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Nature of motor imitation problems in school-aged boys with autism

A motor or a cognitive problem?

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ABSTRACT This case-control study explores the underlying mechanisms of imitation problems in boys with autism by manipulating imitation task variables and by correlating imitation performance with competence on general motor tests (Movement Assessment Battery for Children and Peabody Developmental Motor Scales). Fifty-five boys participated in this study: eight low-functioning with autism (LFA), 13 with mental retardation (MR), 17 high-functioning with autism (HFA) and 17 typically developing (TD). LFA performed significantly worse than MR on the motor test and on all imitation tasks. HFA performed significantly worse than TD on the motor test, but not on imitation tasks, with the exception of non-meaningful gestures. This study supports the notion that mainly perceptual-motor impairment, and not a cognitive weakness of symbolic representation, causes imitation problems in autism. In addition, in boys with autism, general motor as well as imitation abilities were impaired. We suggest that imitation ability has to be assessed in conjunction with motor competence.

KEYWORDS

assessment;
autism
spectrum
disorder;
autistic
disorder;
dyspraxia;
gesture;
imitation

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Heyes (2001) defined motor imitation as copying by an observer the features of body movements of a model. Even before children understand explicit linguistic information, they have access to an infinite arsenal of human social and non-social behaviours by imitating other people (Barr and Hayne, 2003).

The DSM-IV-TR (American Psychiatric Association, 2000) includes imitation problems among the diagnostic criteria of autism spectrum

disorders, but restricts these to a lack of social imitative play. Findings from most studies would appear to support the contention that motor imitation problems are universal and specific in autism (for reviews see Rogers, 1999; Rogers and Pennington, 1991; Smith and Bryson, 1994; Williams et al., 2004). Williams et al. (2004) reviewed 17 well-controlled experimental studies on motor imitation in autism. They calculated the combined *p*-value of group differences with respect to motor imitation to an appropriate control group: $p < 0.00005$ ($n = 248$ subjects). Even adolescents with autism have subtle imitation problems. They imitate the essential configuration of an action, but the reproduction of the proper style of the modelled action, e.g. harsh versus gentle, is diminished (Hobson and Lee 1999). Three studies (Beadle-Brown and Whiten, 2004; Charman and Baron-Cohen, 1994; Morgan et al., 1989) did not confirm motor imitation problems in autism. In the study of Beadle-Brown and Whiten (2004) the ceiling effect on the non-standardized tasks as well as the considerable heterogeneity of the groups may have contributed to this finding. The infant imitation tasks of the Uzgiris–Hunt Sensorimotor Scales used in the other two studies were probably too easy. Nearly all participants performed at or near ceiling levels.

It should be mentioned that imitation problems in children with autism are more robust in gestural imitations (imitations of actions without objects) than in procedural imitations (imitations of object manipulations) (DeMeyer et al., 1972, Hammes and Langdell, 1981; Roeyers et al., 1998). Rogers et al. (2003) came to a different conclusion; in their study, however, the gestural imitation tasks for the toddlers with autism (e.g. pat chest with one hand) were easier than the procedural imitation tasks (e.g. turn car upside-down and pat it).

In the present study, we consider the underlying mechanisms of the gestural imitation problem in autism. Research on this topic is complex, because imitation is not a unitary phenomenon. It is a combination of cognitive-representational and visual perceptual-motor components. One method to study these components is to manipulate task variables, meaningful transitive and intransitive gestures versus non-meaningful single and sequential hand postures. These were also used by Dewey (1993), Hill (1998) and Zoia and colleagues (2002) to evaluate children with developmental coordination disorder. Meaningful gestures are symbolic and language related. Transitive gestures with an imaginary object, e.g. pretend to comb your hair with an imaginary comb, demonstrate a certain level of symbolization and knowledge of the object and tool use. Intransitive gestures without an imaginary object, e.g. wave goodbye, are communicative gestures. Imitation of meaningful gestures requires a proper visual perceptual discrimination of the action, comprehension of the meaning of

the action, and linkage to previous information about the 'time-space' formulas of a to-be-performed action. The imitation of meaningful gestures requires cognitive-representational as well as perceptual-motor processes. Non-meaningful gestures are non-symbolic and not linked to previous knowledge and familiar concepts. Imitation of non-meaningful gestures requires merely a proper visual perceptual discrimination and motor production of the actions. In toddlers with autism, mental retardation and normal development, a better performance on meaningful versus non-meaningful actions has been reported, but, as expected, with a significantly poorer performance of the group with autism on all actions (Stone et al., 1997). Rogers and Pennington (1991) found strong evidence for the existence of problems in imitation of non-meaningful body movements as well as actions with symbolic meaning in children with autism. Rogers and colleagues (1996) compared imitation performances of meaningful and non-meaningful gestures in high-functioning older subjects with autism and concluded that adding meaning to the gestures hinders imitation performances among the age and IQ-matched controls, but helps it in the group with autism.

