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Chapter 5

THE INTERACTION BETWEEN SENSORY-MOTOR DISORDERS AND SOCIAL PARTICIPATION IN PERSONS WITH AN AUTISM SPECTRUM DISORDER

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ABSTRACT

Research has recently revealed additional details about the autism spectrum disorder (ASD) brain, including information regarding the areas affected and the characteristics of their nerve cells. It is also known that these brain differences develop during the neurodevelopmental process, which occurs differently in ASD individuals. The particularities of their nervous system, however, vary from one person to another since different areas of the brain are affected at different levels. These elements are consistent with the clinical picture observed: significant variability and various associated conditions among persons with ASD. The single motor abnormality currently included in the diagnostic criteria for ASD is stereotyped repetitive behaviours. However physical impairments

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commonly observed in ASD children and adults are not limited to motor stereotypes. It is now recognized that over 80% of ASD individuals exhibit various types of sensory-motor disturbance to different degrees: dyspraxia, hypotonia, motor tics, hyposensitivity and hypersensitivity among others. The impairments most frequently described and documented include developmental delays and difficulty as regards gross and fine motor skills, coordination, postural control and motor imitation. These disorders affect the overall development of ASD children and their social participation. Thus, impaired fine motor skills and graphomotor dysfunctions are common in this population and have numerous and significant impacts on learning and self-esteem. Adjustment problems may occur, leading to frustration and behavioural problems among other negative reactions. Sensory-motor difficulties affect all the activities of developing children and may limit their functioning in everyday life. Therefore, play, which is essential to the development of the preschool child, may be disturbed at all stages of development. Several strategies are used to improve the situation of ASD children with sensory-motor disorders, but little research has been done in this area. No treatments have proved effective, and it is sometimes necessary to use compensatory aids to enable these children's learning opportunities and social participation despite their disorders. In this context, the situations of three ASD individuals with sensory-motor disorders are presented to illustrate how the use of mobile technologies can be a relevant option. Scientific evidence on the effectiveness of mobile technologies is also analyzed, and recommendations for practice are provided.

INTRODUCTION

This chapter takes an in-depth look at sensory-motor disorders, a disability frequently encountered in persons with an autism spectrum disorder (ASD) that has received relatively little scholarly attention.

The first part describes the state of current knowledge about these disorders. An overall view of autism spectrum disorder is presented, followed by a discussion of the particular characteristics of sensory-motor disorders including motor imitation difficulties. Their impact on play, an essential element in child development, is then analyzed.

The second part of the chapter focuses on intervention strategies that may be helpful to ASD persons, notably in terms of motor imitation and play. An innovative type of intervention is examined, involving the use of certain computer technologies to deal with sensory-motor disorders.

A case study illustrates how these technologies can assist persons with motor problems, and the reasons for their effectiveness are analyzed.

Finally, recommendations are made for their use in practice.

PART I. SENSORY-MOTOR DISORDERS IN PERSONS WITH AN AUTISM SPECTRUM DISORDER

1.1. Autism Spectrum Disorder

Autism spectrum disorder is characterized by qualitative alterations in reciprocal social interactions and by restricted, stereotyped and repetitive patterns of interests and activities.

These qualitative anomalies, although varying in intensity, permeate the subject’s behaviour as a whole regardless of situation. In most cases, abnormal development begins in early childhood and, with a few rare exceptions, signs and symptoms of the pathology are apparent during the first five years.

ASD persons develop differently as regards language and their motor, cognitive and social capacities. Each one is unique, however, and each has different disabilities, which may be mild in one, but very serious in another. Two persons with the same diagnosis may behave in entirely different ways. The autism spectrum is diversified, grouping together individuals with a wide range of learning abilities and disabilities. Although there is significant variation in the symptoms they exhibit, almost all require an intervention to support the development of social competencies and communication (Lord and McGee, 2001; Lai, Lombardo and Baron-Cohen, 2014).

Some characteristics considered of particular importance when working with them include:

- communication,
- social interaction,
- unusual and difficult behaviours,
- motor deficits, and
- abnormal reactions to sensory stimuli.

1.2. Motor Characteristics of ASD Children

The motor characteristics of ASD persons are now much better known and documented, particularly as regards children and the impact on children's development and functioning (Chukoskie, Townsend and Westerfield, 2013; Gowen and Hamilton, 2013; Miyahara, 2013). In early childhood, children use their motor abilities to explore the environment, engage in physical games, initiate social interactions and develop basic motor skills (Gibson, 2000). Although relatively few studies have been done on the gross and fine motor skills of ASD children, those there are point to the presence of a motor delay (Provost, Lopez and Heimerl, 2007; Fournier, Hass, Naik, Lodha and Cauraugh, 2010; Jasmin, Couture, McKinley, Reid, Fombonne and Gisel, 2009) and motor coordination problems (Smith, Warren, Yoder and Feurer, 2004), in tasks involving body movement imitation (Williams, Waiter, Gilchrist, Rerrett, Murray and Whiten, 2006) as regards motor planning (Mostrofsky, Dubey, Jerath, Janseiwicz, Golberg and Penckla, 2006; Vernazza-Martin et al., 2005), perceptual motor integration (Vanvuchelen, Roeyers and De Weerdt, 2007; Müller, Cauich, Ribio, Mizuno and Courchesne, 2004), and postural control (Minshew, Sung, Jones andFurman, 2004).

Ming, Brimacombe and Wagner (2007) examined characteristic motor deficits in a group of ASD children. Their results indicate a high prevalence of motor impairment, notably hypotonia, dyspraxia, toe-walking, reduced ankle mobility and gross motor delay, especially in younger groups. Leary and Hill (1996) highlight different types of ASD-associated motor disorders and describe motor deficits as an element that alters the development of communication and interaction competencies in ASD children. Studies of these children also reveal they have difficulty with tasks related to gesture production including response to voice commands and imitation of manual gestures, oral gestures and tool use (Green, Baird, Barnett, Henderson, Hubert and Henderson, 2002; Rogers, Hepburn, Stackhouse and Wehner, 2003; Williams, Writen, Suddendorf and Perrett, 2001). Furthermore, ASD children use stereotyped and repetitive motor behaviours that do not indicate a deficit in motor execution or planning, but rather a deviant motor behaviour (Dewey, Cantell and Crawford, 2007). The moment when motor abilities diverge from those of typically developing children, however, is not known. Most of the studies focus on school-aged ASD children. The only studies of pre-schoolers show mitigated results regarding ASD-associated motor deficits compared with typically developing children.

Provost et al. (2007) document deficits in fine and gross motor skills in a group of typically developing children. Jasmin et al. (2009) focus on the impact of sensory-motor development on the daily life skills of ASD children 3 to 4 years old and conclude that pre-school ASD children present, on average, atypical sensory responses, motor difficulties and difficulties with daily life skills. Their poor daily life skills are mainly linked to poor sensory-motor skills and, in particular, to difficulties with fine motor skills. Sacrey et al. (2014) tend in the same direction in their analysis of prehension difficulties in young ASD children.

