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FACULTEIT GENEESKUNDE EN LEVENSWETENSCHAPPEN
master in de revalidatiewetenschappen en de kinesitherapie

Masterproef

Autism Spectrum Disorder Specific Imitation Profiles in Preschoolers Without Intellectual Disabilities

Promotor :
Prof. dr. Marleen VANVUCHELEN

Laura Willems
Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie

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Student: Willems Laura

Promotor: Prof. dr. Vanvuchelen Marleen

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Assent, 15 april 2016

W.L.

Research context

This master thesis is situated in the domain of pediatric rehabilitation. The main goal of this study is to present the imitation abilities and the imitation profile of children with an autism spectrum disorder. This offers the possibility to present the reader with a comprehensive view of the imitation capabilities in children with an autism spectrum disorder. Also, knowing the extensiveness is important to be able to understand and guide persons with an autism spectrum disorder.

Imitation is the aptitude of a person to reproduce an observed action whereby the own motor patterns are related to observed motor patterns (Nadel, 2015). To reach the same end result the imitator uses the same means of actions (Warreyn, Van Der Paelt & Roeyers, 2014). It seems that typically developing children can already imitate facial expressions, gestures and actions with objects in the first year of life (Ingersoll, 2008). Imitation has a social as well as a learning function (Ingersoll, 2008; Warreyn, Van Der Paelt & Roeyers, 2014). It is an important contributor to the social communicative abilities of individuals (Warreyn, Van Der Paelt & Roeyers, 2014). It is stated that children with autism spectrum disorders (ASD) have problems with social communicative skills and restricted, repetitive patterns of behavior. It also seems that they exhibit imitation impairments (Edwards, 2014; Warreyn, Van Der Paelt & Roeyers, 2014). Regarding the importance of imitation to the social communicative abilities it is important to involve imitation training in interventions for children with ASD (Warreyn, Van Der Paelt & Roeyers, 2014).

Autism Spectrum Disorder is a neuro-developmental disorder characterized by profound dysfunctions in social interaction and communication, and by the presence of restricted, repetitive and stereotypical interests and behavior (American Psychiatric Association DSM-V, 2013). These symptoms need to be present in the early development of the child. However, it is possible that these symptoms will only become evident when social demands of the child exceed the limited potential to interact (American Psychiatric Association DSM-V, 2013). The severity of ASD is based on deficits in social communication and restricted, repetitive behavior patterns (American Psychiatric Association DSM-V, 2013). To date, there is still no underlying cause found that could explain the disorder (Faras, Ateeqi & Tidmarsch, 2010).

The main purpose of the present study was to determine imitation abilities and the imitation profile of preschool children with ASD. In addition, it attempts to examine the association between imitation abilities and – profile and developmental level and autism symptom severity respectively. The main findings were that children with ASD have poorer imitation abilities compared to typically developing children (TD). Based on the age equivalents of the Preschool Imitation and Praxis Scale (PIPS), procedural and bodily imitation abilities of children with ASD were statistically significant below their chronological age. The ASD-specific imitation profile is characterized by difficulties to imitate opaque actions, which mainly rely on internal action models and proprioceptive monitoring.

The study subject was provided by promotor Prof. dr. M. Vanvuchelen. The research questions were drafted in dialog with the student and the promotor. The student had no share in the design of the study. Data were already collected by Prof. dr. Vanvuchelen and are part of an existing study of Vanvuchelen, Roeyers and De Weerdt (2011). Data processing was executed by the student in SPSS (version 22.0) with guidance of the promotor. The academic writing process was done by the student under supervision and with guidance of the promotor.

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Autism Spectrum Disorder Specific Imitation Profiles in Preschoolers Without Intellectual Disabilities

Abstract

Background

Imitation is the ability of an individual to reproduce an observed action whereby the own motor patterns are related to observed motor patterns. Regarding the importance of imitation to social communicative abilities it is important to determine imitation abilities in children with an Autism Spectrum Disorder (ASD). Furthermore, the imitation profile of children with ASD may provide insight in how to encompass imitation training in interventions.

Objectives

The goal of the present study was to determine imitation abilities and the imitation profile of preschool children with ASD. In addition, it attempts to examine the association between imitation abilities and – profile and developmental level and autism symptom severity respectively.

Participants

In the present study, 54 preschoolers with ASD between 1.9 and 4.5 years (an IQ above 70) and 54 age- and gender matched typically developing (TD) children were involved.

Measurement

In order to determine procedural and bodily imitation abilities, a standardized developmental imitation test, the Preschool Imitation and Praxis Scale (PIPS), was used. Next, the 30 PIPS items were reorganized in different subscales to determine the children's imitation profile.

Results

Based on the age equivalents of the PIPS, procedural and bodily imitation abilities of children with ASD were statistically significant below their chronological age.