A second way to study underlying mechanisms of gestural imitation difficulties in autism is to investigate the relationship between imitation problems and comorbid motor coordination difficulties. Clumsiness is frequently argued to be a possible specific symptom in Asperger syndrome (Ghazuiddin and Butler, 1998; Ghazuiddin et al., 1994; Gillberg, 1989; Rinehart et al., 2001; Szatmari et al., 1990). Moreover, several studies have drawn attention to motor problems of low-functioning and high-functioning individuals with autism (Berkeley et al., 2001; Leary and Hill, 1996; Manjiviona and Prior, 1995). Jones and Prior (1985) were the first to pay attention to the association between imitation problems in autism and soft neurological signs which may indicate elementary problems of movement control. Green et al. (2002) were the first to investigate this association in a systematic way. They found that their entire Asperger group performed worse both on a general motor test and on gestural imitation tasks than the control group, who had a diagnosis of developmental coordination disorder. Furthermore imitation performance was strongly related to general motor performance in the autism group. This was not the case in the control group. On the contrary, DeMeyer and colleagues (1972) suggested that the inability of the child with autism to imitate reflects a disturbance of the capacity to formulate and execute an intentional motor plan in spite of intact motor abilities. In their view imitation problems in autism have a dyspraxic nature. According to Dewey (1995) dyspraxia is defined as a developmental disorder in gestural performance in children whose basic motor skills are intact.

The purpose of the present study is to explore the underlying mechanisms of gestural imitation difficulties in autism by manipulating imitation task variables and by comparing imitation performance with performance on general motor tests in low-functioning as well as in high-functioning children with autism. This study starts from two experimental paradigms. First, we argue that if children are worse at imitating meaningful gestures than non-meaningful gestures, there is mainly a lack of cognitive representation of the meaning of the gestures. In contrast, if their imitation of non-meaningful gestures is worse than that of meaningful gestures, there is mainly a lack of visual perceptual-motor organization. Second, we argue that if children perform worse on a general motor test than on gestural imitation tasks, the latter is part of a general motor inability. In contrast, if children perform worse on gestural imitation tasks than on a general motor test, they have a specific dyspraxic deficit.

Method

Participants

Fifty-five Flemish boys participated in this study (Table 1). Intelligence level was based on data from their medical file. As several intelligence tests (mean 100, standard deviation 15) were used, the participants are classified in a group with mental impairment (low-functioning group with $IQ < 80$) and without mental impairment (high-functioning group with $IQ \geq 80$).

Eight low-functioning boys with autism (mean age 6:2 years, SD 7.6 months, IQ range 55–79) and 13 mentally retarded controls (mean age 6:3 years, SD 2.8 months, IQ range 55–78) were recruited from special schools for mentally handicapped children. Seventeen high-functioning boys with autism (mean age 8:9 years, SD 11.0 months, IQ range 80–124) were recruited in special schools for children with learning problems in spite of normal intellectual abilities. Seventeen typically developing boys (mean age 8:8 years, SD 11.6 months, with a normal school career) were recruited in mainstream schools. The subjects with autism were diagnosed in the University Hospital KU Leuven according to the DSM-IV-TR diagnostic criteria of childhood autism (American Psychiatric Association, 2000). Boys with a clearly medical condition that could account for motor difficulties (e.g. cerebral palsy) and/or with attention difficulties (e.g. hyperactivity disorder) were excluded.

Table 1 Characteristics of the participants (*N* = 55)

LOW-FUNCTIONING GROUPS													
Low-functioning boys with autism							Low-functioning non-autistic controls						
No.	Age (years)	IQ	PDMS (0–564)	GIT (0–42)	MG (0–12)	NMG (0–30)	No.	Age (years)	IQ	PDMS (0–564)	GIT (0–42)	MG (0–12)	NMG (0–30)
1	5:1	74 ^a	477	13	7	6	1	5:11	68 ^c	544	32	11	21
2	5:8	55 ^b	506	30	10	20	2	5:11	69 ^b	527	34	11	23
3	5:10	77 ^c	515	14	10	4	3	6:1	55 ^a	548	31	12	19
4	6:2	66 ^a	462	16	9	7	4	6:1	76 ^a	534	24	11	13
5	6:7	79 ^a	526	20	10	10	5	6:2	74 ^a	542	23	10	13
6	6:8	61 ^c	440	15	8	7	6	6:4	62 ^a	532	33	11	22
7	6:9	68 ^a	529	24	11	13	7	6:4	67 ^a	541	27	7	20
8	6:11	63 ^b	528	23	11	12	8	6:5	59 ^a	546	32	12	20
							9	6:5	66 ^a	525	29	12	17
							10	6:6	64 ^b	514	24	9	15
							11	6:6	75 ^a	532	32	11	21
							12	6:6	78 ^a	527	28	11	17
							13	6:8	55 ^c	545	34	11	23
Mean	6:2 y		497.8	19.3	9.5	9.8		6:3 y		535.1	29.4	10.6	18.7
SD	7.6 m		34.0	5.9	1.4	5.1		2.8 m		10.1	3.9	1.3	3.4

