory. Also, if exact copying is specific to ASD, then this strategy should appear on the lower end of the spectrum.

A recent study by Vivanti et al. (2011) added the use of eye tracking to behavioural measures in order to investigate the very mechanisms that scaffold action understanding in H-F CWA. Consistently with above, their data show that H-F CWA, like typically developing controls, take into account the environment in which the action occurs and consider information about both the agent's behaviour and the constraints of the situation (see also Bedford et al., 2012, for intact early gaze following in infants later diagnosed with ASD). They also showed typical usage of the agent's emotional expressions to infer his or her intentions. However, they presented subtle atypicalities in the way they responded to an agent's direct gaze and showed impairments in their ability to attend to and interpret referential cues such as a head turn for understanding an agent's intentions. Even though this study again involved only a select subgroup of older, H-F CWA, disentangling these contributors to action understanding is relevant to interpreting the results of our present investigation.

3. Aims of the present study

From this review of literature, two main issues emerge that we wished to address:

(1) Studies show that goal attribution is preserved in H-F CWA. If this ability is generally preserved in ASD, then L-F CWA should also be able to attribute goals (either by inferring the visible outcome of a goal-directed action or by inferring an intentional mental state underlying the goal).
(2) Only few studies (Aldridge et al., 2000; Carpenter et al., 2001; D'Entremont & Yazbek, 2007) tackled the ability to understand a goal as an internal, intentional state and not simply as the outcome of an action. These report that H-F CWA do not take into account the experimenter's intentions when imitating her actions, instead they often showed exact copying as a learning strategy. If this pattern is specific to ASD, (a) then it should be confirmed by responses in tasks where functionality or usual affordances cannot bias the children's responses and (b) L-F CWA should also respond with this strategy.

To answer these issues, we used two imitation tasks, where the model's intent was conveyed by easily observable elements (e.g., situational features or behaviour). The presented object-directed actions were not common functional actions and could only have been acquired from the demonstration in the laboratory. The actions we presented to the children (using the forehead to activate a button or using a ball as a lifter) were not only unusual, but also required the inhibition of existing motor schemas associated with the objects. Both paradigms were adopted from research on the typical development of intentionality (Gergely et al., 2002; Király, 2009); they were nonverbal, involved interesting novel objects, and required only a short attention span. The first task was the 'Head touch' paradigm devised by Gergely et al. (2002) to test goal inference in typically developing infants. The second task, which we refer to as the 'Hidden box' paradigm, was devised by Király (2009) to explore goal inference in situations in which the model's intentions are conveyed by negative behavioural evidence. Participants' deferred imitative responses were the outcome measure in both paradigms. This choice was based on the assumption that deferred imitation requires individuals to store demonstrated actions in memory and intentionally select those actions to reproduce from among several alternatives.

For our study, we recruited L-F CWA, who are known to have severe communication problems (Noens & van Berckelaer-Onnes, 2004). These children's language profile develops unevenly as compared with H-F CWA or children who have an intellectual deficit without autism. For instance, L-F CWA often achieve an expressive language level that is above their receptive language level, whereas comparison groups show the opposite profile (Hudry et al., 2010; Kjelgaard & Tager-Flusberg, 2001; Maljaars, Noens, Scholte, & van Berckelaer-Onnes, 2012). In L-F CWA specifically, language abilities are correlated with joint attention and symbol understanding (Charman et al., 2003; McDuffie, Yoder, & Stone, 2005), which are both considered as precursors to goal understanding and intentionality. In order to avoid the confounding effect of language abilities, we decided to recruit nonverbal children for our study.

4. Method

4.1. Participants

4.1.1. Experiment 1: Head touch

For the Head touch experiment, we recruited 28 CWA (25 boys and 3 girls) from two schools for CWA in Paris. All participants met full DSM-IV (Diagnostic and Statistical Manual of Mental Disorders, 4th edition; American Psychiatric Association, 1994) criteria for autistic disorder. The children's diagnosis was previously established by various health care professionals before the children entered the schools. The schools' professionals assessed the severity of the children's autism with the Childhood Autism Rating Scale (CARS) (Schopler, Reichler, & Renner, 1988) upon admission and each year. We selected children with severe autism for this study, all the participants had CARS scores between 38 and 60 points (mean 45 points), which is associated with severe and low-functioning autism (Mayes et al., 2012). The children were also selected for their nonverbal behaviour, as reported in their diagnosis and confirmed by the school's psychologist and teachers. Their

Table 1
Descriptive data of the clinical samples taking part in the two conditions of the Head touch experiment.