In their meta-analysis of 83 studies on ASDs, Fournier et al. (2010) conclude that these disorders are associated with significant and widespread alterations in motor performance. Their results show that motor deficits are an essential characteristic of ASD, and that treatment plans for ASD should include interventions aimed at improving the motor performances involved, notably, in motor coordination.

Researches have, furthermore, been conducted to compare the motor skills of ASD children with those of children having other forms of developmental delays. Provost et al. (2007) observed no difference in balance, locomotion, prehension, object manipulation and visual-motor integration between 21 to 41-month-old ASD children and children with developmental delays. Similarly, Rogers et al. (2003) found no differences in fine motor maturity or motor planning in 2-year-old ASD children during tasks involving manual imitation, oral-facial imitation and object movement compared with the corresponding group of typically and atypically developing children.

In addition, studies comparing the motor competencies of high-functioning ASD children with those of low-functioning children conclude that these two groups cannot be distinguished by ASD-associated motor deficits. Motor deficits, moreover, do not appear specific to low-functioning ASDs compared with other types of ASDs (Ghaziuddin and Butler, 1998; Miller and Ozonoff, 2000).

The motor difficulties associated with autism therefore include:

- repetitive movements, stereotypes, rituals and repetitions that interfere with motor skill acquisition and lead to the refusal of certain activities (Boursier, 2001);
- dyspraxias (problems with motor skill acquisition, defined as a difficulty planning and automatizing gestures or movements) (Kirby, Sugden and Purcell, 2014; Mostofsky, Dubey, Jerath, Jansiewicz, Goldberg and Denckla, 2006);

- difficulties with movement preparation and planning (Rinehart, Bradshaw, Brereton and Tonge, 2001) that interfere with the acquisition of actions performed in several stages or that are demanding in terms of coordination;
- immature movement patterns during basic actions such as throwing, jumping and running, even in adolescence. This immaturity is characterized, in particular, by non-functional and inappropriate arm movements (Morin and Reid, 1985);
- difficulties performing tasks requiring the integration of visual and proprioceptive information, e.g., balance and ocular-manual coordination;
- motor imitation difficulties (Frith, 1992; Stieglitz Ham, Bartolo, Corley, Rajendran, Szabo and Swanson, 2011); and
- low muscle tone.

Motor deficits impact various capacities and numerous occupations or life habits (Gowen and Hamilton, 2013; Jasmin, Couture, McKinley, Fombonne and Gisel, 2009; Pan, Tsai and Chu, 2009). Hypotonia (more or less severe muscle weakness), dyspraxia (MacNeil and Mostofsky, 2012) and motor tics may lead to problems with walking, eating, prehension and object manipulation. Thus, the person may, for example, experience difficulty moving about, or have problems with gross motor skills (e.g., sports, transporting objects) or fine motor skills (e.g., writing, using a computer), or performing everyday actions (e.g., buttoning, tying laces, preparing meals) (Fournier, Hass, Naik, Lodha and Cauraugh, 2010; Green, Baird, Barnett, Henderson, Hubert and Henderson, 2009; Kopp, Beckung and Gillberg, 2010; Liu and Breslin 2013; Lloyd, MacDonald and Lord, 2013; Pan, Tsai and Chu, 2009; Provost, Lopez and Heimerl, 2007; Staples and Reid, 2010; Vaivre-Douret, 2007; Whyatt and Craig, 2012). Because of dyspraxic and motor difficulties, many ASD persons present more or less severe graphomotor problems, which may have major impacts on many areas of learning, school achievement and, finally, social participation (Ashburner, Ziviani and Pennington, 2012; Hellinckx, Roeyers and Van Waelvelde, 2013; Johnson, Phillips, Papadopoulos, Fielding, Tonge and Rinehart, 2013; Kushki, Chau and Anagnostou, 2011). Other activities that must become automatized also present difficulties, e.g., learning addition, subtraction, multiplication and division tables or everyday life routines (Vaivre-Douret, 2007). Despite the use of numerous learning strategies, automatisms are not acquired, and the individual must use other strategies in order to function.

It is now known that the cerebellum is affected in ASD individuals and that it plays a role not only in movement, but also in different aspects of cognition. Speech, posture, facial expression – indeed all activities - may be affected (Miller, Chukoskie, Zinni, Townsend and Trauner, 2014).

The fact that certain processes are not automatized affects functioning as a whole: these elements monopolize working memory, leaving less room for reasoning, planning, creativity, etc. (Barendse et al., 2013; Chukoskie, Townsend and Westerfield, 2013).

1.3. Sensory Disorders of ASD Persons

Tomchek and Dunn (2007) maintain that up to 95% of ASD persons present, in various degrees, a sensory processing dysfunction, mainly with regard to sensory modulation. All senses can be affected by sensory disorders in such persons (Brown and Dunn, 2010; Dunn, 2008). They may be expressed through hyposensitivity, hypersensitivity, poor sensory regulation or sensory search. With regard to touch, the individual may avoid certain tactile sensations to which he is sensitive, for example, he may not tolerate certain kinds of clothing, shy away from touch, avoid manipulating particular objects or textures, or walk on tiptoe so his feet won't touch the ground. In the mouth area, taste disorders may be expressed by limited food textures (Nadon, Feldman, Dunn and Gisel, 2011) or food choices. Regarding smell, individuals may be overly sensitive to smells or perceive smells that are inoffensive to others as disagreeable. They may also exhibit avoidance reactions, e.g., during meal preparation. As regards hearing, the child may be overly sensitive to ambient noise. Some may perceive noises as aggressive and develop behavioural problems as a result. An individual may avoid noises by covering his ears with his hands, or looking for noise he enjoys.

In terms of kinesthetics, the child may seek vestibular input (swinging, jumping, trampolining. etc.) The same phenomenon is seen at the visual level: avoiding light perceived as intense by looking away or covering the eyes, or, conversely, seeking light (Kramer and Hinojosa, 2010).

The interaction of motor and sensory disorders makes it difficult to perform many occupations (Gowen and Hamilton, 2013; Dunn, 2008). Poor tactile or proprioceptive input can, in fact, affect motor planning and the accomplishment of movements and tasks. The result may be dyspraxic problems: the child is clumsy in sports, have a hard time riding a bicycle and find fine motor activities are difficult, if not impossible.