Continued over

Table 1 continued

HIGH-FUNCTIONING GROUPS															
High-functioning boys with autism								High-functioning non-autistic controls							
No.	Age (years)	IQ	MABC (0-40)	MABC (centile)	GIT (0-42)	MG (0-12)	NMG (0-30)	No.	Age (years)	IQ	MABC (0-40)	MABC (centile)	GIT (0-42)	MG (0-12)	NMG (0-30)
1	7:5	104 ^a	2	79	41	12	29	1	7:5	N	0	96	39	12	27
2	7:10	85 ^d	9	18	35	12	23	2	7:6	N	0	96	39	12	27
3	7:10	94 ^d	0	96	41	12	29	3	8:0	N	1	89	40	11	29
4	7:11	115 ^a	0	96	38	12	26	4	8:1	N	3.4	60	38	12	26
5	7:11	102 ^d	9	18	38	12	26	5	8:1	N	2	79	41	12	29
6	8:0	92 ^a	5.5	40	29	12	17	6	8:4	N	1.5	84	38	11	27
7	8:0	92 ^b	21	1	25	12	13	7	8:4	N	2	79	38	12	26
8	8:5	94 ^a	9	18	42	12	30	8	8:4	N	4	54	38	12	26
9	9:0	86 ^a	5	45	40	12	28	9	8:5	N	0	96	42	12	30
10	9:0	80 ^d	5.5	40	40	12	28	10	8:6	N	0	96	40	12	28
11	9:1	104 ^a	13.5	5	41	12	29	11	8:6	N	5	45	38	12	26
12	9:2	113 ^d	21	1	36	12	24	12	8:11	N	2	79	36	12	24
13	9:4	124 ^d	9.5	16	42	12	30	13	9:0	N	0	96	38	12	26
14	9:6	81 ^d	15.5	3	36	12	24	14	10:1	N	5.5	40	40	12	28
15	9:7	87 ^d	21	1	38	12	26	15	10:3	N	5.5	40	41	12	29
16	10:5	104 ^d	5	45	42	12	30	16	10:3	N	3	65	41	12	29
17	10:5	80 ^d	6.5	32	34	12	22	17	10:6	N	6.5	32	41	12	29
Mean	8:9 y				37.5	12.0	25.5		8:8 y				39.2	11.8	27.4
SD	11.0 m				4.7	0.0	4.7		11.6 m				1.6	0.3	1.6

GIT, Gestural Imitation Total Score; MG Meaningful Gesture score; NMG, Non-Meaningful Gesture score; PDMS, Peabody Developmental Motor Scales; MABC, Movement Assessment Battery for Children; N, normal school career; ^a, Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R); ^b, Snijders-Oomen Non-verbal intelligence test-revised (SON-R 2½-7); ^c, Revised Amsterdam Intelligence Test (RAKIT); ^d, Wechsler Intelligence Scale for Children-Revised (WISC-R).

Instrumentation

Gestural Imitation Test In accordance with the study of Hill (1998) the Gestural Imitation Test consisted of 24 gestural imitation tasks. Twelve meaningful gestures (Dewey, 1993) were subdivided into six transitive gestures with an imaginary object/tool (e.g. to pretend to comb your hair with an imaginary comb) and six intransitive gestures with a communicative meaning (e.g. to salute). The subjects got one attempt to perform each gesture. A quantitative score on a two-point scale was given: 1 for a correct and 0 for an incorrect imitation performance. Twelve non-meaningful gestures were subdivided into six single hand postures and six sequences of hand postures (Kimura and Archibald, 1974). If the subjects failed to copy the single hand posture, they were given a second chance. For each single hand posture a quantitative score on a three-point scale was given: 2 for a correct imitation in the first trial, 1 for a correct imitation in the second trial and 0 for an incorrect imitation performance. If necessary, the subjects got three attempts on the sequences of hand postures. A quantitative score on a four-point scale was given: 3 for a correct imitation in the first trial, 2 for a correct imitation in the second trial, 1 for a correct imitation in the third trial and 0 for an incorrect imitation performance. The item scores were added up to a gestural imitation total scores with a maximum of 42.