Experimental condition	Diagnosis	Mean mental age (months)	Std. deviation	*N*
Hands free	Autism	30.47	8.839	15
	Down syndrome	22.44	9.761	9
	Total	27.46	9.820	24
Hands occupied	Autism	30.00	9.204	15
	Down syndrome	32.71	11.101	7
	Total	30.86	9.662	22
Total	Autism	30.23	8.869	30
	Down syndrome	26.94	11.305	16
	Total	29.09	9.788	46

ages ranged from 6.7 to 16.2 years, with a mean age of 11.3 years. Their mental ages, as defined with the Psychoeducational Profile Revised or PEP-R (Schopler, Reichler, Bashford, Lansing, & Marcus, 1990), ranged from 17 to 46 months, with a mean age of 26 months. The PEP-R (Schopler, Lansing, Reichler, & Marcus, 2005) is designed to evaluate the development of communication and motor skills, and the presence of maladaptive behaviours in children with ASD aged 2 years to 7.5 years (developmental age). We also recruited 16 DSC (7 girls and 9 boys) from a medical and research institute for children with genetic illnesses in Paris. All of the children in this group were diagnosed with Down syndrome via chromosome study. Their chronological age ranged from 1.4 to 5.5 years, with a mean age of 3.3 years. Developmental age was defined by the Brunet-Lézine test (Brunet-Lézine, 2001) and ranged from 14 to 46 months, with a mean developmental age of 27 months. The group of TDC was composed of 18 14-month-old infants (8 girls and 10 boys) recruited from the research participant pool at the Institute of Psychology of the Hungarian Academy of Sciences. All children's parents received an information sheet about the experiments and provided signed consent. Children were excluded from participating in the study if they suffered from epilepsy, serious visual or motor problems, West syndrome, or any other serious medical condition associated with autism or Down syndrome. Children with comorbid Down syndrome and autism were also excluded. We recruited a Down syndrome comparison group to control for the effect of mental retardation; DSC have been demonstrated to have an unimpaired ability to attribute intentions and mental states (Baron-Cohen et al., 1985). We included TDC in this experiment in order to validate an adapted version of Gergely et al.'s (2002) original paradigm; the lamp box was replaced with a soft toy to make it safer for use with CWA.

No significant difference in mean mental age between the two clinical groups was observed ($F = 1.96$; $df = 3$; $p = 0.13$). Please see Table 1 for the descriptive data of the two clinical samples taking part in the Head touch experiment. We did not compare chronological age because DSC were matched with CWA by mental rather than chronological age, and were consistently younger; in DSC, mental age corresponds reliably with chronological age (Anderson et al., 2007; Lord & Luyster, 2006).

4.1.2. Experiment 2: Hidden box

For the Hidden box experiment, we recruited 14 children with autistic disorder (2 girls and 12 boys) from the same schools as for Experiment 1. The children's diagnosis and the assessment of the severity of their symptoms were made in the same way as for Experiment 1. All participants met full DSM-IV (Diagnostic and Statistical Manual of Mental Disorders, 4th edition; American Psychiatric Association, 1994) criteria for autistic disorder and had severe, low-functioning autism, with CARS scores between 38 and 60 points (mean 47 points). The children were again nonverbal, as reported in their diagnosis and confirmed by the school's psychologist and teachers. Exclusion criteria were also the same as for Experiment 1. Chronological age ranged from 3.5 to 17.75 years, with a mean age of 8.3 years. Mental age, as defined with the Psychoeducational Profile Revised or PEP-R (Schopler et al., 1990), ranged from 27 to 46 months, with a mean of 40 months. Twenty DSC (11 girls and 9 boys) were recruited to form the clinical control group. Of the 20 children, 9 were recruited from the same institute as the DSC in the Head touch experiment, 11 were from a school for mentally disabled children. Chronological age in DS group ranged from 2.2 to 6.8 years, with a mean of 4.2 years. Developmental age, as defined with the Brunet-Lézine test, ranged from 17 to 46 months, with a mean of 31 months.

