The Impairment of Symbolic Semantic Functions in Autistic Adolescents

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Abstract

In autism, motor impairments are extremely common and often herald the emergence of ubiquitous atypical development. Few studies so far have explored the autistic motor difficulties. Our work aims to investigate the level motor management of adolescents with autism spectrum disorder, compared to typically developing children. The motor management was realized, in different imitative conditions. We assume that pragmatic sensorimotor management would be functional both in adolescent with autistic spectrum disorder and typical children. However, if high-level cognitive semantic management is gradually acquired in the typical children, it would be deficient in the adolescents with autism spectrum disorder. Our results confirm and justify the selective impairment of symbolic semantic functions of the motor achievements of atypical with autism spectrum disorder.

Keywords: autism, imitation executive functions, pragmatic management, semantic management

1. Introduction

There is a growing body of literature documenting abnormalities and difficulties in different and distinguished imitative behaviors in autism spectrum disorder, claming a global imitation impairment (Tanguy, 1984; Humphrey, Riddoch, & Quilan,1988; 0rnitz, 1986; Frith, 1992; Nadel & Better worth, 1999; William, Whiten,& Sing, 2004; Frith, 2007; Robel, 2009; Frith, 2010; Frith, 2001; Hochmann, 2012; Vivanti & Hamilton, 2014; Louks, Mutschler, & Meltzoff, 2017; Xavier, Gauthier, Cohen, Zhou, & Chetouani, 2018; De Gaulmyn, Miljkovitch, & Montreuil,2018; Edmunds, Kover, & Stone, 2019). Researchs in this area have the potential to allow crucial insight into the mechanism and processes underlying learning difficulties as well as social-cognitive, communicative, and also motor-executive disturbances in the autistic population (Carpenter & Tomasello, 2000; Rogers & Williams, 2006).

Those abnormalities and difficulties point out, to varying degrees, that people with autistic spectrum disorder exhibits fragmented and disorganized perception, stereotypical behaviours, motor deficits, or unconventional social and cultural use of objects and the timely actions

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associated with them (Frith,1992; Rogers, 1996; Berthoz, 1997; Beaune, Réveillère, Delecroix, Carvalho, Nandrino, Pham, & Humez, 1999). One of the most important hypothesis concerning the autistic motor deficits, was proposed by Frith (1992) and shared by Edelman (1992), claming a dysfunction in the bonding between perception elements. They suggested an alteration of the symbolic holistic functions in assembling and integrating the elements of a perceptual picture that allows the construction of a coherent global whole.

People with autism spectrum have disorders with action inhibition (Beaune et al. 1999; Meu lemans, Fabienne, & Van der Linden, 2004; Dewulf, 2008) and more generally intention (Schmitz, Martineau, Barthélémy, & Assai ante, 2003; Trevarthen & Aitken, 2001; Trevar then & Delafield-Butt, 2013). According to Berthoz (1997), an autistic manifests *"a freeze"* on the initiation of actions. By *freeze*, it means that it is often able to act on it, but it does not decide to start. Thus, it is demonstrated their reduction in voluntary action and absence of initiative (Jarrold & Russell,1997). He or she manifests an inability to put local aspects in a central context. Instead of having a coherent perception of the surrounding world, he or she perceives it as a peripheral space, in a disaggregated and fragmented form (Frith, 1992, 1999, 2010). Peripheral coherence would allow for the treatment of stimuli from the environment, while central coherence would allow this information to be processed and analyzed at a high symbolic cognitive level (Poirier, 1998), such as mentalization (Fonagy, György, Elliot, & Mary, 2004).

Frith (1992) considered the centralized global coherence essential, not only to construct a perception of the body's own or its relationship with the environment, or to manipulate objects, but also and above all for developping a theory of mind. The theory of mind refers to the ability to attribute thoughts, mental states to others, to have an idea, a theory of what they have in their minds, their intentions and beliefs (Baron-Cohen, 1989; Hughes, 1997; Frith & Happé,1999; Charman, Baron-Cohen, Swettenham, Baird, Cox, et al,2000; Perra, Williams, Whiten, Fraser, Benzie, & Perrett,2008; Pellicano, 2010). This means that people with autism spectrum disorder do not have this natural capacity to consistently aggregate great quantity of information (Holroys, 1993; Schneider et al., 2019). While children with typical development learn spontaneously through their environment, play, language, or imitation, autistic people do not have this spontaneous ability to learn, due to their cognitive deficits (Frith et al., 1991; Gergey, Bekkering, & Király,2002; Girardot, De Martino, Rey, & Poinso, 2009), called *"executive planning functions"* (work memory, mental planning, attention), highly essential for the motor register (Frith, 1992; Hugues, 1997; Kiep & Spek, 2017).

Despite of the abundance of the different bodies of literature, the motor skills of children with autism spectrum disorder were really few documented and invested. Kanner (1943) was the first to report a muscle tone deficiency in autistic children. Damasio and Maurer (1978) wanted to understand the disturbance of movements, the expression of involuntary movements and a certain facial paralysis in the emotional expression's context. They attributed the motor abnormalities of autistic people, to underlying neurological dysfunction, particularly in the middle frontal and temporal lobes (Pernon, Pry, & Baghdadli, 2007; Mathersul, McDonald, &

Rushby, 2013; Leo, Carcagnì, Distante, Spagnolo, Mazzeo, et al., 2019). The frontal areas are classically considered a high integrative zone. The harmonious functioning of this area should ensure the integration of cognitive and emotional processes. All of these behaviors suggest a deficit in this area well-knowen to be involved in analysis, organization, planning and decision-making (Luria, 1973, 1978). Children with autism spectrum disorder have impaired performance in skill motor gestures (Green, Lingam, Mattocks, Riddoch, Ness, et al., 2011), motor coordination (Fournier, Hass, Naik, Lodha, & Cauraugh, 2010; Green et al., 2011) and muscle tone disorders (Ornitz, 1974; Rutter, 1978; Rutter & Rutter, 1993). They also exibit a failure in the postural adjustments and vestibular system (Ornitz, 1983) and ritualized conducts diverting the conventional use of objects, explained by the deficit of symbolic functions (Ricks & Wing, 1976). Finally, they have deficits in the process of sequentializing gestures and their scheduling (Prior & Bradshaw, 1979) and also in global imitation (William et al., 2004; Cook, Blakemore, & Press, 2013; Vivanti & Hamilton 2014; Parma, 2016; Lim, O'Sullivan, Choi, & Kim,2016).