Motor tests The subject's motor performance was examined with a standardized general motor test suitable for their mental abilities. In the low-functioning group, gross and fine motor development were measured with the Peabody Developmental Motor Scales (PDMS: Folio and Fewell, 1983). In the high-functioning group, manual dexterity, ball skills and balance were measured with the Movement Assessment Battery for Children (MABC: Henderson and Sugden, 1992). A high MABC total score means poor motor performance. Because of the time scores the MABC is rather stressful and more demanding at the cognitive level and is therefore not suitable for mentally retarded children.

Procedure

The test procedure was spread over 2 days in the same week. The imitation and the motor tests were carried out in randomized order. For the imitation tasks the subject was seated at a table in front of a trained investigator. Before the demonstration of each gesture, the child's attention was attracted by calling his name. Meaningful and non-meaningful gestures were presented in randomized order. Video recordings were made of the imitation performances for quantitative scoring. They were also used for qualitative error analysis (Vanvuchelen et al., 2007). Imitation performances

were scored by the investigator who was blind for the diagnosis of the subjects.

Statistical analysis

Group differences regarding age, motor performance and gestural imitation in the low- and high-functioning groups separately were checked with the Mann–Whitney U-test. Comparison of the four groups was carried out with an ANOVA. Correction for multiple comparisons was done with a Bonferroni test. Correlations between scores were examined with the Spearman correlation coefficient.

Results

Characteristics of the groups

Table 1 shows the age, IQ, general motor scores, gestural imitation total scores, and scores for meaningful and non-meaningful gestures for each child, along with the group means and standard deviations. Age differences between both low-functioning groups ($U = 49.0$; $p = 0.82$) and both high-functioning groups ($U = 144.0$; $p = 0.98$) as well as intelligence differences between both low-functioning groups were not statistically significant ($U = 47.5$, $p = 0.74$). Age and intelligence differences between both groups with autism were statistically significant ($U = 0.0$, $p < 0.001$; $U = 2.5$, $p < 0.001$). ANOVA analysis revealed a significant main effect for groups on the gestural imitation total score ($F = 53.9$, $p < 0.001$), meaningful gestures ($F = 19.7$, $p < 0.001$) and non-meaningful gestures ($F = 46.7$, $p < 0.001$). Post hoc analysis in the three conditions proved that the differences between all groups were significant, except for both high-functioning groups. Therefore further analysis was done on low-functioning and high-functioning groups separately.

Low-functioning boys with autism versus mentally retarded non-autistic controls

Analysis of imitation performances and task variables Low-functioning boys with autism (LFA) performed significantly worse than mentally retarded non-autistic boys (MR) on the Gestural Imitation Test total ($U = 8.5$; $p = 0.002$), as well as on meaningful gestures ($U = 23.5$; $p = 0.031$) and non-meaningful gestures ($U = 8.0$; $p = 0.001$) separately. There was no difference in the imitation performances of transitive gestures ($U = 31.5$; $p = 0.105$) and intransitive gestures ($U = 31.5$; $p = 0.110$) separately. In contrast, non-meaningful single hand postures ($U = 6.0$; $p = 0.001$) and

sequences of hand postures ($U = 11.0$; $p = 0.003$) were significantly more difficult for LFA boys in comparison with the non-autistic controls. In both low-functioning groups together, meaningful gesture scores were significantly correlated to non-meaningful gesture scores ($r_s = 0.495$; $p = 0.023$). Subanalyses revealed the same findings in both low-functioning groups separately.

Association between general motor ability and imitation performance

LFA boys performed significantly poorer than non-autistic controls on the Peabody Developmental Motor Scales total score ($U = 11.0$; $p = 0.003$), as well as on the PDMS gross ($U = 11.0$; $p = 0.002$) and fine motor ($U = 20.0$; $p = 0.02$) subscores. The PDMS total, gross and fine motor subscores correlated significantly with the gestural imitation total scores, meaningful gesture and non-meaningful gesture scores (Table 2). Subanalyses of the two subgroups revealed that, in the group with autism, meaningful gesture scores were strongly correlated to motor performance (PDMS total $r_s = 0.896$, $p = 0.003$; PDMS gross motor $r_s = 0.835$, $p = 0.010$; PDMS fine motor $r_s = 0.835$, $p = 0.010$). In contrast, in the control group none of the correlations between imitation and PDMS scores were significant.