Analysis revealed significant differences in mental age between groups ($F = 3.28$; $df = 3$; $p = 0.04$). Tukey's post hoc test revealed a significant difference in mean mental age between CWA in the Hand Action Possible condition and the DSC in the Hand Action Unsuccessful condition ($p = 0.05$, CWA had a higher mean). Since the objective of the study was to compare children's performances within a clinical diagnosis or within an experimental condition (i.e., not to compare the performances of CWA and DSC across different experimental groups), we retained the original group assignments. Please see Table 2 for the descriptive data of the two clinical samples taking part in the Hidden box experiment. Again, for the reasons explained above, we did not compare the chronological ages.

4.2. Baseline group

Prior to the experiments, to assess spontaneous production of the target actions (touching with head or lifting with ball) in the absence of adult demonstration, we exposed a baseline control group of 10 children with severe autism to the

Table 2
Descriptive data of the clinical samples taking part in the two conditions of the Hidden box experiment.

Experimental condition	Diagnosis	Mean mental age (months)	Std. deviation	*N*
Hand action unsuccessful	Autism	36.25	6.319	8
	Down syndrome	30.27	9.951	11
	Total	32.79	8.929	19
Hand action possible	Autism	39.78	5.848	9
	Down syndrome	31.44	7.552	9
	Total	35.61	7.830	18
Total	Autism	38.12	6.153	17
	Down syndrome	30.80	8.746	20
	Total	34.16	8.418	37

experimental toys (5 children for each apparatus). These children were recruited from the same schools for CWA, diagnosis and the assessment of the severity of their symptoms were made in the same way as for Experiments 1 and 2.

4.3. Apparatus

4.3.1. Experiment 1: Head touch

For the Head touch experiment, we adapted Gergely et al.'s (2002) paradigm to be safer for use with CWA by replacing the lamp box with a stuffed bee. Upon gentle pressure on the button on its belly, the bee makes a friendly noise accompanied by a light effect. The toy is shown in Fig. 1.

4.3.2. Experiment 2: Hidden box

For the Hidden box experiment (see Fig. 2), we used exact replicas of Király's (2009) objects. Children were presented (1) a small red box with (2) a slightly smaller box hidden inside and a (3) magnet attached to a ball by a short string; this was used to lift the smaller box.

4.4. Procedure

During the experiments, the child was seated at a small table opposite the model. The experimental objects were arranged on the table prior to the child's arrival, and covered with a cloth. The child's parent or caregiver sat behind the child or took the child in her or her lap if necessary. Parents and caregivers were instructed not to interact with the child during the model's demonstration. All sessions were videotaped for later analysis.

4.4.1. Experiment 1: Head touch

The procedure for the Head touch study was identical to that used by Gergely et al. (2002). In the Hands Occupied condition, the model pretended to be cold and asked for her shawl. An assistant wrapped the shawl tightly around the model's shoulders, covering her arms and hands. The model then told the child that she was going to show him or her something interesting. Holding the shawl from underneath, the model bent forward from the waist and pressed the button on the bee's belly with her forehead, eliciting the noise and light effect. The model repeated the action three times, at one-second intervals. The Hands Free condition proceeded in the same manner as did the Hands Occupied condition, with one important exception: the experimenter's hands were free and she placed them on the table with one hand on either side of the object, making it clear that they were not occupied. Each child was assigned to one of the two conditions. After the demonstration, children were provided a short break during they engaged in free play (in fact, 7 DSC had their regular check-up with their doctor during this time- as this regular visit consisted mostly of observing the child during play in the doctor's

Fig. 1. Head touch paradigm apparatus.