Between group analyses revealed that children with ASD scored significantly poorer than TD on both procedural and bodily imitation scales, as well as on all subscales with exception of sequential actions. Within group analyses revealed that in both samples procedural imitation

was better than bodily imitation. In addition, imitation of meaningful, goal-directed actions was better than these of non-meaningful non-goal directed actions. In children with ASD, but not in TD, actions with visual feedback were significant better imitated than opaque ones. In TD, but not in ASD, single actions were better imitated than sequential ones.

Conclusion

Overall, children with ASD have poorer imitation abilities compared to TD children. The ASD-specific imitation profile is characterized by difficulties to imitate opaque actions, which mainly rely on internal action models and proprioceptive monitoring.

Introduction

Imitation is the ability of an individual to reproduce an observed action whereby the own motor patterns are related to observed motor patterns. Relating one's own motor patterns with the observed motor patterns is possible if the child has a repertoire of movements available where they can resort on (Nadel, 2015). True imitation is a more defined definition that describes imitation as a novel action whereby the means (action plan) and ends (result) are executed. The child copies the means of the other to achieve a goal. (Byrne & Russon, 1998; Tomasello, Carpenter, Call, Behne, & Moll, 2005). The term imitation will be used from here on. Newborns can imitate facial expressions such as tongue protrusions, eye blinking or opening of the mouth. The imitation repertoire extends the more it is used (Nadel, 2015). Typically developing children relate their own motor patterns to those of others. Imitation concerns a social environment in which the observed actions are reproduced (Nadel, 2015; Srinivasan et al., 2015). Imitation plays a major role in shaping the motor, language and social development of the child (Nadel, 2015).

There are multiple taxonomies that are used to define the variable forms of imitation (Byrne & Russon, 1998; Want and Harris, 2002). Imitation tasks are generally subdivided by the presence or absence of an object or tool (Sevlever & Gillis, 2010). That way, imitation can be distinguished between procedural and bodily imitation (Sevlever & Gillis, 2010; Vanvuchelen, Roeyers & De Weerdt, 2011). Procedural imitation tasks consist of actions upon objects. Actions with tools or objects can also be named transitive actions (Carmo & Rumiati, 2009). Bodily imitation tasks can be either orofacial or gestural (Vanvuchelen, Roeyers & De Weerdt, 2011). When gestures are performed with imaginary tools or objects, they are named transitive gestures. Intransitive gestures are the gestures without an imaginary tool or object (Vanvuchelen, 2009). Imitation tasks can also be distinguished by the representational level, the visual monitoring possibilities and temporal complexities (Vanvuchelen, Roeyers & De Weerdt, 2011). The representational level consists of imitation tasks whereby the observer imitates meaningful or non-meaningful tasks and goal directed or non- goal directed tasks (Vanvuchelen, 2009; Vanvuchelen, Roeyers & De Weerdt, 2011). To imitate a meaningful or goal directed task the observer is assumed to understand the meaning of the action and also needs to have a previous knowledge about the result of the observed action (Vanvuchelen, Roeyers & De Weerdt, 2011). The non-meaningful and non-goal directed imitation tasks are unknown and novel to the child (Vanvuchelen, Roeyers & De Weerdt, 2011). Dependent on the visibility of the imitator's hand, imitation tasks are opaque or transparent (Vanvuchelen, Roeyers & De Weerdt, 2011). In opaque imitation tasks (e.g. facial gestures: nodding yes or no), the observer cannot see his own body part moving (Ray & Heyes, 2011). The observer will need to use the kinesthetic system to feel the movement because they cannot use the sensory (visual) information system (Ray & Heyes, 2011). However, when executing transparent tasks the observer can rely on the sensory and visual system to compare his motor output of the movement with the observed movement (Ray & Heyes, 2011). The last subdivision that can be made in imitation tasks is based on the temporal complexities (Vanvuchelen, Roeyers & De Weerdt, 2011). The tasks can be differentiated as the performance of one task (single) or as the performance of a sequence of actions (sequential). The single tasks can be either non-repetitive or repetitive. Thereby means non-repetitive that the same action is executed just once and repetitive means that the same action is executed a number of times.

Imitation has been well studied over the past years in various populations, including individuals with an autism spectrum disorder (ASD). ASD is a neurodevelopmental disorder with two core dimensions that manifest themselves through deficits in social-communication and repetitive behaviors (American Psychiatric Association DSM-V, 2013; National Collaborating Centre for Mental Health, 2012). It is suggested that the prevalence of ASD is 1% of the population (National Collaborating Centre for Mental Health, 2012). The onset of the disorder is before the age of three, but depending on the severity and demands of the environment the symptoms are more or less obvious, which sometimes makes it more difficult to diagnose the disorder in early childhood (National Collaborating Centre for Mental Health, 2012). The imitative abilities of children with ASD have been long studied, giving that these children have social and communicative deficits and the importance of imitation for social and communicative functions (see for a comprehensive review and meta-analysis Edwards, 2014). The meta-analysis of Edwards (2014) confirms that individuals with ASD have impairments in their overall imitation abilities compared to typically developing children or developmentally delayed non-autistic children. A systematic review of Williams, Whiten and Singh (2004) similarly reported imitation difficulties in children with ASD. Hereby are gestures more difficult to imitate than actions on objects (Williams et al., 2004).