In the two past decades, imitation is considered as an efficient way and effective method of learning, both in childhood and adulthood. It is the subject of many contrasting results, making this theoretical field an extremely complex picture (Meltzoff & Prinz, 2002; Meltzoff & Decety, 2003; Prinz, 2005; Meltzoff, 2005, 2007; Wang, Williamson, & Meltzoff,2015). Imitation is defined as a central mechanism of social, cognitive and emotional development (Bandura, 1969, 1977, 1986; Meltzoff & Moore, 1977; Nadel & Butterworth, 1999; Nadel, 2005; Lainé, Tardif, & Gepner,2008). Imitation is commonly defined as a correspondence between immediate or delayed represented perceptions and motor productions in acquiring or communication goals (Nadel & Decety, 2002; Labiadh, Ramanantsoa, & Golomer, 2010, 2012, 2013). Imitation is also recognized as a complex form of learning (Moore, 1996; Hommel, Müsseler, Aschersleben, & Prinz, 2001; Nadel, 2011). Imitating is simply *"doing like the other"* (Nadel, 2011). However, these definitions are very vague, opening the field to too many different forms of imitation that require different sensory and cognitive abilities. Some abilities are common to all imitation forms. This is the case of attention: one must look and observe to imitate (Bandura, 1986; Hein, van Schie Koelewijn, Jensen, & Bekkering, 2008). Other abilities, on the one hand, are needed in only certain forms of imitation. For example, the ability to plan is not indispensable, when imitation is reduced to reproducing an isolated singular action, such as lifting the lid of a box. On the other hand, this same ability is essential when imitating actions that combine a series of actions, such as taking a screwdriver in a box and unscrewing a door handle with this screwdriver (Labiadh et al., 2013). Overall, imitation involves different neural networks, depending on the nature of tasks (Bekkering, Wohlschläger, & Gattis, 2000; Rizzolatti, Fogassi, & Gallese, 2001; Carpenter, Call, & Tomasello, 2002; Wohlschleger, Gattis, & Bekkering, 2003; Decety, 2006; Csibra, 2008; Flynn & Whiten, 2008).

In imitation of a given task by the child, the cooperative functioning of neural networks depends, in part, on the characteristics of the task and involved neural circuits (Cestari, Lucidi, Pieroni, & Rossi-Arnaud, 2007). For example, motor action oriented towards a self-centered localized object can be assumed by a small number of sensory circuits circumscribed in limited brain areas

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(Edelman, 1992; Rossetti, 1996; Mengottia, Ripamontib, Pesaventoc, & Rumiati, 2015). However, the requirements of carrying out a task are rarely sufficient for pragmatic motor management (Jeannerod, 1994; Jeannerod & Jacob, 2005). The motor production would require, in addition to pragmatic management, a semantic management of recognition and understanding (Jeanne rod, 1994; Rossetti, 1996; Jeanne rod & Jacob, 2005). The pragmatic or sensory system would involve a small number of specialized areas (Pail lard, 1984, 1985). However, semantic or cognitive management, would involve for an extended period of time a substantial number of subsystems, dispersed over larger cortical areas (Rossetti & Reigner, 1995; Rizzolatti et al., 2001). Other authors report that pragmatic management participates to carry out an action, while semantic management is involved in verbalizations, conscious representations, requiring executive functions (Frith & Happé, 1999). Producing, for example, a combination of actions would require not only the realization of each of these actions, but also their planning and memorization (Jeannerod, 1994; Ramanantsoa, Labiadh, & Pavis, 1999; Frith, 2007).

The child's learning with autism spectrum disorder will be hampered by certain executive cognitive deficits, like the memory. The Memory is in fact, an indispensable cognitive function in the acquisition of knowledge (Gras-Vincendon, Bursztejn, & Danion, 2008). It is essential to any form of learning. Short term memory, working memory and long term memory are intact, except when they involve more complex tasks and hardware (in experiments). When verbal and spatial stimuli are complex, memory is disrupted (Renner, Klinger, & Klinger, 2000; Gras-Vincendon, et al., 2008; Xavier et al., 2018; Garcia-Molina & Clemente-Estevan, 2019). Two factors could be involved in the development of working memory; increasing the ability of attention quantity and the evolution of the skills of the attentional alternation mechanism (Massion, 2006; Camos & Barrouillet, 2013). However, it has been observed that this attentional mechanism is deficient in children with autism spectrum disorder (Hugues, 1997; Schmitz et al., 2003; Ten Eycke & Muller, 2018). It is clear that working memory is a decisive executive function in the learning process. Working memory can be involved in the child's learning and development, namely imitation (Girardot, De Martino, Rey, & Poinso, 2009).