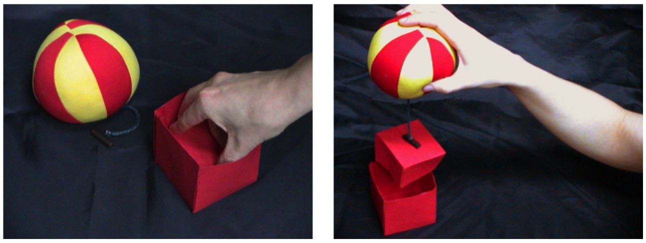

Fig. 2. Hidden box paradigm apparatus. In the photo on the left, the model demonstrates an unsuccessful hand action. In the photo on the right, no negative evidence is provided and the model simply uses the ball to lift the smaller box.

room and asking standard questions from the parents, there was no reason to analyse the responses of these children separately). Following the break, the child was returned to the original room and given the opportunity to play with the toy. The instruction was "Here is the bee; you can play with it now!"

4.4.2. Experiment 2: Hidden box

Our Hidden box study replicated Király's (2009) procedure. In the Hand Action Possible condition, the model held the ball and used the magnet (novel tool) hanging from the ball to connect with the small box and lift it out of the slightly larger box. The model repeated the demonstration three times, at one-second intervals. In the Hand Action Unsuccessful condition, prior to the 'lifting with the ball' action, the model used her hand to attempt to remove the smaller box from the larger box, but failed; her fingers repeatedly slipped off the smaller box and she was unable to hold it. Following the failed efforts, the model successfully completed the ball and magnet action presented in the Hand Action Possible condition. The model repeated the sequence of failed action followed by successful action three times, at one-second intervals. The child was then provided with a short break for free play; as in the Head touch study. After the break, the child was returned to the original room and given the opportunity to play with the toy. The instruction was "Here is the toy; you can play with it now!"

4.5. Scoring

Our method of scoring the children's responses was comparable to that used in most imitation research (see Table 3). If the child did not act on the toy or clearly refused to play with it a score of 0 was given. If the child explored the toy with hands, but did not produce target-relevant acts, a score of 1 was given. Score 2 was given when the child produced a hand action: pressing the toy bee or taking out the small box from the container. Score 3 was given when the child produced the head action on the toy bee or took out the small box from the container using the ball. Interrater agreement, as calculated with Cohen's Kappa statistic ($\kappa = 0.82$), was very good. The dependent variables used for the statistical analysis were: hand action on toy bee, hand action on small box, head action on toy bee and ball action on small box.

5. Results

5.1. Baseline results

In the baseline group, none of the CWA used their forehead to activate the bee or attempted to use the ball to connect with the magnet on the Hidden box. Fisher's exact tests confirmed that baseline responses differed significantly from the responses of children in the experimental conditions. The number of children who produced the head action in the Head touch experiment was significantly greater than in the baseline group ($p = 0.007$). The number of children who used the ball was also significantly greater in the Hidden box experiment than in the baseline group ($p = 0.005$).

5.1.1. Experiment 1. Effect of diagnosis in the Head touch experiment

Statistical analysis on the amount of imitators in each condition (Hands Free and Hands Occupied conditions) revealed a significant difference between TDC's responses ($\text{Chi}^2 = 4.22$; df = 1; $p = 0.04$). The frequency with which typical children imitated the model's head action decreased significantly when the model's hands were occupied during the demonstration. These results are consistent with Gergely et al.'s (2002) findings on selective imitation in infancy, and validate the use of the stuffed bee as an experimental object.

Table 3
Scoring method for the Head touch and the Hidden box experiments.

Score	Response
0	Does not act on toy or clearly refuses to play with it
1	Explores toy with hands, but does not produce target-relevant acts
2	Produces hand action: pressing toy bee or taking out box
3	Produces head action or takes out box with the ball

Table 4
Responses of children with autism, children with Down syndrome and typically developing children in the Head touch experiment.

Condition	Diagnosis	Head action
Hands free	Autism	57
	Down syndrome	67
	Typical	64*
Hands occupied	Autism	71
	Down syndrome	71
	Typical	15*

Note: The values represent percentages of children who re-enacted the head action.
* $p < 0.01$.