Furthermore, results of Rogers, Bennetto, McEvoy and Pennington ‘s (1996) study indicate that children with ASD show more difficulties with performing non-meaningful, non-goal directed imitation tasks than meaningful, goal directed tasks. According to Piaget (1962) cited in Ray & Heyes (2011) the imitation of visible or transparent actions occurs sooner than invisible or opaque actions. These opaque actions are assumed to be intrinsically more difficult meaning that it is harder for the internal mechanism to figure out a motor command that produces the same output that matches the observed action. Additionally, results of Rogers et al. (1996) showed that children with ASD have more difficulties with sequential imitation tasks than single tasks. Finally, the meta-analysis of Edwards (2014) shows that the autism symptom severity (average ADOS score) is negative, significantly associated with the imitation performance of children with ASD compared to children without ASD (typically developing and or developmentally delayed non-autistic children). The association means that children with a more severe ASD diagnosis perform significantly poorer on imitation tasks compared to children without ASD.

The first aim of the present study is to determine imitation abilities of preschoolers with ASD by comparing their imitation performances to that of a normative sample on one hand and to age-and gender matched typically developing peers on the other hand. For this purpose the preschool Imitation and Praxis Scale (PIPS), which is a standardized and normed-referenced imitation test, was used. The PIPS is a reliable and valid multidimensional instrument to measure the accuracy of imitation performance of preschool children (Vanvuchelen, Roeyers & De Weerdt, 2011). Imitation age-equivalents are derived from PIPS scores of a normative sample of 654 typically developing children between 12 and 59 months of age (Vanvuchelen, 2015). The second aim is to determine the imitation profile of children with ASD compared to typically developing children. Converted subscale scores from imitation tasks of the PIPS (i.e. bodily versus procedural-, non-meaningful, non-goal directed versus meaningful, goal directed -, opaque versus transparent -, single non-repetitive versus single repetitive versus sequential imitation tasks) will be used to examine the children’s imitation profile. The third aim of the present study was to investigate the association between imitation performance, children’s developmental level and ASD symptom severity.

The following research questions will be addressed. First, do children with ASD imitate according to their chronological age? Second, do children with ASD have a similar of different imitation profile compared to age and gender matched typically developing children? Third, what is the association between imitation abilities and developmental level and ASD symptom severity? Hereby, we hypothesized that children with ASD will perform worse on all imitation tasks than the normative sample and by consequence that there imitation age will be below their chronological age. Next, we hypothesized that children with ASD will have another imitation profile than TD children. Based on the results of Rogers et al. (2006) and Piaget (1962) cited in Ray & Heyes (2011), we expected that children with ASD, in contrast to TD children, will have more difficulties in performing non-meaningful, non-goal directed and opaque imitation tasks than meaningful, goal directed and transparent imitation tasks respectively. Also, the performance of sequential and single- repetitive imitation tasks will be more difficult than single non-repetitive imitation tasks. Finally following the meta-analysis of Edwards (2014), we expect a positive significant association between imitation scores and developmental level and a negative significant association between imitation scores and autism symptom severity.

Methods

Participants

The present study is based on data of a previous study (Vanvuchelen, Roeyers, & De Weerdt, 2011) in which 54 preschoolers (13 female, 41 male) with an autism spectrum disorder (ASD) and an IQ above 70 were involved. The participants had no visual or hearing impairments. Their chronological age (CA) ranged between 1.9 and 4.5 years with a mean CA of 40.6 months, SD 8.1 months. The diagnosis of ASD was based on a multidisciplinary clinical consensus classification. Their IQ scores ranged between 71 and 145 (X= 99.1, SD 17.2). Eleven participants had borderline mental abilities, 35 had average mental abilities, 6 participants had above average mental abilities and the remaining 2 participants were gifted. The age and sex matched control group of 54 typically developing children TD (13 female and 41 male) were selected from the normative sample database of the Preschool Imitation and Praxis Scale (PIPS) (Vanvuchelen, 2015). The CA of TD ranged between 1.9 and 4.5 years with a mean CA of 40.7 months, SD 8.1 months. Both groups were not different in their mean chronological age (*U*=1453.5; *p*=0.97).

This study was approved by the ethics committees of the University Hospitals Louvain, Antwerp, Brussels and Ghent (Flanders, Belgium) before the data collection. All families gave their written consent for the participation of their child.