Our current study focuses on the imitation of motor course composed of elementary motor actions and conventional daily gestures. As a child grows older, he or she gradually becomes able to perform motor actions demonstrated by a model. However, their execution within a coherent whole, would require other cognitive semantic processing than those only required by pragmatic sensorimotor production. We postulate that the motor behaviors mobilizing complex integrative treatment would be deficient in the adolescents with autism spectrum disorder. Their motor response will be disrupted, every time it requires semantic treatment for its exercise. To do this, we compared the imitative performance of the adolescents with autism spectrum disorder to that of typical children, depending on whether they imitate immediately (sensory memory), in time lag imitation (working memory) or in deferred imitation (long term memory). We agree that in an immediate imitation, the child will perform the elementary motor actions and conventional daily gestures, at the same time as the model. It is therefore possible that memory and executive functions, especially through planning faculties, may be less stressed. We also assume that in time lag imitation, there may be an involvement of working memory, as several items will have to be quickly recalled. We finally assume that in deferred imitation, there may be a long term involvement this time, as many items will have to be retained, as a result, from each other. We expect that the adolescents with autism spectrum disorder would be able to imitate in isolation elementary actions (walking, jumping, grabbing, tidying, wearing, posing, pointing): pragmatic management. However, the sequence and scheduling of these same actions and gestures would be in deficit: semantic management.

This idea of a dual exploitation of sensory information (Rossetti & koga 1997), distinguishing a level of sensory and cognitive processing (Pail lard, 1990) or pragmatic and semantic management (Jeanne rod, 1993), receives in the social cognition field, more and more validation of experimental and clinical data. The question we are addressing in our work, on how motor imitation is managed represents an important topic that broadens the debate on executive planning functions. It is based on previous works because few studies have tested a motion motor course, composed of successive transitive and intransitive motor actions, demonstrated by a living human model. Moreover, our work evaluated the impact of different imitation conditions in a specific age groups. In the Bekkering et al's (2000) study, data were collected from children over two years of age from the youngest to the oldest child. In the Wohlschleger et al' s (2003) study, the authors also examined children of an even wider age group, which is 3.8 to 6.1 years. In contrast, in our study, the age group of typical children is precisely defined between 4 and 6 years of age and exactly between 14 and 19 years in the adolescents with autism spectrum disorder. The ability to gather information, objects, events is globally disrupted in people with autism. At the behavioural level, this theme around a defect of holistic function is widely studied in the perceptual, cognitive and relational fields. But to our knowledge, it has not been tested in the executive-motor register.

2. Methods

2.1 Participants

Two experimental and control groups participated in this study. The experimental group was composed often adolescents with autism spectrum disorder, staying in an Educational Medical Institute. These children were male adolescents between the ages of 14 and 19, (three adolescent 14 years old, four adolescents 16 years old, one adolescent 17 years old, two adolescent 19 years old). The chronological and cognitive age of these adolescents are:

-A: chronological age 14 years and cognitive age 5 years.
-F: chronogical age 14 years and cognitive age 4 years.
-M: chronogical age 14 and cognitive age 4.6 years.
-N: chronogical age 16 years and cognitive age 1.6 years.
-D: chronogical age 16 years and cognitive age 2 years.
-H: chronogical age 16 years and cognitive age 2 years.
-W: chronological age 16 and cognitive age 10 years.
-T: chronological age 17 and cognitive age 6 years.
-E: chronological age 19 and cognitive age 5 years.

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-S: chronical age 19 years and cognitive age 3 years.

The control group was also composed of ten typical children. They were all male attended in a maternal school in Paris. They were aged between 4 and 6 years old (four children 4 years old, three children 5 years old, three children of 6 years).

Both groups participated on a voluntary basis and with the consent of their parents. The study was in accordance with the ethical standards of the local Ethics Committee and in accordance with the Declaration of Helsinki of 1975, as revised in 1983.

2.2 Materials

Coat racks: two 170 cm high coat doors, for atypical adolescent with autism spectrum disorder and two other 130 cm high coat doors, for atypical children.

Hoops: two hoops 60 cm in diameter. The first hoop placed at the beginning of the course was used to materialize the start of the walk. The second hoop served as a reception area after the jump.

Cases: two cases 40 cm long, 30 cm wide and 10 cm high. The distance between these cases was 40 cm. They were used to reproduce locomotion movements related to walking and jumping.

Table: it measured 75 cm on each side. It was used to store cutlery, plates and glasses that the participants would use to set the table.

Covered and glasses: two knives, two forks and two plastic glasses, so you can set the table. Chair: a classic chair.

2.3 Imitation conditions

A sequence of elementary motor actions and daily conventional gestures were reproduced by the two participant groups in a sports room:

Immediate Imitation (II): One by one, each participant of each group was positioned behind the adult model and immediately performed one trial after his demonstration. It was supposed that the participants mimicked the model behave or, answering on a sensory memory basis.

Time lag Imitation (TLI): just after finishing the immediate imitation (10-s delay), the adult model demanded to each participant of each group to reproduce alone the same motor course without his accompanying for one trial. It was supposed that the participants answered on a short term memory basis.

Deferred Imitation (DI): after one week to the two latter imitations, and during six following weeks, each participant of each group was instructed to reproduce alone after the adult model's demonstration (5-min delay) at the beginning of each session. Each week, the participants reproduced the same motor course in random order. It was supposed that they answered on a long term memory basis.

2.4 Task: motor course

The motor course consisted to: (i) take, put and close his coat attached to the coat rack (zip or with buttons) and put his shoes (lace or scratch them). (ii) Feet joined in hoop N°1, walk on both cases without stopping, (iii) chain by jumping into hoop N°2., (iv) open and remove his coat and hang it on the coat rack and then remove his shoes (unlacing or unclogging them). From this position, (v) fetch from a box a plate, a knife, a fork, a spoon and a glass that should be arranged on the table. The order in which they take and lay the utensils is not important. What is important is that the layout of the utensils is the right one and corresponds to the photo of the expected layout. Once the table is set, (vi) sit on the chair in front of his plate (Figure 1).