Log-linear analyses were conducted to explore the effect of clinical diagnosis (independent variables: autism, Down syndrome or typical) and experimental condition (independent variables: Hands Free or Hands Occupied) on the children's responses (dependent variable: reproduction of the head action). Significant differences were revealed when comparing the responses of the typical group with both clinical groups (for differences between the typical and the autism group: G2 = 10.7, df = 4, $p < 0.05$; for differences between the typical and the DS group; G2 = 14.6, df = 4, $p < 0.01$). When comparing the responses of the two clinical groups, no significant effects or interactions were observed (G2 = 3.11, df = 4, $p = 0.54$). There was no main effect of experimental condition, indeed.

Subsequent chi-square tests as follow up analyses were conducted to examine the pattern of differences between typical and clinical groups. We compared the responses of the typical group with the autism group for both conditions and found a significant effect of autism on the reproduction of the head action in the Hands Occupied condition ($Chi^2 = 8.65$; $df = 1$; $p = 0.03$), but not in the Hands Free condition ($Chi^2 = 0.21$; $df = 1$; $p = 0.65$). Comparing the responses of the typical group with the DS group for both conditions, again the effect of diagnosis was found in the Hands Occupied condition ($Chi^2 = 9.55$; $df = 1$; $p = 0.00$) and there was no effect in the Hands Free condition ($Chi^2 = 1.04$; df = 1; $p = 0.31$).

All in all, these results show that clinical diagnosis had a significant effect on the reproduction of the head action in the Hands Occupied condition. CWA and DSC produced the head action significantly more frequently than typicals in the Hands Occupied condition. The diagnosis of autism, however, did not have a specific effect, CWA and DSC responded in the same way. Table 4 summarises the results obtained for the three groups of children in the two conditions of the Head touch paradigm.

We also investigated hand actions across experimental groups and obtained similar results to Gergely et al. (2002): all (100%) of the TDC who produced the head action also touched the toy with their hands. This is an expected effect: manual manipulation is the prepotent instrumental response associated with achieving an effect. Similarly, the majority of the CWA and DSC who reproduced the head action (73% and 67%, respectively) produced the hand action first. Fisher's exact tests revealed no significant differences between the three experimental groups in this respect ($p = 0.68$).

5.1.2. Experiment 2. Effect of diagnosis in the Hidden box experiment

In this experiment, two action steps were demonstrated in one of the conditions, the Hand Action Unsuccessful condition (a hand action that served as negative evidence and the target ball action), following Király (2009). For this reason, not only (1) the reproduction of the ball action, but also (2) the production of the hand action, and (3) their sequence was analysed, since Király (2009) reports selective production in typical infants for both actions. In her study, infants in the Hand Action Unsuccessful condition performed the target ball action more frequently, together with inhibiting the prepotent hand action. Thus, there was a selective effect of demonstration condition regarding the *sequence* of these responses. From this perspective, the pattern of hand and ball actions can reflect whether the model's overall intention was detected (inhibiting the prepotent hand action together with performing the target action), or the exact copying of behaviour occurred (performing the demonstrated hand action together with the target action). For this reason, we involved all three variables in the present analyses as well.

Log-linear analyses were performed to explore the effect of clinical diagnosis (independent variables: autism or Down syndrome), experimental condition (independent variables: Hand Action Unsuccessful or Hand Action Possible) on the children's responses. We conducted three separate analyses with the following dependent variables:(1) reproduction of the demonstrated ball action only, (2) reproduction of the hand action only and (3) reproduction of the hand and ball action in sequence. No significant interactions between diagnosis and experimental condition were observed for (1) the ball action alone (G2 = 2.28, df = 4, $p = 0.68$). This is in striking contrast with Király's (2009) results; Király reported that typically developing 14-month-olds demonstrated selectivity in frequency of ball actions across the two conditions, and were less likely to reproduce the use of the novel tool when no negative evidence about the more rational hand action was presented. The interaction between diagnosis and experimental condition was significant, however, for reproduction of (2) the hand action alone (G2 = 9.7, df = 4, $p = 0.008$) and (3) the sequence of hand and ball actions (G2 = 21.74, df = 4, $p < 0.001$).

Subsequent Fisher's exact tests as follow up analyses revealed a significant effect of experimental condition in the autism group for the hand action ($p = 0.003$) and for the hand and ball sequence ($p = 0.0005$). CWA touched the smaller box with their hands and produced the sequence of means actions significantly more frequently than DSC in the Hand Action Unsuccessful

Table 5
Imitative reproduction of modelled behaviour in children with autism and children with Down syndrome in the Hidden box experiment.