Measures

Multidisciplinary clinical consensus diagnosis

The children were observed in different contexts according to DSM-IV-TR diagnostic criteria for autism by a team consisting of child psychiatrists, pediatricians, psychologists, speech therapists, physical therapists in four by the Belgian Government certified University Autism Clinics (American Psychiatric Association, 2000). Detailed information on developmental history, and everyday behaviour and activities of the child were provided by parents and caregivers. When a case was considered difficult to assess, clinical consensus classification was reached through reviewing and discussing the available information and observation reports (Vanvuchelen et al., 2011).

Measurement of mental development in children with ASD

Only children with ASD (n= 54) were assessed with a mental scale. Since children with ASD may have language difficulties, nonverbal measures were used to assess the children's mental level. Standardized tests appropriate to the child's age were used: 14 participants were measured with the Dutch modification of the nonverbal version of mental scale of the Bayley Scales of Infant Development (BSID-II-NL; Van der Meulen, Ruiter, Lutje Spelberg, & Smrkovský, 2000), 36 participants with the revised version of the Snijders-Oomen Nonverbal Intelligence Test for Children (SON-R 2.5-7; Tellegen, Winkel, Wijnberg-Williams, & Laros, 1998) and 4 participants with the Wechsler Preschool and Primary Scale of Intelligence- III-NL *(*WPPSI- III-NL; Hendriksen & P. Hurks, 2009*)*. The mean time between imitation and mental assessment was 0.88 month (SD 1.55 month). The mental age at the day of the imitation test was calculated as follows: chronological age (day of imitation test) multiplied by the IQ and divided by 100 (CA x IQ/ 100).

Bayley Scales of Infant Development –II- Nederlandse versie (BSID-II-NL; Van der Meulen, Ruiter, Lutje Spelberg & Smrkovský, 2000) is the Dutch modification of the nonverbal version of the mental scale of the Bayley Scales of Infant Development (Van der Meulen, Ruiter, Lutje Spelberg & Smrkovský, 2000). It provides the examiners with information about the mental and motor developmental level of children of 1 to 42 months of age (Van der Meulen et al., 2000). The present study used the total developmental index of the mental subscale of the BSID-II-NL.

Snijders-Oomen Nonverbal Intelligence Test for Children, Revised (SON-R 2.5-7; Tellegen et al. 1998) is a nonverbal intelligence standardized test that measures the general intelligence of children between the ages of 2.5 to 7 years (Snijders, Tellegen, & Laros, 1989). The test consists of a reasoning and performance subtest. In the reasoning subtest the child needs to choose the correct answer from different alternative answers and in the performance subtest the child needs to manipulate certain stimuli (Snijders et al., 1989). The IQ of the SON-R test has a mean of 100, a standard deviation of 15.

Wechsler Preschool and Primary Scale of Intelligence- III-NL (WPPSI- III-NL; Hendriksen & P. Hurks, 2009) is an instrument that provides an impression about the overall cognitive abilities (full IQ) and performance and verbal IQ separately of children between 2 years 6 months to 7 years 3 months of age (Hendriksen, & Hurks, 2009). In the present study the performance IQ of the WPPSI-III-NL was used to assess the children's nonverbal intelligence.

Measurement of imitation ability

Preschool and Imitation Praxis Scale (PIPS; Vanvuchelen 2015) is a standardized imitation test which examines imitation abilities of children between 12 and 59 months of age. The test consists of 30 imitation tasks: 9 procedural and 21 bodily imitation tasks. Overall, the PIPS measures the ability of the child to imitate actions with objects (i.e. procedural imitation) and without objects (i.e. bodily imitation). The imitation tasks are chosen so that spontaneous actions are unlikely to take place. The tasks consist of different action types: actions with different effects (i.e. actions on objects with salient environmental effects versus actions without object with internal effects), actions with different representational levels (i.e. goal directed, meaningful versus non- goal directed, non-meaningful), actions with different temporal complexities (i.e. single versus sequential) and actions with different visual monitoring possibilities (i.e. transparent versus opaque) are different aspects of this test. Imitation performances are immediately scored on a 3 or 5 point scale in accordance with the criteria of the scoring system of the PIPS, which evaluated the spatiotemporal resemblance between the modelled and copied action. The final PIPS score is a reflection on the accuracy of the child's imitation performance. Total imitation, bodily and procedural imitation age-equivalents were derived from PIPS scores of a normative sample of 654 typically developing children between 12 and 59 months of age (Vanvuchelen, 2015)

In the present study the 30 items of the PIPS were reorganized as follows: actions with different representational levels (i.e. 15 meaningful, goal directed versus 15 non-meaningful, non- goal directed), actions with different visual monitoring possibilities (i.e. 8 opaque versus 22 transparent) and actions with different temporal complexities (i.e. 14 single non-repetitive versus 7 singe repetitive versus 9 sequential). The sumscores on these items were calculated and converted to 100. These converted sumscores were used to analyze the participants' imitation profile.