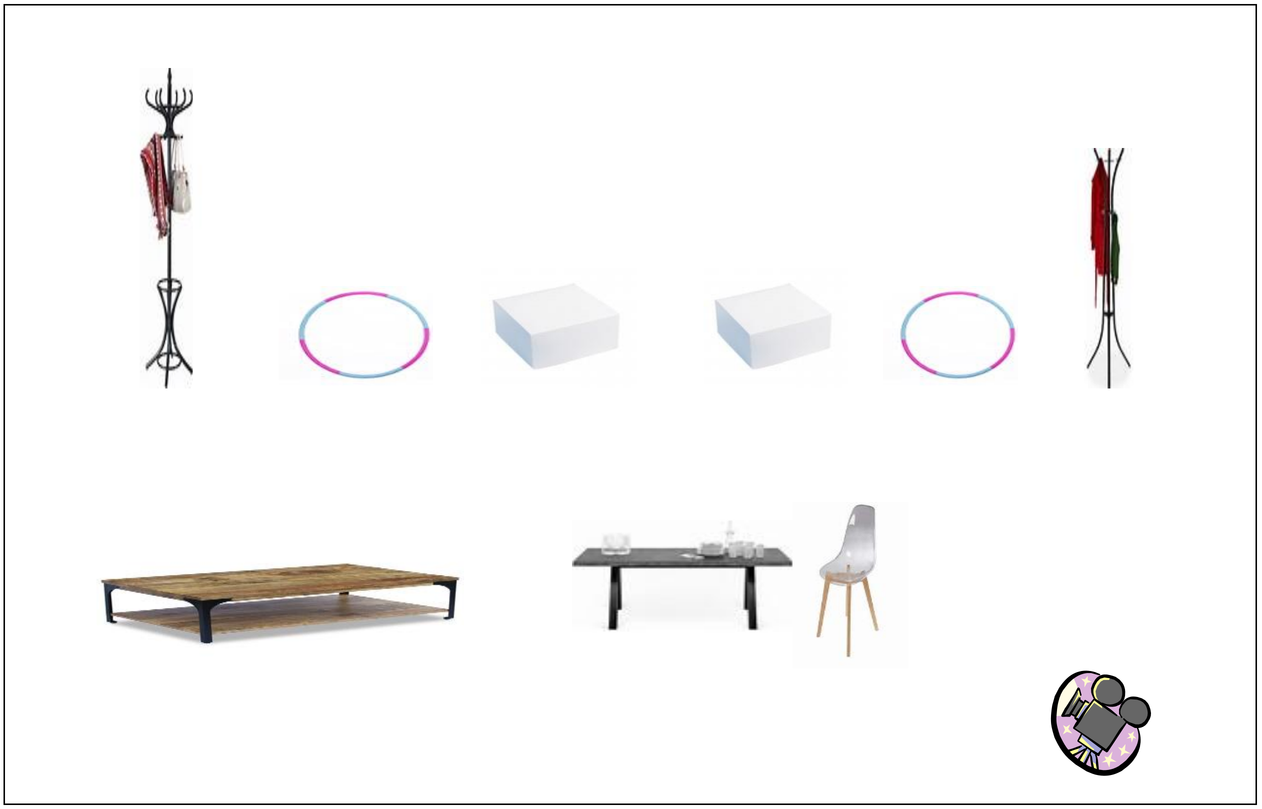

Figure1. The experimental disposition's scheme to carry out the elementary motor actions and conventional daily gestures

2.5 Procedure

The atypical and atypical participants imitations were filmed with an Apple phone, by a 24-year-old adult, who was following the participant and adult model reproductions at the same time. The latter went to pick up the children one by one, and escorted them in the same way, at the end of the realization. The child performed successively in (II, TLI). The instruction was always: *"look at me and do as I do"*. The handover of the children in (DI), during the sessions, was also individual and in a random order.

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2.6 Variables

The independent variables concern age: adolescents with autism spectrum disorder: 14 to 19 years, typical children: 4 to 6 years; imitation conditions: immediate imitation (II), time lag imitation (TLI), deferred imitation (DI). The dependent variables concern the management of motor actions: walking and jumping; conventional daily gestures: wearing-close-put on your coat, wearying-scratching shoes, setting the table, sitting down.

2.8 Scoring of the data and statistical analysis

The reproductions of motor actions and conventional daily gestures by adolescents with autism spectrum disorder and typical children were recorded in observation record card (Table 1). The performance was coded as **1**, for motor actions and conventional daily gestures, imitated regardless of the adult model fidelity, as **2**, for actions and gestures imitated with the adult model fidelity and as**0**, for forgotten actions and gestures. Statistical tests were applied with the ***R software***. The unpaired ***Student Test*** is used to compare two averages and find out if the progression is significant or not. The non-parametric ***Wilcox on Test*** compares averages of two independent or matched samples. This last test will determine whether two samples are significantly different. The linear regression test that seeks to establish a linear relationship between a variable, said to be explained, and one or more variables called explanatory.