Association between intelligence ability and imitation performance

Intelligence did not correlate significantly with gestural imitation total score, meaningful gesture and non-meaningful gesture scores (Table 2). Subanalyses revealed the same findings in both groups separately.

High-functioning boys with autism versus typically developing controls

Analysis of imitation performances and task variables Group differences were not found on the Gestural Imitation Test total score ($U = 125.5$; $p = 0.506$), meaningful gestures ($U = 127.5$; $p = 0.151$) and non-meaningful gestures ($U = 121.5$; $p = 0.421$). High-functioning boys with autism (HFA) imitated just non-meaningful single hand postures significantly worse than typically developing (TD) controls ($U = 77.0$; $p = 0.009$). Three-quarters of the controls and 30 percent of high-functioning boys performed all single hand postures correct. In both high-functioning groups together, meaningful gesture scores were not significantly correlated to non-meaningful gesture scores ($r_s = -0.110$; $p = 0.536$).

Association between general motor ability and imitation performances

HFA boys performed significantly worse on the Movement Assessment Battery for Children (MABC) than TD controls. This was the case not only

Table 2 Correlation matrix (Spearman's Rho) of gestural imitation test and general motor tests and IQ for boys with and without autism group-matched for age

Low-functioning (both groups)	Peabody developmental motor scales			
	PDMS (total)	PDMS (GM)	PDMS (FM)	IQ
Gestural imitation total score	0.604**	0.565**	0.544*	-0.374
Meaningful gestures	0.597**	0.505*	0.696**	-0.204
Non-meaningful gestures	0.580**	0.569**	0.472*	-0.351
High-functioning (both groups)	Movement assessment battery for children			
	MABC (total)	MABC (manual)	MABC (ball)	MABC (balance)
Gestural imitation total score	-0.195	-0.212	-0.242	-0.108
Meaningful gestures	-0.231	-0.142	-0.115	-0.210
Non-meaningful gestures	-0.217	-0.225	-0.248	-0.128

PDMS (total), Peabody Developmental Motor Scales total score; PDMS (GM), Peabody Developmental Motor Scales gross motor score; PDMS (FM), Peabody Developmental Motor Scales fine motor score; MABC (total), Movement Assessment Battery for Children total score (high score means poor motor performance); MABC (manual), Movement Assessment Battery for Children manual dexterity; MABC (ball), Movement Assessment Battery for Children ball skills; MABC (balance), Movement Assessment Battery for Children static and dynamic balance; *, correlation is significant at the 0.05 level (2-tailed); **, correlation is significant at the 0.01 level.

for the MABC total score ($U = 49.0$; $p = 0.001$), but also for MABC manual dexterity ($U = 61.0$; $p = 0.004$), ball skills ($U = 78.5$; $p = 0.016$) and static and dynamic balance ($U = 73.4$; $p = 0.007$). Five out of 17 (30%) HFA boys achieved an MABC centile below 15 and were suspected to have motor problems. This did not occur in the typically developing children. In the total high-functioning group there were no significant correlations between the performances on the gestural imitation test and the general motor test (Table 2). Subanalyses of the two groups revealed one significant correlation. In the group with autism, imitation of non-meaningful sequences of hand postures was significantly correlated with motor performance (MABC total score $r_s = -0.482$, $p = 0.05$). The minus sign in the correlation is caused by the scoring system of the Movement Assessment Battery for Children.

Association between intelligence ability and imitation performance

Intelligence did not correlate significantly with gestural imitation total score ($r_s = 0.474$, $p = 0.055$) and non-meaningful gesture scores ($r_s = 0.474$, $p = 0.055$). This correlation was not measured in meaningful gestures because of the ceiling scores.

Discussion

The major goal of this study was to investigate whether gestural imitation difficulties of children with autism have a cognitive-representational or a perceptual-motor nature. The present study was the first to combine two methods. Apart from the manipulation of task variables, the association was examined between general motor competence and imitation abilities. This was done for two groups of subjects with autism in comparison with controls, group matched on age, gender and developmental level.