Measurement of autism symptom severity

Autism Diagnostic Observation Schedule- Generic (ADOS-G, Lord et al., 2000) is a semi-structured autism diagnostic observation which can be used for research and clinical diagnostic purposes as well (Gotham, Risi, Pickles & Lord, 2007). The ADOS gives an estimation of the severity of autism by testing for symptoms of ASD in communication, social interaction, play behaviour and repetitive behaviour and interests (Gotham et al., 2007). Dependent on the participants language abilities, which can range from no expressive language to verbally fluent, the examiner chooses one of the four available test modules (Gotham, Pickles & Lord, 2009). The items are scored on a 4-point scale. The higher the total score of the ADOS, the greater the severity of the impairment (Gotham et al., 2009). The participants in the present study were examined by trained investigators: 22 participants received module 1 (minimal or no language) and 32 participants received module 2 (non-echoed phrase speech).

Data-analysis

Since the data were not normally distributed according to the Shapiro-Wilk test of normality, a non-parametric test was used.

Between group analysis: the Mann-Whitney U test was used to check differences between both groups under investigation. Correction for multiple comparisons was done with Bonferroni-test: p-values below .02 were considered as significant.

Within group analysis: the Wilcoxon Signed Ranks Test (Z) and Friedman test (χ^2) were used to check differences in two and three related samples respectively. To circumvent the risk of a type I error due to an increased number of tests, the Bonferroni correction test was used as a post-hoc analysis with the Friedman Test (χ^2). In this post-hoc analysis, the new significance value (p=0.02) was calculated manually by dividing the significance value of 0.05 by the number of executed statistical tests. To examine where the differences actually occurred, a Wilcoxon Signed Ranks test was conducted whereby the Bonferroni correction was used on the results.

Spearman rank correlation coefficient (r_S) was used to measure the strength of association between imitation ages (total, bodily and procedural imitation) and converted sumscores on one hand and developmental level (CA and MA) and autism symptom severity (ADOS score) on the other hand. The r_s values range between minus 1 (i.e. perfect negative correlation) and plus 1 (i.e. perfect positive correlation). The interpretation of r_s – values was done according to Mukaka (Mukaka, 2012): .90 to 1.00 (−.90 to −1.00) a very high, .70 to .90 (−.70 to −.90) a high, .50 to .70 (−.50 to −.70) a moderate, .30 to .50 (−.30 to −.50) a low and .00 to .30 (.00 to −.30) a negligible correlation.
All statistical analyses have been performed using the statistical software SPSS version 22.0.

Results

Imitation abilities of participants with ASD (n= 54) and TD (n= 54) according to the age equivalents of normative sample (Table 1)

Overall, children with ASD had statistically significant poorer imitation abilities (i.e. total, bodily and procedural imitation ages) compared to TD children (see table 1 for Mann-Whitney U tests).

In the ASD sample, total, bodily and procedural imitation ages were statistically significant below their CA (see table 1 for Wilcoxon signed rank test). The same was true when compared to MA (data not reported). Within group analysis revealed that in children with ASD imitation of procedural tasks was statistically significant better than bodily imitation tasks (*Z*= -6.19, *p*<0.001).

In the TD sample, total and bodily imitation ages were according to their CA. Their procedural imitation age was statistically significant above their CA (see table 1 for Wilcoxon signed rank tests). Within group analysis revealed that TD performed statistically significant better on procedural imitation tasks compared to bodily imitation tasks (*Z*= -6.11, *p*<0.001).

Table 1: Imitation ages (total, bodily and procedural) and chronological ages in ASD (n= 54) and TD (n= 54)

	ASD Mean (SD)	TD Mean (SD)	*U*	*p*
Total I., age	33.3 (SD 10.5)	40.8 (SD 8.5)	829.5	<.001
CA	40.7 (SD 8.2)	40.7 (SD 8.1)	842.0	<.001
	Z= -5.53, p= 0.000	Z= -0.27, p= 0.788		
Bodily I., age	32.5 (SD 12.0)	40.6 (SD 9.5)	895.0	.001
CA	40.7 (SD 8.2)	40.7 (SD 8.1)	898.5	.001
	Z= -5.38, p= 0.000	Z= -0.34, p= 0.732		
Procedural I., Age	36.0 (SD 12.0)	43.4 (SD 11.4)	951.0	.002
CA	40.7 (SD 8.2)	40.7 (SD 8.1)	951.0	.002
	Z= -3.18, p= 0.001	Z= -2.06, p= 0.04		