Table1. Observation record card

Motor actions and daily gestures	**Imitated actions/gestures (1 / 2)**	**Forgotten actions/gestures (0)**
Pick up your coat from the coat rack		
Put on the coat		
Close the coat (button or zipper)		
Put the right shoes		
Put the left shoes		
Make the laces (or scratch) of the right shoes		
Make the laces (or scratch) of the left shoes		
Walking on the first case with your right foot		
Alternate and bring the left foot back to the second case		
Chain and take the pulse on the left foot from the second case		
Reception in hoop No. 2 on joined feet		
Detach your coat (button or zipper)		
Take off your coat		
Hang his coat on the coat rack		
Take a plate		
Take the cutlery (fork and knife) and place them on the plate		
Have a glass and put it on the plate		
Lift and carry the plate with both hands to the table		
Place the plate (with everything in it) on the table in front of the chair		
Install the fork to the left of the plate		
Install the knife to the right of the plate		

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3. Results

3.1 Imitative performance of atypical and typical participants over six sessions

The adolescents with autism spectrum disorder increased their performance in deferred imitation (DI), over the six sessions, by an average of 12.2 points compared to 20 points in typical children (Figure. 2). The *student test* for comparing the first and sixth session, did not show a significant learning effect in adolescents with autism spectrum disorder *(p = 0.149*). However, in typical children, the same test revealed a learning effect *(p = 0.006)*, demonstrating a significant progression and improvement over the sessions. The *Wilcox on test* revealed that: (i) in adolescents with autism spectrum disorder, S1-S6 are not significantly different *(p = 0.07)* (despite a significant effect trend), (ii) while in typical children, S1-S6 are, however, significantly different *(p = 0.02)*, (iii) the first session of each group of participants are significantly different (*p = 0.04*) as their last sixth session *(p = 0.02)*.

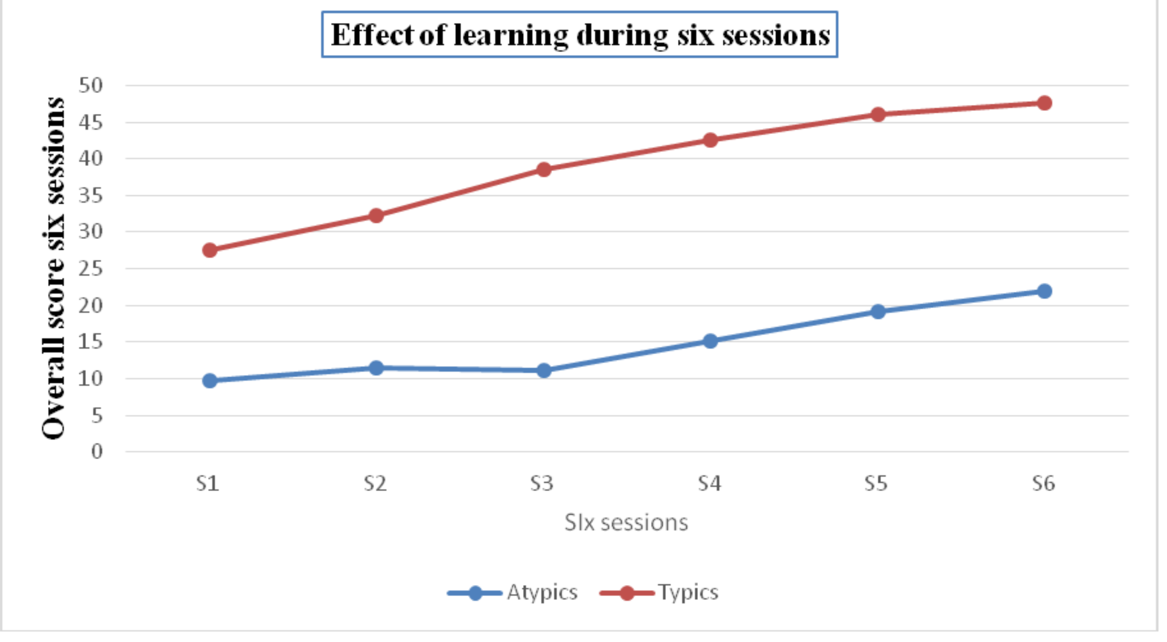

Figure 2. Effect of learning in adolescents with autism spectrum disorder compared to typical children

3.2 The performance of atypical and typical participants in II-TLI-DI imitations

For the adolescents with autism spectrum disorder, the *Wilcox on test* did not show a significant effect either between the (II) and (TLI) *(p = 0.2)*, (Figure 3), the (TLI) and (S1) conditions *(p = 0.8)*, nor between the (S1) and (II) conditions: *(p = 0.2)*. However, in typical children, this same test revealed a significant effect between the (II) and (TLI) conditions *(p = 0.01)*, (S1) and (II) *(p = 0.03)*, but with no significant effect between (TLI) and (S1) conditions *(p = 0.3)* (Figure 4).