Condition	Diagnosis	Hand action	Both hand and ball actions
Hand action possible	Autism	13**	0**
	Down syndrome	22	11
	Typical (as reported in Király, 2009)	85	15
Hand action unsuccessful	Autism	100**	100**
	Down syndrome	45	36*
	Typical (as reported in Király, 2009)	36	0

Note. The values represent percentages of children who produced the hand action or both means actions.
* $p < 0.01$.
** $p < 0.001$.

condition. No effect of experimental condition was observed in the Down syndrome group for the hand action ($p = 0.27$) or for the hand and ball sequence ($p = 0.22$); children in this group produced the hand action and the sequence of means actions with equal frequency in the two experimental conditions. Table 5 summarises the two clinical groups' results in the two conditions of the Hidden box paradigm.

6. Discussion

The primary objective of the current study was to explore interpretations of a model's behaviour in simplified social situations in a group of nonverbal, L-F CWA. We wished to explore (1) whether the ability to attribute goals is preserved in L-F CWA, just as in H-F CWA (Abell et al., 2000; Castelli, 2006; Hamilton et al., 2007; Rogers et al., 2010) and (2) whether L-F CWA (a) will show ability to attribute intentions in tasks where functionality or usual affordances cannot bias the children's responses or (b) respond by copying exactly the experimenter's actions, a strategy described by studies involving H-F CWA (Carpenter et al., 2001; D'Entremont & Yazbek, 2007).

We devised imitation tasks involving object-directed actions that were not common everyday actions and could only have been acquired from the demonstration in the laboratory. The experimenter's intention across these tasks was marked by nonverbal cues.

Our results for the typical infants repeat Gergely et al.'s (2002) finding that 14-month-olds are sensitive to contextual features that provide information about the model's circumstances and about the rationale for an unusual action. Infants' imitative performance in such situations is guided by a selective interpretive process that involves evaluation of the relative effectiveness of the action as a function of the model's constraints. CWA and DSC frequently reproduced the unusual head action in the Head touch paradigm and the novel ball action in the Hidden box paradigm, indicating that they interpreted the model's behaviour as a teleological, means-end action. In the Head touch paradigm CWA and DSC also reproduced the prepotent hand action in order to achieve the objective, demonstrating that they identified both the means and the end-state as the model's goals. This finding shows that the ability to attribute goals is preserved in L-F CWA, confirming our first hypothesis, namely that goal attribution is generally preserved in ASD.

Although CWA and DSC both demonstrated a teleological interpretation of the model's behaviour, our results indicated that they did not take the model's circumstances into consideration and did not use context to interpret the model's unusual and non-affordant actions in the same manner as did TDC. In the clinical groups, imitative behaviour did not show the same selective pattern across demonstration conditions as in the typical group. Current research on contextual constraints in selective imitation raises the possibility that, for typically developing infants, communicative cues during a behavioural demonstration convey information about a model's intended goal (Csibra & Gergely, 2009; Király, Csibra, & Gergely, 2012). Our results demonstrate that the use of ostensive-communicative cues during the demonstration did not make the situation more transparent for CWA and DSC. Although children in these two groups succeeded in learning the novel means presented, they did not interpret the model's behaviour in terms of her intended goal.

This replicates the results reported in D'Entremont and Yazbek's study (2007), where the authors concluded that, (consistently with Carpenter et al.'s (2001) inferences), H-F CWA were guided by stimulus enhancement, that is, the model's actions highlighted affordances of the objects and the children subsequently performed the actions that the objects afforded. In our study, the demonstrated actions were not consistent with the objects' affordances (to touch a button with the head or to use a ball as a lifter), and CWA still imitated all the actions in the stream of the demonstrator's behaviour. Regarding the first part of our second hypothesis, we can therefore conclude that even in better-controlled tasks where functionality or usual affordances could not trigger the children's responses, L-F CWA did not show ability to attribute intention.

DSC clearly engage in social interaction, and the lack of inferential processing and selectivity observed in DSC is therefore probably not attributable to an avoidance of cues. Rather, our evidence that DSC do not learn from failed attempts suggests that they are unable to harness the information presented, possibly as a result of memory or inferential processing problems.