SD= standard deviation; U= Mann-Whitney U test; p= significance level set up 0.017 after Bonferroni correction; Z= Wilcoxon signed rank test; total i., age= total imitation age-equivalent; bodily i., age= bodily imitation age equivalent; procedural i., age= procedural imitation age-equivalent; CA= Chronological age; note that the significance level was set on p=0.02

Imitation profile of participants with ASD (n= 54) compared to TD (n= 54) (Table 2)

Children with ASD had statistically significant lower converted sumscores of bodily and procedural imitation tasks than TD children. Converted sumscores of meaningful, goal directed and non-meaningful, non-goal directed imitation tasks as well as on opaque and transparent imitation tasks of children with ASD were statistically significant below these of TD children. Regarding the temporal complexities, ASD children performed statistically significant poorer on single non-repetitive as well as single repetitive imitation tasks. The difference on the sequential imitation tasks were nearly significant different between the ASD- and TD sample (see table 2 for Mann- Whitney U tests).

Children with ASD as well as TD children performed statistically significant better on procedural imitation tasks compared to bodily imitation tasks. In both samples (ASD and TD), converted subscale scores of meaningful, goal directed items were statistically significant higher than these of non-meaningful, non-goal directed items.

In the ASD sample, but not in the TD sample, converted subscale scores on the transparent items were significant higher than these on the opaque items (see Table 1 for Wilcoxon signed rank scores).

In the ASD sample, in contrast to the TD sample, converted subscale scores of single repetitive, single non-repetitive and sequential imitation items were not statistically different (see Table 1 for Friedman test).

Sub analyses in the TD group revealed that there was a statistically significant difference between the sequential and single non-repetitive imitation converted subscale scores (Z= -2.36, p= 0.02). There was a nearly significant difference between sequential and single-repetitive imitation items (Z= -2.17, p= 0.03; note the Bonferroni correction). In the TD group there was no statistically significant difference between the single- non repetitive and single repetitive imitation items.

Table 2: Converted PIPS subscale scores (max. 100) in ASD (n= 54) and TD (n= 54)

		ASD	TD	*U*	*p*
Object effects	Bodily (mean, SD)	42.9 (24.9)	58.5 (16.5)	898.5	.001
	Procedural (mean, SD)	70.2 (21.2)	82.1 (12.0)	951.0	.002
		Z= -6.19, p= 0.000	Z= -6.11, p= 0.000		
Representational levels	MF, G (mean, SD)	58.5 (24.2)	74.5 (14.8)	875.5	<.001
	NMG, NG (mean, SD)	43.1 (22.7)	56.7 (15.8)	911.0	.001
		Z=-5.51, p= 0.000	Z= - 5.86, p= 0.000		
Visual monitoring possibilities	OP (mean, SD)	43.1 (28.3)	63.6 (19.1)	840.0	<.001
	TR (mean, SD)	52.7 (21.0)	65.0 (13.3)	910.5	.001
		Z= -3.95, p= 0.000	Z= -0.63, p= 0.53		
Temporal complexities	S-NR (mean, SD)	49.0 (22.9)	66.0 (16.3)	777.0	<.001
	S-R (mean, SD)	48.4 (29.6)	66.4 (20.5)	938.0	.001
	SQ (mean, SD)	52.7 (21.7)	60.9 (14.3)	1143.0	.052
		χ^2 (2)= 1.81, p= 0.404	χ^2 (2) = 11.7, p=0.003		

U= Mann-Whitney U test; p= significance level, after Bonferroni correction the significance level was set up 0.001; Z= Wilcoxon signed rank test; χ^2 (df) = Friedman test (degrees of freedom); MF,G= meaningful, goal directed; NMF,G= non- meaningful, non- goal directed; OP= opaque; TR= transparent; S-NR= single non-repetitive; S-R= single repetitive; SQ= sequential; note that the significance level was set on p=0.02

Correlation between the imitation ages (total, bodily and procedural imitation) and developmental level (CA and MA) as well as autism symptom severity (ADOS score) in children with ASD (n=54) (Table 3)

In children with ASD (n= 54), there was a positive, significant moderate to high association between the age-equivalent imitation scores and the developmental levels (CA and MA). There was no meaningful association between imitation ages and autism symptom severity (see table 3 for the correlation matrix).

Table 3: Correlation matrix (Spearman's rho) of imitation ages (total, bodily and procedural) and chronological age (CA), mental age (MA) and autism symptom severity (ADOS score) in children with ASD (n= 54)

	Total I., age	Bodily I., age	Procedural I., age	CA	MA	ADOS score
Total I., age	_					
Bodily I., age	0.97**	_				
Procedural I., age	0.69**	0.54**	_			
CA	0.68**	0.67**	0.52**	_		
MA	0.63**	0.60**	0.60**	0.79**	_	
ADOS score	0.07	0.06	-0.02	0.10	-0.03	_

***. Correlation is significant at the 0.01 level (2-tailed)*

Correlation between the converted subscale score of the PIPS and developmental level (CA and MA) as well as autism symptom severity (ADOS score) in children with ASD (n=54) (Table 4).