These difficulties may sometimes be interpreted as a behavioural disorder (e.g., rigid avoidance certain activities), but the cause may be a primary sensory-motor disorder (Ben-Sasson, Carter and Briggs-Gowan, 2009; Brown and Dunn, 2010; Jasmin, Couture, McKinley, Fombonne and Gisel, 2009; O'Donnell, Deitz, Kartin, Nalty and Dawson, 2012; Tomchek and Dunn, 2007). Furthermore, the individual presenting these difficulties may experience such situations as constant frustrations and aggressions in a world that fails to correspond to his perceptions, aptitudes and capacities.

Many persons develop anxiety, because the demands of our usual lifestyle may constitute insurmountable constraints and obstacles for them. Their learning processes are likewise disrupted insofar as their perceptions of the world differ and their ability to manipulate objects is limited. These elements are recognized as essential to learning, i.e., the possibility to explore and experiment. Cognitive development may thus be affected.

1.4. ASD Children and Motor Imitation

Motor imitation is a motor particularity of ASD children and has been the focus of a number of studies that discuss its impact on the development of different skills (Edwards, 2014; Warrenyn, Van der Paelt and Roeyers, 2014).

In typically developing children, motor imitation emerges early in development (Meltzoff and Moore, 1997) and has two distinct functions: a learning or instrumental function, by which children acquire new competencies and knowledge, and a social function, by which they engage in social and emotional exchanges with others (Uzgiris, 1981). Motor imitation is a salient component of social and cognitive development (Uzgiris, 1999).

From a social perspective, the first function of motor imitation, which involves body movements, vocalizations and facial expressions, conveys a sense of belonging, mutuality and a way to communicate with social partners (Nadel and Butterworth, 1999; Trevarthen, Kokkinaki and Fiamenghi Jr, 1999).

The second function is to give the child information about other people's actions and intentions vis-à-vis the physical and social world, allowing for social learning through imitation (Kugiumutzakis, 1999; Uzgiris, 1999).

Socially, imitation appears essential to the young child's acquisition of the skill for detecting the correspondence between self and others (Meltzoff and Gopnik, 1993). A young child's first opportunity to observe that others are "like me" leads, therefore, to an understanding of other people's intentional behaviour (Meltzoff and Moore, 1999). At the social level, imitation is one of the first forms of reciprocal interaction between a child and those around him (Nadel and Butterworth, 1999). Reciprocal imitation plays a key role in precocious interactions with peers (Ingersoll, 2008).

Executing the same action on the same object allows the child to initiate interactions with preschool-age peers and often leads to maintaining or increasing the level of social interactions (Ingersoll, 2008).

The social role of motor imitation in early childhood is linked to the development of more sophisticated communication competencies. At the same time, the child learns to communicate by imitating the codes and acts of the other. A study by Bates et al. (1979) demonstrates the existence of correlations between gestural and vocal imitation and communication in typically developing children. In addition, motor skills are associated with language development and social communication competencies (Williams, Whiten, Suddendorf and Perrett, 2001). Adrien et al. (1992) includes imitation within the context of social interactions; imitation allows the child to attract attention and enter into contact. Nadel (2005), for her part, views imitation as an integral part of wordless communication, while Uzgiris (1999) views it as an important way to learn during development.

Imitation is an acquired skill that calls upon a child to generate an idea about an action and then plan how that action will unfold. The normal development of imitation depends on the development of several other skills (cognitive, language and motor). Accordingly, problems with the development of certain skills can affect the development of imitation (Dewey, Cantell and Crawford, 2007). Some authors have, moreover, noted a relation between dyspraxia and imitation problems (Stieglitz Ham, Bartolo, Corley, Rajendran, Szabo and Swanson, 2011).

Problems imitating the movements of other persons appear very pronounced in persons with ASD disorders. Rogers and Pennington (1991) early maintained that imitation problems in ASD individuals could play an essential role in the development of social anomalies and communication difficulties. Their review of the literature (1991) highlighted a deficit in the imitation of simple and symbolic gestures.

Imitation is one of the first social behaviours observed in typically developing children and one of the first symptoms of the social functioning deficit noted in ASD children (Rogers, 1999; Stone, Lemanek, Fishel, Fernandez and Altemeier, 1990; Watson, Baranek and DiLavore, 2003; Williams, Whiten, Suddendorf and Perrett, 2001). Although debate continues on the exact nature of the relation between imitation and social deficits, researchers agree in emphasizing that, socially, the absence of spontaneous imitation affects the development of ASD children (Field, Sanders and Nadel, 2001; Ingersoll and Schreibman, 2006).

Vanvuchelen et al. (2007) conducted a comparative study of young ASD boys and typically developing boys that focused on the imitation of 24 tasks: 12 meaningful gesture tasks (e.g., combing one's hair or greeting someone) and 12 meaningless gesture tasks involving hand postures. Their results reveal that for ASD children, imitation requires far more effort (more attempts) and is less precise (more spatial errors) than for typically developing children. The authors postulate that the action production system is delayed rather than defective. The high number of partial imitations in ASD children is characteristic of a delay in motor development. The results of Vanvuchelen et al. (2007) may have consequences for the diagnosis of ASD. The authors maintain that a combination of motor and motor imitation tests should be considered with a view to a more accurate diagnosis.

Starting at 20 months of age, a motor imitation deficit can be observed during imitation actions on objects (Charman, Swettenham, Baron-Cohen, Cox, Baird and Drew, 1997) and, despite some improvements during the child's development (Rogers, Bennetto, McEvoy and Pennington, 1996; Stone, Ousley and Littleford, 1997), this deficit is a primary one for the ASD individual (Rogers, Benetto, McEvoy and Pennington, 1996; Stone, Ousley and Littleford, 1997).

Researchers have advanced a number of hypotheses to explain motor imitation deficits in ASD persons. The possible underlying mechanisms proposed include gross and fine motor deficits (Hauck and Dewey, 2001; Osterling, Dawson and Munson, 2002), dyspraxia (Stieglitz Ham, Bartolo, Corley, Rajendran, Szabo and Swanson, 2011, executive function deficits (Dawson, Osterling, Rinaldi, Carver and McPartland, 2001) and social deficits (McDuffie, Turner, Stone, Yoder, Wolery and Ulman, 2007; Rogers, Hepburn, Stackhouse and Wehner, 2003). Smith and Bryson (1994) observe an imitation deficit associated with ASD, which they attribute to a particular cause: a deficit in the perceptual organization of movement. Perceptual organization consists of the ability to detect, organize and interpret information supplied by the environment based on different sensory sources: sight, hearing, touch and kinesthetics to correct an ongoing action. Perceptual organization depends on the child's motor skills, and it improves thanks to the diversity of sensory-motor activities (Rigal, 2003).