Results revealed that all boys with autism, with and without mental impairment, had more problems in imitating non-meaningful gestures than meaningful gestures in comparison with non-autistic controls. This finding supports the notion, in accordance with Rogers and Pennington (1991), that mainly perceptual-motor components are involved in gestural imitation difficulties in children with autism. We found no support for the idea of Baron-Cohen (1988) that mainly cognitive weakness of conceptualization causes these imitation problems. These results are in contrast with those of the study of Hill (1998) in children with specific language impairment and with developmental coordination disorder, but in line with other studies in children with autism with mental impairment (Roeyers et al., 1998; Stone et al., 1997) and without mental impairment (Rogers et al., 1996; Smith and Bryson, 1998). There are two possible explanations for this. First, adding meaning to the gestures possibly improved the imitation

performances in children with autism. For example, to imitate the gesture of pretending to comb their hair with an imaginary comb, children showed that they understood the meaning of the gesture and the symbolization of the tool use. Second, previous experience with the real action itself possibly also contributes to a better imitation performance. In contrast with the meaningful gestures, the children were not acquainted with the non-meaningful gestures. They could not fall back on previous information about the 'time-space' formulas of the to-be-performed actions. The imitation of non-meaningful gestures was largely founded on an accurate visual perceptual-motor organization. Theoretically it may be speculated that problems in imitating non-meaningful gestures are due not to poor perceptual-motor control but to inadequate visual perception and/or difficulties in remembering the gestures. Smith and Bryson (1998) investigated this issue in relatively high-functioning children with autism in comparison to language-impaired and younger controls. Subjects were asked to recognize non-meaningful hand postures and sequences. There were no significant group differences in these recognition and memory tasks (Smith and Bryson, 1998).

The finding in this study that perceptual-motor components have a key role in imitation difficulties is confirmed by the relationship between imitation performance and general motor ability in children with autism. First, the motor impairment of children with autism was more apparent than their imitation problems in comparison with non-autistic controls. This finding supports the notion that imitation difficulties in autism are part of a broader motor problem. This contradicts the idea of DeMeyer and colleagues (1972) that imitation problems in autism are of a dyspraxic nature. Second, in the low-functioning group with autism, motor performances explained 80 percent of the variance of the imitation performances of meaningful gestures. In the high-functioning group with autism, only the imitation scores on non-meaningful sequences of hand postures correlated significantly with the score on the Movement Assessment Battery for Children. The motor impairment accounted for 23 percent of the variance of this imitation performance. Significant correlations between gestural imitation scores and motor performance were not found in the non-autistic control groups. Studies that did not use developmental motor tests did not support this view. In the study of Rogers and colleagues (1996), high-functioning subjects with autism spectrum disorder and the heterogeneous clinical control group were given as many verbal and physical prompts as needed to correct their imitation performance. They found no group differences and concluded that there was no general motor impairment that interfered with the ability of subjects with autism to perform the necessary hand movements in the imitation tasks. Nevertheless, they recommended

the use of standardized motor tests to assess motor competence to rule out a motor dysfunction in autism (Rogers et al., 1996). Several years later the same research group found neither a motor deficit nor a significant correlation between the motor and imitation performances in toddlers with autism. It has to be noted that they again used a non-standardized motor test (Rogers et al., 2003). In contrast, Smith and Bryson (1998) investigated manual dexterity with the Grooved Pegboard. High-functioning children with autism were significantly slower than language-impaired controls. They concluded that reduced manual dexterity explained 37 percent of the variance of the imitative deficit of the children with autism. Green and colleagues (2002) explored the correlation between imitation performance and performance on a general motor test in boys with Asperger syndrome. In this group, in contrast to the control group with developmental coordination disorder, imitation scores correlated significantly with performance on the Movement Assessment Battery for Children. Motor impairment accounted for 45 percent of the variance of imitation performance.

It remains a matter of debate why in the present study the association between imitation performance and motor ability was more robust in younger children with a lower developmental level than in older children with a higher level. A possible explanation is the following. Motor ability was measured with standardized motor tests suitable for the developmental levels of the children. As there is no developmental imitation test available, imitation was measured with non-standardized imitation tests (Dewey, 1993; Kimura and Archibald, 1974) applied in research on children with developmental coordination disorder (Dewey, 1993; Hill, 1998) and adults with acquired apraxia (Kimura and Archibald, 1974). Thirty-seven percent of the low-functioning children with autism did not achieve 50 percent or more of the maximum score of this gestural imitation test. This is in sharp contrast with the mentally retarded controls. All of them achieved 50 percent or more of the maximum. With the exception of two boys with autism, all high-functioning children achieved a score of more than 80 percent of the maximum. This implies that the set of imitation tasks used in this study was probably too easy for children with a higher developmental level. However, boys with autism imitated less well than controls of the same developmental level. This difference was more marked for low-functioning than for high-functioning boys. These results confirmed that motor imitation problems are common in autism. Our results also endorse the notion that imitation in autism is more impaired in younger children and/or in those with a lower developmental level (Roux et al., 1998).

Some limitations of this study can be noticed. First, the sample size of the four groups was small because of the time-consuming qualitative error analysis of imitation performances reported in another study (Vanvuchelen

et al., 2007). Second, because of the way the children were recruited, different intelligence tests were used. Third, the ceiling effect of the imitation test in the high-functioning groups probably diminished the variability of the possible scores, and therefore the power to detect a clear association between imitation performance and motor ability. Fourth, the motor tests are administered by the examiner demonstrating the tasks. As most developmental tests do, this test also places demands on the imitation abilities of young children.