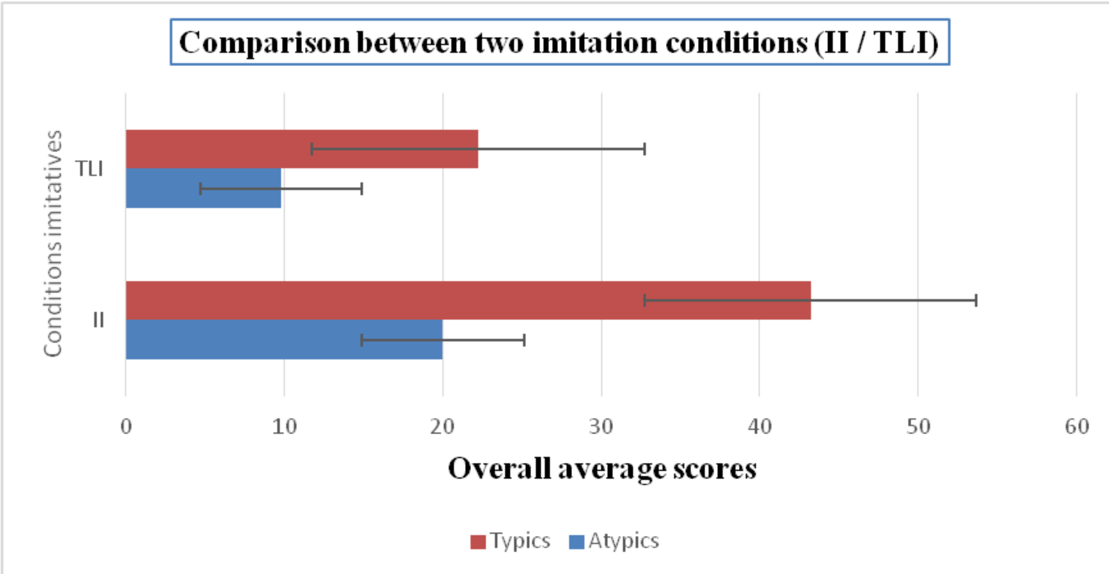

Figure 3. Comparison of the two imitation conditions in the two groups of participants

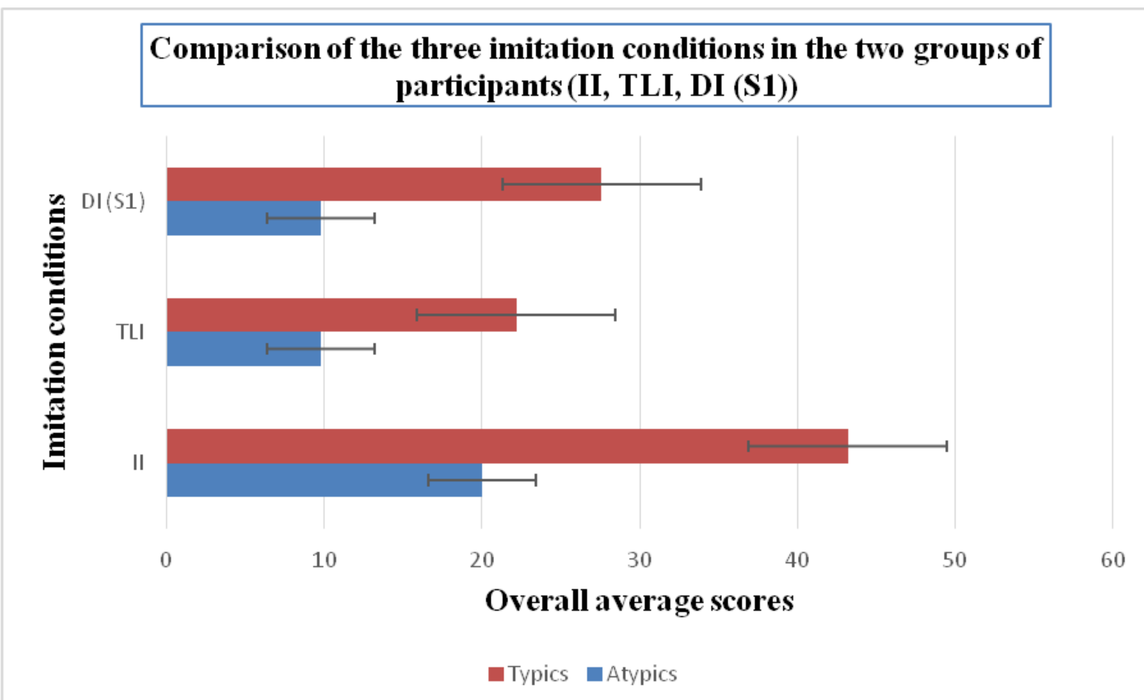

Figure 4. Comparisons of the three imitative conditions in the two groups of participants

For the adolescents with autistic spectrum, *R-squared* (0.831) under the three imitation conditions (II, TLI, DI (S1)) revealed 83% variability in the overall effect. The imitative condition that most influences the overall effect is the (II) *(p = 0.677)* but not significant. In typical children, *R-squared* (0.9896) under the three imitative conditions (II, TLI-DI (S1)) revealed a 99% variability in the overall effect. The imitative condition that most influences the overall effect is the (TLI) *(p = 0.065)*, with a tendency of significance) (Figure 5).