The correlation matrix presented in table 4 indicated moderate to strong positive significant associations between the converted subscale scores of the PIPS and the developmental levels (CA and MA). There was no meaningful association between these scores and with autism symptom severity.

Table 4: Correlation matrix (Spearman's rho) of converted subscale scores (meaningful-goal directed, non- meaningful-non goal directed, opaque, transparent, single non-repetitive, single repetitive and sequential) and chronological age (CA), mental age (MA) and autism symptom severity (ADOS score) in children with ASD (n= 54)

	MF,G	NMF-NG	OP	TR	S-NR	S-R	SQ	CA	MA	ADOS score
MF,G	_									
NMF-NG	0.71**	_								
OP	0.89**	0.80**	_							
TR	0.81**	0.97**	0.80**	_						
S-NR	0.74**	0.94**	0.80**	0.93**	_					
S-R	0.95**	0.68**	0.87**	0.76**	0.70**	_				
SQ	0.68**	0.87**	0.71**	0.87**	0.71**	0.58**	_			
CA	0.63**	0.69**	0.69**	0.68**	0.67**	0.63**	0.57**	_		
MA	0.55**	0.66**	0.67**	0.63**	0.59**	0.53**	0.52**	0.79**	_	
ADOS score	0.13	0.02	0.04	0.06	-0.01	0.10	0.04	0.10	-0.03	_

***. Correlation is significant at the 0.01 level (2-tailed)*

Discussion

This study is the first to examine imitation abilities and the imitation profile of young children with an autism spectrum disorder (ASD) compared to a normative sample of children between 12 and 59 months of age and age- and gender matched typically developing (TD) children respectively. Also, this study makes use of normed values of the imitation ability using a standardized and normed test (PIPS) to evaluate the imitation profile in depth. The expectation that children with ASD score below their chronological age was confirmed by our results, whereby children with ASD performed below their chronological age for the total imitation, the procedural and bodily imitation tasks. Typically developing children performed according to their chronological age for the total and bodily imitation tasks. Further, they performed above their chronological age for the procedural imitation tasks. According to Rogers (1999) (cited in Williams, Whiten and Singh, 2004) there is strong evidence that supports the presence of an imitative impairment in children with ASD, but there was a lack of sufficient data to be concerning the affected components of imitation. This study supports our findings that children with ASD have statistically significant poorer imitation abilities compared to TD children.

The second objective of the present study was to provide an imitation profile of children with autism compared to typically developing children. The imitation tasks were divided in object effects, representational levels, visual monitoring possibilities and temporal complexities of imitation tasks. With regard to the object effects, children with ASD had statistically significant poorer performances than TD children on bodily and procedural imitation tasks. However, according to the review of Edwards (2014) there was no statistically significant effect observed of the domain of imitation tasks to be imitated of individuals with ASD compared to children without ASD. In the study of Edwards (2014) the domain of tasks implies oral-facial, body and object-oriented tasks. This inconsistency between our results and the meta-analysis of Edwards (2014) can be due to a broad variability in methodologies, different imitation tasks used and the different definitions of imitation (Sevlever & Gillis, 2010).

Regarding the representational levels, children with ASD perform statistically significant higher on meaningful, goal directed imitation tasks than on the non-meaningful, non-goal directed tasks. This was also the case in TD children. A possible explanation could be that they have used different mechanisms to imitate. According to the dual-route theory of imitation children could have used a direct- or non- semantic route and an indirect or semantic route of imitation (Tessari, Canessa, Ukmar, & Rumiati, 2007; Rumiati, Carmo, & Corradi-Dell'Acqua, 2009). Imitation of non-meaningful or unfamiliar actions and non-goal directed actions upon objects may rely on the direct route which is used to transform the visuospatial characteristics of the observed actions directly into motor representations. The indirect route constitutes the imitation of meaningful or familiar bodily actions and goal directed actions upon objects (Rumiati & Tessari, 2002; Tessari et al., 2007; Rumiati et al., 2009). This route is based on the long-term memory that stores previously acquired actions and that allows the reproduction of these acquired actions (Rumiati & Tessari, 2002). However, the imitation of meaningful and goal-directed actions can theoretically also rely on the direct or non-semantic route if the child did not take into account the meaning or goal of the actions when imitating. This was suggested by the experiments of Rumiati and Tessari (2002) and Tessari and Rumiati (2004). It seems that the direct route works as a relief of switching costs in cases of reduced cognitive resources whereby the direct mechanism is more convenient (Tessari & Rumiati, 2004). Also, the results of Rogers, Bennetto, McEvoy, & Pennington's study (1996) suggested that children with ASD were aided rather than hindered in certain tasks by the symbolic content of these tasks. It is also plausible from our results that the symbolic content of the imitation tasks improved the imitation performance of the children with ASD, whereby these performed statistically significant better on meaningful imitation tasks.