The ceiling effect obtained in the Head touch experiment may be attributable to the simplicity of the experimental setting, where the saliency of the head action may have averted the children's attention from the cues indicating the model's intention. We controlled this possibility in the Hidden box experiment, where we increased the explicitness of the model's intention. In this setting, rather than using a situational constraint (tying the model's hands), an additional explicit behavioural step (a failed action) was used to indicate the reason for the model's non-affordant action. In addition, the Hidden box experiment created identical situational constraints for the model and the child, which can also be expected to make the situation more transparent for the child. Again, children in the two clinical groups reproduced the model's non-affordant action (the ball action) with equal frequency across the two experimental conditions. This indicates that it was not the saliency of the actions presented that lead L-F CWA to imitate these regardless of the model's intention. Instead, their responses reflected a specific imitative strategy: after witnessing the adult model's failed efforts, unlike TDC, they included the failed attempt in their response and reproduced the hand action, as well as the exact hand and ball sequence significantly more in the failed attempt condition than in the condition where no failed attempt was demonstrated. We did not observe similar selectivity for the reproduction of the hand action in DSC; that is, the children reproduced the action with equal frequency in the two conditions. Regarding the last part of our second hypothesis, we can therefore conclude that copying exactly the experimenter's actions is strategy that CWA, H-F or L-F, generally employ to manage social situations.

It is interesting to note that, although the addition of a behavioural step could render the underlying reasons for an overall action more opaque, a contrary effect was observed in Király's (2009) study of typically developing infants. Here, the additional step helped typical children interpret the model's unaffordant action with the ball, and they did not retain this 'indicator' action (although a prepotent one) when it was their turn to interact with the experimental objects. The pattern observed in L-F CWA was quite the opposite.

Why do CWA, H-F or L-F use exact imitation to manage social situations? Rather than analyzing the context – behavioural, situational, or mental – of an observed behaviour and selecting the most efficient means to achieve an observed goal, why do they reproduce the entirety of a model's demonstrated actions? As pointed out by Gergely et al. (2002), without the ability to take into account the context of a presented behaviour, most social situations become cognitively opaque or difficult to interpret. The strategy that CWA applied across our experimental conditions seems appropriate for addressing this difficulty. That is, reproducing the entire sequence of witnessed behaviour is a redundant but safe method of producing relevant and efficient action (Gergely & Csibra, 2006). It remains possible though, that similarly to H-F CWA in Vivanti et al.'s study (2011) L-F CWA do take into account the environment in which the action occurs, but are unable to analyse or interpret in a second step the referential cues observed in the situation.

Three main conclusions can be drawn from the results of the present study. First, consistently with the studies showing that in high-functioning autism there is an intact ability to understand others' goals (Hamilton, 2009), we show that children at the other end of the spectrum, L-F CWA imitate goal-directed actions. This finding implies that they perceive other people as goal-directed agents whose behaviour is driven by the desire to achieve an end state. L-F CWA not only reproduced the most efficient means action to achieve the objective, but also reproduced the model's unusual means action. This indicates that the L-F CWA in this study differentiated between the two methods presented for achieving the goal; however, the model's ostensive-communicative cues did not guide the children in determining which method was more congruent with the model's intended goal.

Second, the results presented here indicate that nonverbal L-F CWA do not generate a hierarchical interpretation of the means act as a function of the goal and of the model's circumstances or constraints. In other words, CWA's imitative performance was not influenced by factors that account for selectivity in TDC. One possible explanation is that CWA have deficits in inhibition and difficulty applying top-down selection rather than primed motor programmes activated through motor resonance. We suggest that CWA use alternative strategies to cope with social situations. The strategy revealed by the experimental paradigms in the present study consists of reproducing the full set of behaviours witnessed, without selectivity. This strategy may allow CWA to respond appropriately in social situations.

Third, that our sample of CWA readily participated in the study and responded to the experimental conditions demonstrates that deferred imitation tasks are indeed an appropriate means to evaluate the strategies that this population – otherwise very difficult to evaluate – uses to navigate their environment.

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