Some implications of this study for the clinical practice of diagnosis in autism can be made. First, to improve the assessment of children with autism a combination of a general motor and an imitation test is to be used. Second, there is a need for a standardized developmental imitation test with broad task variability to assess young children suspected of autism. It is our intention to develop such an instrument. Finally, we have to reflect how motor, cognitive and language ability can be assessed without demonstration of the task so that we avoid the additional burden of difficulty when assessing children with autism.

References

- AMERICAN PSYCHIATRIC ASSOCIATION (2000) *Diagnostic and Statistical Manual of Mental Disorders*, 4th edn text rev. (DSM-IV-TR). Washington, DC: APA.
- BARON-COHEN, S. (1988) 'Social and Pragmatic Deficits in Autism: Cognitive or Affective?', *Journal of Autism Developmental Disorders* 18 (3): 379–402.
- BARR, R. & HAYNE, H. (2003) 'It's Not What You Know, It's Who You Know': Older Siblings Facilitate Imitation during Infancy', *International Journal of Early Years Education* 11 (1): 7–21.
- BEADLE-BROWN, J.D. & WHITEN, A. (2004) 'Elicited Imitation in Children and Adults with Autism: Is There a Deficit?', *Journal of Intellectual and Developmental Disability* 29 (2): 147–63.
- BERKELEY, S.L., ZITTEL, L.L., PITNEY, L.V. & NICHOLS, S.E. (2001) 'Locomotor and Object Control Skills of Children Diagnosed with Autism', *Adapted Physical Activity Quarterly* 18: 405–16.
- CHARMAN, T. & BARON-COHEN, S. (1994) 'Another Look at Imitation in Autism', *Development and Psychopathology* 6: 403–13.
- DEMEYER, M.K., ALPERN, G.D., BARTON, S., DEMYER, W.E., CHURCHILL, D.W., HINGTGEN, J.N., BRYSON, C.Q., PONTIUS, W. & KIMBERLIN, C. (1972) 'Imitation in Autistic, Early Schizophrenic, and Non-Psychotic Subnormal Children', *Journal of Autism and Child Schizophrenia* 2 (3): 264–87.
- DEWEY, D. (1993) 'Error Analysis of Limb and Orofacial Praxis in Children with Developmental Motor Deficits', *Brain and Cognition* 23: 203–21.
- DEWEY, D. (1995) 'What is Developmental Dyspraxia?', *Brain and Cognition* 29: 254–74.
- FOLIO, M.R. & FEWELL, R.R. (1983) *Peabody Developmental Motor Scales*. Austin, TX: Pro-Ed.
- GHAZIUDDIN, M. & BUTLER, E. (1998) 'Clumsiness in Autism and Asperger Syndrome: A Further Report', *Journal of Intellectual Disability Research* 42 (1): 43–8.