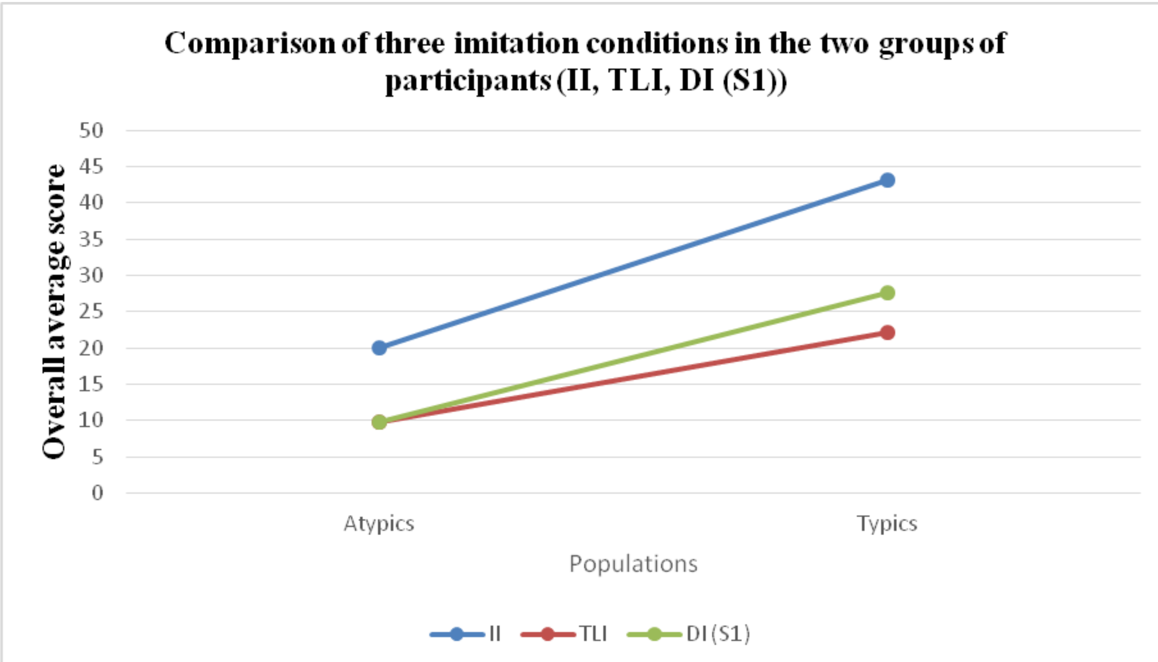

Figure 5. Evolution of the overall average scores of the two groups of participants during the three imitation conditions

4. Discussion

The behave of a child with an autistic spectrum disorder, whether strictly perceptive or also includes motor skills, should be even more affected as it requires complex cognitive process (Frith, 1992; Berthoz, 1997; Jarrold & Russell, 1997). We showed that child deficits with autism spectrum disorder would relate to high-level cognitive records (Pail lard, 1984, 1985, 1986, 1999), semantics (Jeanne rod, 1988, 1994, 1997) in motor management. While its sensorimotor management (Pail lard, 1984, 1985, 1986, 1999) pragmatic (Jeanne rod, 1994) of the action should not be overall achieved. Indeed, linked successive actions requires a different level of management, than that devolved to their basic execution (Labiadh et al., 2013; Labiadh, Landolsi, & Ramanantsoa, 2017). They must be combined, grouped in chuncks, links created, and they should be considered within a coherent whole that would gradually encompass them (Frith, 1991, 1992; Berthoz, 1997; Frith, 2010). We had demonstrated in a comparative study between typical children, aged between 5 and 6 years, and children with autism spectrum disorder, of the same mental age, that they perform elementary motor productions such as, walking, jumping, throwing, in the same way as other typical children (Labiadh, 1997). The difference is when it is necessary to induce semantic dimensions in the management of collected motor actions. Imitation of single actions seems to be easier in this autistic population that imitation of action sequences (Young, Rogers, Hutman, Rozga, Sigman, et al., 2011). Achieving a motor task, which requires the incorporation of simple elementary gestures into unified relational whole, poses difficulties for the adolescents with autism spectrum disorder.

Our results are consistent with our main hypothesis, that the construction of a coherent whole is deficient in adolescents with autism spectrum disorder, because of a deficit holistic function (Frith, 1992). In addition, there are defects in the overall coherence of the central nervous system (Jarrold & Russell, 1997). These brain deficits could make it difficult for an adolescent with autism spectrum disorder to assemble all the information inherent in the sequence, in order to realize it as a whole. Gepner's theory (2002) holds up a deficit in temporal coding, which, in the context of the sequence, could cause a lag for the child, between the model's demonstration and the integration of the information demonstrated by the latter. The defect in visual processing observed in autistic adolescents, that they do not predispose all model visual information (Planche, Lemonnier, Moalic, Labous, & Lazartigues, 2002).

Comparing the motor performance of adolescents with autism spectrum disorder to typical children under different imitation conditions, following a living human model, is relevant, to explain above all the motor construction, which seems to us little explored, or incidental. First, we analyzed the progression of these two groups of adolescents with autism spectrum disorder and typical children, over learning sessions, in deferred imitation (DI). All participants progressed and significantly improved their motor performance. This improvement is significantly natural in typicals, which follow a gradual development calendar, compared to adolescent with autism spectrum disorder. Our results suggest that with a larger sample of participants and more learning sessions, the progression could have been more significantly interesting and conclusive. Second, we demonstrated that the first (S1), and the last (S6) sessions, in the two atypical and typical participants were significantly different. This is consistent on the one hand, in terms of the delay of the atypical on imitation and, on the other hand, in their fragmented perception of the sequence (Frith, 1992; Berthoz, 1997). Indeed, in a reminder task, it is generally observed that subjects remember the items at the beginning and end of the list better, compared to the items in the middle. The high score, when recalling motor actions and conventional gestures at the beginning of learning is called the primacy effect. These same high scores when recalling the end of learning is called the recency effect (Miller, 1956). The inconsistency between statistical results and expectations can be explained in part, by the nature of management, age, or sampling (Sigman & Ungerer, 1984; Stone, Ousley, & Little ford, 1997; Roeyers, van Oost, & Bothuyne, 1998; Toth, Munson, Meltzoff, & Dawson, 2006; Vanvuchelen, Roeyers, & De Weerdt, 2007; Poon, Watson, Baranek, & Poe, 2012). On the other hand, in the deferred imitation, the visual plays a central and crucial role in the memorization process. It may be difficult for people with autism spectrum disorder to gather all the items in the demonstrated sequence. The autistic person's gaze is focused on a detail without apprehending the whole. It is therefore possible that adolescents with autism spectrum disorder fail to imitate, because they do not pay attention to actions that are demonstrated to them. As consequence, there is a lack of attention to the model (Vivanti, Nadig, Ozon off, & Rogers, 2008; Vivanti, McCormick, Young, Abucayen, Hatt, et al., 2011). We can support this through some observations during the adolescents with autism spectrum disorder realizations into deferred imitation. Some inappropriate and stereotypical behaviors were observed. The realization was sometimes interrupted by the use of an unproved object and not demonstrated in the adult model's demonstration. The child's over-focused attention to an object probably jeopardizes the overall memorization of the linked actions in the deferred imitation.