Rogers and Pennington (1991), on the other hand, suggest that a motor imitation deficit represents a major weakness of the autistic spectrum. After electroencephalograms (EEGs) were conducted, they hypothesized that a deficit in the prefrontal limbic neural system was responsible for motor imitation deficits in ASD children. Finally, Williams et al. (2001) suggested a different reason: they linked the imitation deficit found in ASDs to “mirror neurons ”, a set of neurons in the premotor cortex, which generates both a deficit in the ability to represent the actions of others and the achievement of the higher-level cognitive functions involved in the construction of intersubjectivity (Gallese, 2006). A possible explanation is that this mirror mechanism, although functional, may be dissociated from socio-affective capacities. Researches tend to show that although mirror neurons are mainly involved in the perception and comprehension of motor actions, they can also play a crucial role in the higher system of cognitive processes such as imitation (Gallese, Rochat and Berchio, 2013; Hamilton, 2013; Rizzolatti, Fogassi and Gallese, 2001), theory of mind (ability to infer others’ mental states (Gallese and Goldman, 1998)), and language (Rizzolatti and Arbib, 1998), all known to be reduced in ASD individuals (Baron-Cohen and Belmonte, 2005; Rogers, Helpburn, Stackhouse and Wehner, 2003). This set of hypotheses has led to the implementation of diverse interventions focused on motor imitation to facilitate social interactions.

Motor imitation in the ASD child involves language and play skills (Charman, Baron-Cohen, Swettenham, Baird, Drew and Cox, 2003; Charman, Swettenham, Baron-Cohen, Cox, Baird and Drew, 1997; Stone, Ousley and Littleford, 1997; Stone and Yoder, 2001). Play is the right moment for children, handicapped or not, to imitate movements and implement social interactions.

1.5. Play and ASD

Play is essential to a child’s development and the same is true for ASD children. The DSM-5 (American Psychiatric Association, 2013), however, includes diagnostic criteria indicating that the lack of variety and spontaneity in pretend play or social imitation appropriate to the child’s stage of development are signs of ASD. Play may be disturbed at all stages of development.

Roeyers and van Berckelaer-Onnes (1994) show that ASD children demonstrate less curiosity than typically developing children. The authors conclude that the play behaviours of ASD children are often limited to simple manipulation, their quality of play is inferior to that of typically developing children and spontaneous symbolic play is generally absent or impaired.

There are various theories to explain this developmental delay in play skills. Some authors mention that the ASD child's tendency to engage in repetitive behaviours interferes with the learning of new skills (Williams, Whiten, Suddendorf and Perrett, 2001). The child may be so absorbed in his own activity - e.g., knocking two blocks together - that he pays no attention to the children around him using the blocks to build a house.

For Jarrold (1997), these reactions are explained by the difficulty in creating new behavioural schemes. In typically developing children, the first forms of pretend play involve functional actions such as talking on a play phone. This skill requires producing behaviour in a context other than the one where it usually takes place. Williams et al. (2001) maintain that ASD children cannot proceed with this decontextualization. Their difficulties become obvious during skill acquisition rather than during the production of new schemes. These authors state that the ASD child experiences difficulties in learning based on information coming from the social group he belongs to, owing to his problems interacting with others. Sigman et al. (1992) specify that ASD children are unable to use others' emotional responses as a guide to the use of an object. Wolfberg and Schuler (1993) also believe that deficits observed in ASD children during play are explained by their social isolation rather than by cognitive disorders. They add that guided play may be a way to reduce this isolation.

There is a consensus among researchers that ASD children present a major developmental delay as regards symbolic play (Jarrold, Boucher and Smith, 1993; Ungerer and Sigman, 1981; Wolfberg and Schuler, 1993). Furthermore, researches indicate these children may be totally incapable of engaging in symbolic play, especially those that are highly structured (Jarrold, Boucher and Smith, 1996). Jarrold, Boucher and Smith (1996) conclude that ASD children have difficulty with generating symbolic play rather than with the mechanics of symbolization as such.

Competencies relative to play, social communication, adaptation and imitation have been studied based on various aspects of development. Given the strong interaction between the physical and social spheres during critical periods of development (Fournier, Hass, Naik, Lodha and Cauraugh, 2010), it is not surprising that motor competencies are integrated into each of these areas. The detached, unimaginative play of many autistic children offers them less interesting learning opportunities. Ideation difficulties can lead to stereotyped and restricted patterns of play such as lining objects up in a row, focusing on certain parts of objects only, (e.g., the wheels of a car rather than the car as a whole), and repetitive actions like banging blocks together. This ritual or repetitive use of toys tends to replace more sophisticated imagination or pretend play (Audet, 2004).

Difficulties with problem-solving may also lead to a lack of variety during play, resulting in repetitive and stereotyped responses. A lack of figurative or abstract thought also lessens the possibility of playing imaginative games (Craig and Baron-Cohen, 1999). Often, ASD children engage in functional or construction games rather than pretend play, which are cognitively and socially more advanced (Desha, Ziviani and Rodger, 2003). This may be partially due to difficulties with receptive or expressive language, poor motor abilities and deficits in imitation (Mastrangelo, 2009). ASD children often spend a considerable amount of time wandering, observing or engaging in stereotyped behaviours involving their body or objects and are often less intrinsically playful than typically developing children (Desha, Ziviani and Rodger, 2003; Skaines, Rodger and Bundy, 2006).

PART II. INTERVENTION IN THE PRESENCE OF SENSORY-MOTOR DISORDERS IN PERSONS WITH AN AUTISM SPECTRUM DISORDER

What strategies have proved effective in the presence of sensory-motor disorders in persons with an autism spectrum disorder? These strategies can target the person's disorders themselves, their impact on occupations or participation, including play, the environment and the interactions among these various components.

2.1. Interventions Aimed at the Person

A motor impairment is generally treated with standard re-education approaches (Kramer and Hinojosa, 2010). More specifically, the Cognitive Orientation to Daily Occupational Performance (CO-OP) approach (Polatajko and Mandrich, 2004) has demonstrated its effectiveness with developmental coordination disorder or dyspraxia, but it cannot always be used with ASD persons. This particular approach is founded on cognitive-behavioural theories.

Occupational therapists have developed different curative approaches to sensory problems. Sensory integration tends to be privileged, but its effectiveness remains a subject of controversy among scientists (Case-Smith, Weaver and Fristad, 2014; Hazen, Stronelli, O'Rourke, Koesterer and McDougle, 2014; Zimmer and Desch, 2012). Regarding cognitive functions, occupational therapists employ approaches that target child development and divided attention in particular (Frolek Clark and Schlabach, 2013).

2.2. Imitative Skills

Many intervention strategies for autistic children rely heavily on imitative skills. Behavioural interventions such as those using discrete-trial training (Lovaas and Smith, 2003) or strategies based on video modeling and feedback by peers (Charlop and Milstein, 1989; Goldstein, Kaczmarek, Pennington and Shafer, 1992; Pierce and Schreibman, 1995, 1997) call on imitation to facilitate the acquisition of intervention objectives.