In line with our expectations were the results on the visual monitoring possibilities whereby children with ASD, in contrast to TD children, performed better on transparent imitation tasks compared to opaque imitation tasks. The study of Ingersoll, Schreibman and Tran (2003) investigated the effect of sensory feedback on the imitation performances of children with autism. Participants needed to perform an imitation task with an object, by which 6 novel objects were used (with and without sensory effects). Results of this study suggested that children are more likely to imitate tasks with sensory effects relative to tasks without sensory effects. However, a study of Haswell, Izawa, Dowell, Mostofsky, and Shadmehr (2009) found that when children with ASD learn a novel action pattern, they seem to extensively depend on proprioceptive feedback from their own bodies. Here, children with ASD learned to control an unfamiliar novel tool. According to a study of Izawa, Pekny, Marko, Haswell, Shadmehr and Mostofsky (2012), it is plausible that this overreliance on proprioceptive feedback not only contributes to a deficit in motor skill development, but also to the core features (social and communicative) that characterize ASD. In contrast to children with ASD, TD children, in our study, imitated transparent and opaque actions at a similar level.

Next, the results of the present study indicate that children with ASD imitated single non-repetitive, single repetitive and sequential tasks at a similar level. This study is the first that made a distinction in the single imitation tasks whereby the tasks were divided in single non-repetitive and single repetitive tasks. Our results were not confirmed by the review of Williams, Whiten and Singh (2004) whereby a larger impairment was found in the imitation of sequential meaningful gestures. Additionally, Rogers et al. (1996) postulated that in children with ASD sequential imitation tasks are more difficult to perform than single imitation tasks. However, the meta-analysis of Edwards (2014) supports our findings that there seems to be no significant difference in the extent of single or sequential imitation tasks.

The third objective of the present study was to examine the association between the imitation abilities and – profile and developmental level and autism symptom severity respectively. Our expectations were confirmed by our results that there would be a positive significant association between the imitation ability and imitation profile with the developmental levels (CA and MA). However, the results did not support our hypothesis that the symptom severity of autism would be negatively significant related with the imitation ability as well as the imitation profile. This in contrast with the meta-analysis of Edwards (2014), which found that the autism symptom severity (ADOS score) was significantly, strongly and negatively associated with the imitation performance compared to the individuals without ASD. The negative association means that participants with more severe ASD show greater imitation deficits compared to the individuals without ASD. However, the meta-analysis refers to the fact that the result is based only on the small number of studies that included enough information to test the association between imitation and autism symptom severity. A possible explanation of the lack of meaningful association of imitation performances and ASD symptom severity in our study could be the use of measures on individual level, whereas the review of Edwards (2004) used average group measures.

As with all research, results of the present study must be considered within the limitations of its design and sample. The strengths of the present study include the use of a normative sample to compare the imitation abilities of children with ASD. Furthermore, a standardized and normed test, Preschool Imitation and Praxis Scale (PIPS), was used to measure the imitation abilities of the participants. The accuracy of imitation performance was measured with controlling for age. A limitation of the present study is the use of elicited imitation tasks. Hence, results cannot be generalized to spontaneous imitation. Another remark is that the demographic characteristics of the participants are not equal with respect to sex. In the

ASD sample were more male than female participants. Likewise, in the TD sample were more male than female participants. This could possibly yield a sampling bias. Male participants were more represented in our study than female participants. It could be that ASD is presented differently in boys and girls, which makes it possible that there is a difference in the expression of imitation. According to a study of Hiller, Young and Weber (2014) the ability to integrate social gestures and the engagement in conversations (e.g. nonverbal and verbal) were better preserved in female than male participants with ASD.

Since this is the first study to examine the imitation profile of children with ASD, the results need to be interpreted with caution. There is a need for further research concerning this topic. Further research, can investigate the imitation profile of children with ASD in both spontaneous and elicited imitation conditions. Additionally, further research is needed with an increased sample size. Researchers could also examine the association between gender and the imitation profile. Lastly, since a study of Fouts, and Liikanen, (1975) showed that children that differ in age and developmental level show different tendencies to imitate, it could be of interest to investigate the effect of development on the imitation profile in a follow-up study.

In summary, although a lot of research has been done concerning imitative abilities of children with ASD, the extent of impairments is still unclear. Overall, children with ASD without intellectual impairment have poorer imitation abilities compared to TD. Moreover they have a different imitation profile than TD. The ASD-specific imitation profile is characterized by difficulties to imitate opaque actions, which mainly rely on internal action models and proprioceptive monitoring.

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