We have also shown, for adolescents with autism spectrum disorder, under the three imitation conditions, a variability that amounts to 83% of the overall effect, but without significant inter-conditions imitative variability. This would be explained by the fact that the autistic adolescents would be deficient in their ability to memorize (in encoding, storage, and restitution) (Atkinson & Shiffrin, 1968; Renner, Klinger, & Klinger, 2000), in imitation (Rogers, 1996). Thus, imitations with a single repetition (II-TLI) and imitation with several repetitions (DI)could have a significant influence only after a certain time, in a much longer period. In terms of the influence of imitative conditions on the overall effect in typical children, it is 99%. The importance of any form of learning to the typical children can both be seen and emphasized. Children is developing normally learn spontaneously in their environment, through play, language, imitation (Nadel, 2005, 2011). The participants with autism spectrum disorder are able to learn, but may be only in a particularly structured setting, in which conditions are optimal to develop the same skills, which other children naturally acquire (Nadel, 2011). Frith (2007) had observed the ability of children with autism spectrum disorder to reproduce a series of five basic tasks that can involve mirror neurons (Rizzolatti et al., 2001; Southgate & Hamilton, 2008; Casartellia, Frederica, Fumagallia, Cesareod, Nicolas, et al., 2020). Bird Leighton, Press and Heyes (2007) had demonstrated that autistic people were able to instantaneous imitation. During a study, they had to open or close their hands when the hand on the screen began to move. People with autism spectrum disorder responded in the same way as typical people to the sight of movement (Nadel, 2005). Their short term memory would be impaired leaving intact their immediate sensory memory and long term memory.

Our statistical results are consistent with the literature, which considers that people with autism spectrum disorder do not have a disposition, arrangement nor organization, like the typical children, to consistently group large quantities of information associated with the motor actions and daily gestures of the sequence. They have difficulties in constructing a global theory of thought, because of a central cohesion weakness. *"Autistic people are behaviorists; they think of behaviours as such"* (Frith, 1992). They do not have a coherent representation of the world and consequently, they are not capable of constructing an internal assumption of the other's intention (Baron-Cohen, Leslie, & Frith, 1986; Berthoz, 1997; Cattaneo, Fabbri-Destro, Borie, Pieraccini, Monti, Cossu, & Rizzolatti, 2007; Rizzolatti & Fabbri-Destro, 2010; Rizzolatti & Sinigaglia, 2010).

We think that the nature of the management of autistic people in specialized institutions can also influence the results of their motor performance. Support, whatever its nature, generally requires time, patience and, above all, a lot of investment and especially pedagogy. It can influence the data, because if the autistic person has learned in some way the task to be performed (putting the knife on the left and the fork on the right), it will be more difficult for him to get rid of and change his habits (learning by conditioning). Thus, with a longer duration of the experimental protocol, more learning sessions, more physical exercises adapted as a lover, the results would be more significant and relevant. Sowa and Meulenbroek (2012) have observed that adapted physical exercise has an effect on people with autism spectrum disorder. Their results concluded that all adapted physical activity programs reported significant progress. They also demonstrated that exercises in individual intervention programs were more advantageous to children with autism spectrum disorder in terms of motor performance but also social competence (Obrusnikova, Dillon, & Suzanna, 2011; Compte, Bui-Xuan, & Mikulovic, 2012; Trevarthen & Delafield-Butt, 2013). Chassagnite (2014) had also demonstrated that adapted physical activities, rollerblading and motor course, had a positive impact on the ability to imitate in time lag and deferred imitations, in children with autism spectrum disorder. Improvements in imitation conditions testify that the working memory and imitative skills of children with autism spectrum disorder are not completely defective (Louks, Mutschler, & Meltzoff, 2017). Our results allow a positive observation for the psychomotor development of the autistic child. Their cognitive and neurological deficits do not completely take over their learning opportunity.

Conclusion

In conclusion, the results of our study reveal the difficulties of autistic adolescents in giving a clear socio cognitive thickness to the perceptive motor stimuli demonstrated by the model. This mobilizes the intervention of cognitive management, which supports a semantic, attentive and symbolic analysis of the motor situations. This analysis would be at stake when scheduling and memorizing action sequences. Based on our results, it is demonstrated that, in the imitation of the model motor course, the participants should not only manage the identification of objects but also their semantic and cultural use. However, pragmatic motor management allowing action to be carried out without involving semantic management is retained. For the adolescents with autism spectrum disorder, pragmatic imitation of single actions seems to be globally easier in this population, than the semantic imitation of action sequences. This double exploitation of pragmatic and semantic management enriches and determinates our view of the autistic motor skills. Their motor driving level requiring complex, higher-order integrative management is deficient.

Real issues need to be raised through research to help children with autism spectrum disorder grow as independently as possible. The adapted physical activities, regularly practiced by autistic people, since childhood, a time conducive to learning, should allow, in the adult stage, to achieve more independence, autonomy and well-being. Given that imitation is one of the most powerful tools for learning and sociolazing, advances in the field can make a significant difference in our ability to facilate learning and support participation in cultural and social activities for individuals with spectrum autism disorder.

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Captions

Figure 1 The experimental disposition's scheme to carry out the sequence of elementary motor actions and conventional daily gestures

Figure 2 Effect of learning in adolescents with autism spectrum compared to typical children

Figure 3 Comparison of the two imitation conditions in the two groups of participants

Figure 4 Comparisons of the three imitation conditions in the two groups of participants

Figure 5 Evolution of the overall average scores of the two groups of participants over the three imitation conditions

Table 1 Observation record card