D'Ateno et al. (2003) observe that the introduction of an intervention by video modeling produces an increase in the number of both verbal and motor responses during play, and the review by Lindsay et al. (2013) provides details on how to implement this type of intervention effectively.

A systematic review by Reichow and Wolkmar (2010) focuses on interventions aimed at improving social skills. The authors conclude that technologies such as visual support and video modeling have proved effective and recommend their use in a clinical setting. The mainly computer-based technologies used for video modeling apparently create an intermediary that facilitates learning through imitation. Thus, prior to 2004, studies generally concluded that autistics showed a deficit in executive function compared with typically developing persons (Hill, 2004a; 2004b). The findings of researches subsequent to that date, however, were different. One explanation is that the procedures for certain tests were modified. Indeed, a computerized version of tests like *Tower of London* and *Tower of Hanoi* was used in studies after 2004. Since that time, findings no longer show a deficit in the aspect of executive function evaluated by these tests (planning) (Kenworthy, Yerys, Antony and Wallace, 2008). Results improve when the examiner is replaced by a computer, suggesting it is the relational aspect that most ASD persons find challenging. The findings of a study on the use of a computerized avatar as assistant (Hopkins et al., 2011) - one demonstrating that ASD persons can understand irony when the situation is presented on a computer (Glenwright and Agbayewa, 2012) and another indicating they prefer video presentations to instructions from a person (Cardon and Azuma, 2012) - point in the same direction.

In a similar vein, experiments with training or therapy using robotic dolls have been conducted and appear promising. These intermediaries are in fact easier to access for ASD persons and can assist with learning social skills (Dautenhahn, 2007; Kalioubi, Picard and Baron-Cohen, 2006). Furthermore, a review by Parsons and Mitchell (2002) shows that virtual reality is promising for teaching social skills in certain conditions. The findings of several subsequent studies, moreover, demonstrate the effectiveness of virtual reality for ASD persons (Kandalaft, Didehbani, Krawczyk, Allen and Chapman, 2013). More generally, the meta-analysis by Grynszpan et al. (2014) concludes in the effectiveness of technology-based interventions, including virtual reality and computer programs, for ASD persons.

2.3. Play

As for play in particular, occupational therapists focus mainly on teaching play skills and integrating toys that allow for different types of play routines (Beyer and Gammeltoft, 2000). Evidence concerning the effectiveness of these interventions, together with a small body of research, suggests that adults who play facilitate play in ASD children (Reed, Dunbar and Bundy, 2000). Play-based interventions can be classified as "behavioural" or "developmental".

Behavioural interventions emphasize respect and the acquisition of skills through imitation, while developmental interventions stress children’s strengths and interests, using them to extend and develop play (Rodger and Ziviani, 2012). Because developmental approaches allow children to lead the interaction, they tend to be more fun. Adults in the child’s environment have an essential role regardless of the approach used. With the help of adult supervision, peers can also support the play of ASD children in playgrounds (Wolfberg and Schuler, 1993).

2.4. Interventions Aimed at the Environment

Actions to make the environment inclusive or adapted to ASD persons constitute another particularly important target (Lai, Limbardo and Baron-Cohen, 2014; Mottron and Dawson, 2013).

Creating favourable environments or adjusting an environment to foster development, autonomy and engagement in occupations for these persons is a path to improving their situation, as no curative treatment has really proved effective.

Many environmental adjustments are used to treat sensory problems, e.g., soft, supple clothing for tactile hypersensitivity, muffs for auditory hypersensitivity, heavy or enveloping clothing for proprioceptive disorders, and certain tools like balls that offer vestibular stimulation, etc. (Case-Smith, Weaver and Fristad, 2014; Hazen, Stronelli, O'Rourke, Koesterer and McDougle, 2014; Zimmer and Desch, 2012). Weighted vests are notably used to increase proprioceptive input and may be suitable for certain individuals. The testimony of Temple Grandin, a famous autistic woman, is eloquent in this regard. Environmental adaptations are used to a greater extent, notably, by the TEACCH approach (*Treatment and Education of Autistic and Communication Related Handicapped Children*) (Mesibov, Schopler and Hearsey, 1994), as well as other adaptation in school settings (Kinnealey, Pfeiffer, Miller, Roan, Shoener and Ellner, 2012) and, generally, in environments that are inclusive and open to difference.

2.5. Mobile Technologies

In recent years, promising new tools in the form of mobile technologies (MT) - iPads™, iPhones™, iPods™, etc. - have been developed and are being increasingly used by persons with ASD (Hoesterey and Chappelle, 2012). Tablets and smartphones are information and communication technologies with unique characteristics. Thanks to wireless communication, they allow for access to the Internet and its innumerable possibilities through various places (email, Web, YouTube, telephone…). These devices include a camera, a recorder, a video device, loud speakers and speech synthesizers, a GPS, a time clock, an automatic calendar and thus an agenda, a gyroscope (adapts to positions or adjusts to movements) and the "cloud" (iCloud™ or other) for extra storage space, making them versatile tools with a wealth of possibilities. They are operated by touch or with a special pencil. Millions of applications are available and their number continues to grow. These tools are closer to life, because they respond directly to touch and movement, react to us, speak to us, hear us, see us…

Many people have testified to the iPad™'s potential value for autistics, and many have called it a miracle (Shannon Des Roches, 2010). Indeed, a simple

Web search with the words *iPad, autism and miracle* provides many testimonials in this regard (see box below).

Since scientific researchers don't believe in miracles, however, we will attempt to explain the reasons for this tool's effectiveness. A key part of this chapter focuses on this issue because of the innovative and promising aspects of these tools. Three elements are considered when researching the explanation for MT effectiveness. The first consists of a scientific literature review and expert consultations to gather information and evidence related to MT effectiveness. The second involves case studies of persons who experimented with the tablet and obtained positive results. The third concerns an analysis of MT based on the principles of universal design.

Some websites discussing the effectiveness of iPads™
http://www.blogher.com/ipad-nearmiracle-my-son-autism
http://www.foxnews.com/tech/2011/03/09/can-apple-ipad-cure-autism/
http://www.parenting.com/blogs/show-and-tell/kate-parentingcom/how-ipad-can-help-kids-autism
http://www.cncahealth.com/ipad-seen-as-learning-miracle-for-those-with-autism?blogPostId=23968

2.5.1. Evidence on the Effectiveness of Mobile Technologies for ASD Persons

To better understand the effectiveness of MTs, we conducted a literature review and consulted experts who had experimented with these technologies to assist ASD persons. This section presents a synthesis of the information collected.

The experts were specialized workers in four rehabilitation centers for persons with intellectual handicaps and/or autism who agreed to take part in a recorded interview. The verbal recordings were transcribed and divided into headings. The interviews lasted an hour on average and were conducted by the main researcher in winter and spring 2013. The interview group was composed of fifteen persons - eight men and seven women – including 12 special educators, two speech therapists and an occupational therapist. All had experimented with mobile technologies to assist users they were either supervising or had been following in therapy in the preceding months.