- GHAZIUDDIN, M., BUTLER, E., TSAI, L. & GHAZIUDDIN, N. (1994) 'Is Clumsiness a Marker for Asperger Syndrome?' *Journal of Intellectual Disability Research* 38 (5): 519–27.
- GILLBERG, C. (1989) 'Asperger Syndrome in 23 Swedish Children', *Developmental Medicine and Child Neurology* 31: 520–31.
- GREEN, D., BAIRD, G., BARNETT, A.L., HENDERSON, L., HUBER, J. & HENDERSON, S.E. (2002) 'The Severity and Nature of Motor Impairment in Asperger's Syndrome: A Comparison with Specific Developmental Disorder of Motor Function', *Journal of Child Psychology and Psychiatry* 43 (5): 655–68.
- HAMMES, J.G. & LANGDELL, T. (1981) 'Precursors of Symbol Formation and Childhood Autism', *Journal of Autism and Developmental Disorders* 11 (3): 331–46.
- HENDERSON, S.E. & SUGDEN, D.A. (1992) *Movement Assessment Battery for Children: Manual*. London: Psychological Corporation, Harcourt Brace.
- HEYES, C. (2001) 'Causes and Consequences of Imitation', *Trends in Cognitive Science* 5 (6): 253–61.
- HILL, E.L. (1998) 'A Dyspraxic Deficit in Specific Language Impairment and Developmental Coordination Disorder? Evidence from Hand and Arm Movements', *Developmental Medicine and Child Neurology* 40 (6): 388–95.
- HOBSON, R.P. & LEE, A. (1999) 'Imitation and Identification in Autism', *Journal of Child Psychology and Psychiatry* 40 (4): 649–59.
- JONES, V. & PRIOR, M. (1985) 'Motor Imitation Abilities and Neurological Signs in Autistic Children', *Journal of Autism and Developmental Disorders* 15 (1): 37–46.
- KIMURA, D. & ARCHIBALD, Y. (1974) 'Motor Functions of the Left Hemisphere', *Brain* 97 (2): 337–50.
- LEARY, M.R. & HILL, D.A. (1996) 'Moving On: Autism and Movement Disturbance', *Mental Retardation* 34 (1): 39–53.
- MANJIVIONA, J. & PRIOR, M. (1995) 'Comparison of Asperger Syndrome and High-Functioning Autistic Children on a Test of Motor Impairment', *Journal of Autism and Developmental Disorders* 25 (1): 23–39.
- MORGAN, S.B., CUTRER, P.S., COPLIN, J.W. & RODRIGUE, J.R. (1989) 'Do Autistic Children Differ from Retarded and Normal Children in Piagetian Sensorimotor Functioning?', *Journal of Child Psychology and Psychiatry* 30 (6): 857–64.
- RINEHART, N.J., BRADSHAW, J.L., BRERETON, A.V. & TONGE, B.J. (2001) 'Movement Preparation in High-Functioning Autism and Asperger Disorder: A Serial Choice Reaction Time Task Involving Motor Reprogramming', *Journal of Autism and Developmental Disorders* 31: 79–88.
- ROEYERS, H., VAN OOST, P. & BOTHUYNE, S. (1998) 'Immediate Imitation and Joint Attention in Young Children with Autism', *Development and Psychopathology* 10 (3): 441–50.
- ROGERS, S.J. (1999) 'An Examination of the Imitation Deficit in Autism', in J. NADEL & G. BUTTERWORTH (eds) *Imitation in Infancy*, pp. 254–83. Cambridge: Cambridge University Press.
- ROGERS, S.J. & PENNINGTON, B.F. (1991) 'A Theoretical Approach to the Deficits in Infantile Autism', *Development and Psychopathology* 3: 137–62.
- ROGERS, S.J., BENNETTO, L., MCEVOY, R. & PENNINGTON, B.F. (1996) 'Imitation and Pantomime in High-Functioning Adolescents with Autism Spectrum Disorders', *Child Development* 67 (5): 2060–73.
- ROGERS, S.J., HEPBURN, S.L., STACKHOUSE, T. & WEHNER, E. (2003) 'Imitation Performance in Toddlers with Autism and Those with Other Developmental Disorders', *Journal of Child Psychology and Psychiatry* 44 (5): 763–81.

- ROUX, S., ADRIEN, J.L., BRUNEAU, N., MALVY, J. & BARTHELEMY, C. (1998) 'Behaviour Profiles within a Population of 145 Children with Autism Using the Behaviour Summarized Evaluation Scale: Influence of Developmental Age', *Autism* 2 (4): 345–66.
- SMITH, I.M. & BRYSON, S.E. (1994) 'Imitation and Action in Autism: A Critical Review', *Psychological Bulletin* 116: 259–73.
- SMITH, I.M. & BRYSON, S.E. (1998) 'Gesture Imitation in Autism I: Nonsymbolic Postures and Sequences', *Cognitive Neuropsychology* 15: 747–70.
- STONE, W.L., OUSLEY, O.Y. & LITTLEFORD, C.D. (1997) 'Motor Imitation in Young Children with Autism: What's the Object?', *Journal of Abnormal Child Psychology* 25 (6): 475–85.
- SZATMARI, P., TUFF, L., FINLAYSON, M.A. & BARTOLUCCI, G. (1990) 'Asperger's Syndrome and Autism: Neurocognitive Aspects', *Journal of the American Academy Child Adolescence Psychiatry* 29: 130–6.
- VANVUCHELEN, M., ROEYERS, H. & DE WEERDT, W. (2007) 'Nature of Motor Imitation Problems in School-Aged Boys with Autism: How Congruent Are the Error Types?', *Developmental Medicine and Child Neurology* 49: 6–12.
- WILLIAMS, J.H., WHITEN, A. & SINGH, T. (2004) 'A Systematic Review of Action Imitation in Autistic Spectrum Disorder', *Journal of Autism and Developmental Disorders* 34 (3): 285–99.
- ZOIA, S., PELAMATTI, G., CUTTINI, M., CASOTTO, V. & SCABAR, A. (2002) 'Performance of Gesture in Children with and without DCD: Effects of Sensory Input Modalities', *Developmental Medicine and Child Neurology* 44: 699–705.