The participants reported on the various occasions they had used MT and on its benefits and disadvantages based on their experience. Some had experimented with dozens of users and others with only one.

In total, these interviews reveal the outcomes of MT experiments with 67 different users having an ASD or intellectual handicap. Opinions were triangulated with the scientific literature on the subject. Accordingly, the following tables report the expert opinions of those interviewed concerning their use of mobile technologies and indicate the main references for each element. The information is grouped under headings in terms of benefits, disadvantages and tips for effective use (Tables 1, 2 and 3).

Table 1. Benefits of Mobile Technologies

● Simple to use, intuitive (Campigotto et al., 2013; Chen, 2012; Kagohara et al., 2013; Stephenson et al., 2013)
● Use of icons, not written instructions (Chen, 2012)
● Visual and auditory instruction, modeling (Chen, 2012)
● Multisensory (sight, hearing, touch, kinesthetics, haptics) (Campigotto et al., 2013; Mintz et al., 2012)
● Flexible, customizable, adaptable to the user (Campigotto et al., 2013; Chen, 2012; Mechling et al., 2011)
● Many applications can be adjusted to correspond to the user's characteristics and targeted objectives (Campigotto et al., 2013; Chen, 2012; Mechling et al., 2011, Hulusic et al., 2012)
● Immediate, reliable and ongoing feedback (Campigotto et al., 2013; Hulusic et al., 2012; Mintz et al., 2012; Moore et al., 2013)
● *Kairos*: response at the right time and the right place (Mintz et al., 2012; Mintz, 2013)
● Motivation, interest, normalizing, non-stigmatizing (Arthanat et al., 2013; Campigotto et al., 2013; Hulusic et al., 2012; Jowett et al., 2012; Kagohara et al., 2013; McNaughton and Light, 2013; Neely et al., 2013)
● Correspond to their interests; tool is appreciated, socially valued, therefore a reinforcement (Kagohara et al., 2013)
● Available and affordable technology (Kagohara et al., 2013),
● Less need for assistance (Arthanat et al., 2013; Campigotto et al., 2013; Hulusic et al., 2012; Moore et al., 2013; Murdock et al., 2013; Neely et al., 2013)
● User is more active and in control, can make choices (McNaughton and Light, 2013)
● Develops self-determination (McNaughton and Light, 2013)
● Autonomous learning possible, including learning by trial and error (Arthanat et al., 2013; Hulusic et al., 2012; Moore et al., 2013; Neely et al., 2013)
● Less pressure from the environment, therapist or specialist, less stress in the relationship (Campigotto et al., 2013; Hulusic et al., 2012; Murdock et al., 2013)

● Reduce stress in learning and managing everyday living
● Users work at their own pace (Campigotto et al., 2013; Hulusic et al., 2012; Murdock et al., 2013)
● As many repetitions as necessary (Campigotto et al., 2013; Hulusic et al., 2012; Murdock et al., 2013)
● Mobile, user can move from place to place, which facilitates interactions, usable face-to-face or in a group (Campigotto et al., 2013; Chen, 2012)
● Possible to check state of knowledge and skills through a mode of dynamic interactions (Hulusic et al., 2012)
● Modification of therapist-client relationship, distance supervision possible
● Multitasking tool that can support several objectives
● May lead to a sense of success, acknowledgement, self-esteem and self-efficacy if the applications are properly adapted to the user
● Captivating, prolonged active time, which can help in terms of family functioning, e.g., outings
● The exercise - setting objectives, choosing appropriate applications - is sometimes as important as the tool; motivation of the specialist or the family is helpful; attraction to novelty can be an incentive
● Tool can save time spent to prepare materials, less cumbersome to carry, etc.

Table 2. Disadvantages of Mobile Technologies

● Interest in several applications may interfere with sustained concentration (Arthanat et al., 2013)
● Many stimulations may be stressful or undermine (self-stimulation) (Arthanat et al., 2013)
● Some have difficulty understanding verbal instructions (Hulusic et al., 2012)
● Some have difficulty understanding hierarchical structure (Campigotto et al., 2013)
● Difficulty generalizing in a real environment (Murdock et al., 2013)
● Technology relatively costly for disadvantaged families
● Therapists or assistants may have difficulty adjusting the device to a user's specific needs (Campigotto et al., 2013)
● Technology requirements (upgrades, bugs, costs, limited Wi-Fi access in certain places, risks of Internet use) (Palmen et al., 2012)

2.5.2. Case Studies

A research action project, aimed at understanding the effectiveness of mobile technologies for improving the participation of ASD individuals, was conducted.

Table 3. Tips for the Effective Use of Mobile Technologies

● Integrate use of the tablet as a long-term, rather than a short-term personal assistant; plan certain lessons and stages of learning for the first year, determine what is to follow, etc. (Arthanat et al., 2013)
● Adapt and adjust stimulation levels to user's sensory profile (Arthanat et al., 2013; Venkatesh et al., 2012)
● Customize applications to user's specific capacities and needs (Hulusic et al., 2012; Venkatesh et al., 2012)
● Graduate the task from simple to more complex. Tasks that are too easy fail to improve abilities; those that are too difficult lead to feelings of failure and frustration (Hulusic et al., 2012; Sigafoos et al., 2013; Venkatesh et al., 2012)
● Allow the user to make choices to foster a higher level of engagement (Lee et al., 2013; Mechling et al., 2011)
● Optimize the context of the technology with a view to improved performance (Campigotto et al., 2013)
● Use the technology in several environments to ensure *kairos* and generalize acquired skills (Mintz et al., 2012)

The objectives were twofold: 1) evaluate the effectiveness of mobile technologies for improving the participation of ASD individuals, and 2) explain why these technologies are effective or how they can help improve these persons' situation. This study employs a qualitative, descriptive research design and focuses also on the pre- and post-intervention periods. It involves the experimental use of the tablet by ASD persons during a 12-week period. Objectives targeting occupations, autonomy, participation and learning were established for each participant and an intervention plan was implemented. Tablet applications that allowed for the achievement of objectives were identified. The frequency and duration of the interventions were adjusted based on each one's needs. Notes were taken at each intervention to indicate progress or difficulty, and a report was made at the end of the trial period. Participants were recruited from establishments in the province of Quebec offering services to clienteles with ASD. The measurement instrument used to compare the pre and post-intervention situations was the Canadian Occupational Performance Measure (COPM) (McColl, Carswell, Law, Pollock Baptiste and Polatjako, 2006). Qualitative data were also gathered on the experiments conducted (description of progress of experiments, observations, user's opinions, comments, etc.).

The COPM is a standardized tool that makes it possible to detect the changes produced, as they are perceived by the individuals themselves, regarding difficulties in occupational performance. This tool focuses on the client's priorities, thus determining the occupational areas (personal care, recreation and productivity) that present a problem he wishes to improve. Four key steps are used to gather the information: 1) identify occupational difficulties, 2) prioritize the importance of these difficulties, 3) rate levels of performance and satisfaction for each difficulty pinpointed before the intervention, and 4) rate the same elements after the intervention. Three 10-point ordinal scales are used: 1) the individual's prioritization of the occupations causing the difficulty (1 = least important and 10 = most important), 2) his occupational performance (1 = weakest performance and 10 = strongest performance), and 3) his satisfaction regarding the targeted occupations (1 = lowest satisfaction and 10 = highest satisfaction). These scales allow users themselves to rate the importance of the occupation selected, validate their current functioning accordingly and indicate their satisfaction in terms of carrying out the occupation.

The tool can be administered in about 40 minutes. Several studies have focused on the metrological properties of the COPM with diverse clienteles. This tool has good overall validity and reliability (Canadian Association of Occupational Therapists (CAOT), 2005; McColl, Carswell, Law, Pollock Baptiste and Polatjako, 2006). Its clinical usefulness has been widely examined and the studies support its use with a diverse clientele and in numerous contexts (CAOT, 2005). In addition, the COPM is recognized as being sensitive to changes (CAOT, 2005).

A number of ASD persons took part in the project and were able to improve their situation consistent with the literature mentioned above. Of these, however, three situations stood out in demonstrating how technologies can support learning, autonomy, development and participation by persons having sensory-motor disorders, because the gains obtained on the COPM scales were clearly superior to those in other situations (gains of 4.5 on scales for objectives relative to overall motor skills compared with average gains of 3 for the other targeted objectives). The three individuals in question shared major sensory-motor disorders along with other symptoms common to ASD individuals. What's more, they were not able to write with a pencil or use the mouse to access a computer. Because fine motor activities were difficult or impossible, they were severely limited in their learning and activities. They presented an academic delay and behaviour problems, leading, notably, to anxiety. They had experienced several failures following attempts to improve their capacities or reduce impairments by means of different approaches.

Experiments with the tablet constituted an attempt to see if this tool could help improve these persons' functioning where other approaches had failed.

The tablet used was the iPad™, which has the notable advantage of reducing motor effort insofar as it requires less precision and motor control than a pencil or a mouse. It has the potential to be helpful for ASD persons. The participants all benefited from an intensive intervention period involving an average of three hour-long sessions per week. The following paragraphs discuss the results, which can only be described as spectacular.

Lucie

Lucie is 8 years old. She lives with her parents and her brothers and sisters. She attends a special education class part-time in a primary school. Lucie expresses her needs with pictograms. She can walk and run, but her walking pattern is jerky and uneven. She can recognize the letters of the alphabet but cannot read. She does not know the numbers. She presents many manifestations of sensory disorders (kinesthetic, auditory…) and very poor movement dissociation of the upper limbs. She cannot grasp a pencil properly or make a controlled drawing in any direction. She can only scribble with a pencil clenched in her fist, using an overall trunk movement with the upper arm immobile. She cannot manage a single-piece peg puzzle over five centimeters in diameter with easy-grasp pegs because she lacks the motor skills needed to place the pieces in the proper cut out. Her productive work time is virtually nil, as her major sensory-motor difficulties prevent her from completing a task. An experiment was done with the computer in the hope she might access various learning and stimulation activities, since the movements required for a computer are simpler than those for a pencil.

However, she was unable to handle the mouse, even a trackball (inverted mouse) that simplified manipulations. Software using the mouse was also too complex, and operating the keyboard was for all practical purposes impossible. The child reacted to difficulties most of the time by giving up. She refused to continue the activity and left.

An experiment was then done with the tablet. The movements required for using the tablet are simpler than those for a computer or a pencil. As well, there are numerous applications designed for children that are clear and simple and require minimal motor control (Dumont, 2013). The first objective was to allow Lucie to use the tablet by herself, which would then allow for many learning and stimulation activities.

Prior to this, applications had to be found that corresponded to her level of development and capacities. The first experiment was to introduce her to the tablet with a simple game she might find attractive. Teaching her to use the tablet appeared almost impossible. Capturing her attention and having her succeed at simple tasks was a challenge. The applications *Injini*™, *Ready to Print*™ and *Trace and Share*™ were used in the beginning. These applications are well designed for teaching or rehabilitation, as they provide reinforcement and simple, clear instructions. The images are uncomplicated to avoid distraction, and adjustments can be made for levels of difficulty.

At the very start of the sessions, the specialist involved described the child's reaction as a miracle: Lucie was attentive, focused and motivated, and succeeded in performing very simple motor activities.

It was immediately possible to plan at least an hour of stimulation and learning activities using the tablet. Several sessions were needed to practice touch control, i.e., a one-finger touch in the right place. Sound feedback was a problem at times because Lucie liked hearing sound and could produce it by tapping all over the keyboard; the options therefore had to be adjusted to prevent undesirable reinforcements. Images needed to be simplified for the same reason as well. The design options, notably the guided access offered on the iPad™, enabled better control and graduated learning.

Once she had mastered the basic movements for using simple applications, Lucie demonstrated a surprising ability to understand instructions she may not previously have been able to express. Progress was made thanks to patience, perseverance, adjusted levels of difficulty, guided movement in the beginning and gradually reduced assistance. After a few weeks, she succeeded in making her first controlled drawings. She is now tracing letters and starting to read. She has been able to learn numbers, and many other kinds of learning are now available to her.

Among other things, the therapists have observed improved visual scanning of screen elements, reduced self-stimulation behaviours while using the iPad™, the development of cognitive skills - including deductive skills, categorization, detail perception and colour perception - and the development of learning through imitation (e.g., opening the iPad™, tapping three times on the button to deactivate Guided access, and learning access codes).

Alexandra

Alexandra is 15 years old and attends a special education class. She has speaking difficulties (simple words and non-sentences, slow and sometimes difficult pronunciation). She reads at a second grade level and can hold a pencil, but her writing is practically illegible. Alexandra can use a computer keyboard, but has major problems using the regular mouse. She requires help with all fine motor activities such as buttoning, tying laces, opening containers, hair-combing, colouring and cutting. She also has difficulties with respect to posture (accentuated lordosis) and overall motor skills (poor walking pattern, cannot run, jump, walk in a straight line, etc.). She tires quickly, and there is a limit to the amount of work she can do in a day. Because of her motor problems in particular, the kinds of learning and activities she can participate in are limited. These numerous difficulties have led to behavioural problems. Last year (2011-2012), Alexandra was unable to attend a special education class on a regular basis. She reacted to the slightest fear, contradiction or change by self-cutting and expressed frustration over the slightest mistake. This year (2012-2013), it took several weeks for her to adapt to the class: at first, she came to sit for a few hours a week in a room adjacent to the classroom with someone accompanying her. The amount of time was gradually increased, and she was finally able to integrate the classroom in the same manner.

The iPad™ was then tried for basic learning. Alexandra managed to carry out the required manipulations (tap and glide) by herself to use the applications selected for her. She was motivated by the pleasant and stimulating visual presentation, the musical accompaniment that helped sustain attention, the auditory and visual feedback that reinforced every success, and the possibility to act autonomously; for example, she insisted on doing things without outside help, which was practically never the case during other activities. In the beginning, she reacted by self-cutting when she made mistakes. Setting levels of difficulty so she could experience success gave her a sense of self-efficacy, and the negative reactions ceased. Correcting mistakes became easy and produced no negative reactions. She could now demonstrate her real cognitive abilities.

Several persons were surprised to see her succeed in activities that involved reasoning, logic and mathematics; this had never happened before, in large part because of motor difficulties. Removing this obstacle allowed her to develop an unsuspected potential.

Furthermore, Alexandra could work several hours at once, while maintaining her motivation, interest and attention and showing no signs of fatigue. Her behaviour had likewise improved; she smiled and appeared less stressed and anxious. She had been attending school part time at the start of the school year. After a few months, she increased her class time, saying she wanted to come to school more often because she enjoyed learning and seeing friends. The iPad™ thus offered her the chance to enjoy activities on her own;

she experienced successes and fewer frustrations. Alexandra's behaviour changed dramatically, and she was able to continue learning and developing.

Pierre

Pierre is 6 years old. He presents major graphomotor problems associated with language problems. After completing a first year of kindergarten (regular sector), he was still unable to print his name legibly. He had benefited from several months of traditional writing retraining, with no significant improvement (for example tracing letters on the dotted line, connecting the dots). The decision was made to have him repeat kindergarten. At the end of this second year, his writing had still not improved despite substantial work on motor rehabilitation. It was then decided to give him an iPad™ so he could write with the virtual keyboard. The iPad™ could also be used for different types of learning (reading, calculations, reasoning, etc.). Because Pierre's difficulties were a major source of stress, he was insecure and demonstrated poor self-esteem. Being able to use a tablet in class changed his perception of himself. He became a person with strengths, someone who could do interesting things and even be envied by others. There was no stigma to using an iPad™; it was fun and rewarding as well. He quickly learned to play various educational games that captured his attention, exhibiting no signs of fatigue, even after several hours. He experienced success and demonstrated strong motivation. The removal of obstacles caused by motor difficulties was a boon for Pierre as well; now he was no longer limited by his difficulties manipulating a pencil. The use of the tablet in class brought its share of problems, however: written assignments had to be emailed to the teacher, and it was necessary to install the Wi-Fi, anticipate the cost of the applications, and train teachers and other specialized personnel. Nevertheless, Pierre was able to attend regular first grade with his friends and continue his learning.

2.5.3. Effectiveness in Relation with Sense of Self-Efficacy

This study demonstrates the importance of considering the sensory-motor problems of ASD persons and the advantages of reducing requirements in this regard to allow them to better function and develop their potential. The tablet's features enabled these persons to improve their situation.

The motor requirements for carrying out a task are reduced, but other elements are contributing factors as well. Thus, thanks to the tablet, these persons could experience success instead of frustration. They received positive feedback. They were socially supported and acknowledged. Finally, they had fun learning since the tablet has an undeniably playful aspect. An analysis of these positive results points to another fundamental reason for its effectiveness: the tablet addresses the main avenues for an improved sense of self-efficacy, namely: 1) personal experience of success and failure; 2) observation of performance by others; 3) social support, and 4) emotional and physiological states (Bandura, 2007). It has been widely demonstrated, moreover, that self-efficacy is the best predictor of participation (Bandura, 2007). In addition, another element is considered when researching the explanation for MT effectiveness: the tablet is based on the principles of universal design, and this element will be discussed in the next paragraphs.

2.5.4. Universal Design

Regarding environmental adaptation, principles of universal design have been formulated to create environments that allow individuals with various difficulties, handicaps or levels of functioning to participate socially. Architectural accessibility is the best known example of environmental amenities for those living with reduced mobility (e.g., access ramps). Audible warning devices and tactile symbols are available for persons with visual impairments.

As well, universal product design enables the use of these amenities by as many people as possible (e.g., persons who are illiterate, intellectually impaired, mentally ill, elderly, etc.). Tools that take into account different sensory, motor, cognitive and perceptual problems are conceived based on the seven principles of universal design: equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort and, finally, size and space for approach and use (Center for Universal Design, 1997). Each principle is described below in relation to mobile technologies.

The following paragraphs briefly describe each principle of universal design (in italics) and discuss how MTs operationalize each of these principles (Center for Universal Design, 1997). The design of applications for tablets and smartphones based on these principles is also considered.

Equitable use: *The design is useful and marketable to people with diverse abilities*. The iPad™ can be easily used by very young children, the elderly and those who are illiterate, intellectually impaired, mentally ill, etc. The enormous variety of applications designed for these devices makes it possible to respond to diverse needs and levels of ability.

Flexibility in use: *The design accommodates a wide range of individual preferences and abilities.* MTs allow for numerous settings in the accessibility options (e.g., easily enlarging letters or images, adjusting sound volume, etc.).

Applications offering possibilities for adjustment, settings, levels of difficulty and other options may also respond to this criterion.

Simple and intuitive use: *Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills or current concentration level.* Control buttons on the iPad™ are reduced to a minimum, and its use is relatively easy to understand without instructions. The only thing required is to touch the image that corresponds to one's preference, and the choice is usually correct. This is the opposite of computer programs where the user is offered the largest number of options possible and must navigate carefully through menus and submenus. Applications designed to avoid information overload, guide the user to key elements or provide indications respond to this criterion.

Perceptible information: *The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.* MT icons can be easily understood without knowing how to read. Furthermore, they may offer a voice synthesizer that reads instructions. Applications that provide spoken and visual instructions and different forms of feedback respond to this criterion.

Tolerance for error: *The design minimizes hazards and the adverse consequences of accidental or unintended actions.* The iPad™'s main control button is easy to access and few problems occur if the user touches it by accident. Furthermore, restrictions may be placed in the accessibility options to control the buttons. Applications designed for teaching that tolerate a certain level of movement imprecision respond to this criterion. To give an example, if an icon must be moved to a certain place during a proposed activity, the operation will be completed by the program if the user lacks the necessary precision skill to perform it.

Low physical effort: *The design can be used efficiently and comfortably and with a minimum of fatigue.* The iPad™ requires less precision skill and movement dissociation than the pencil or the mouse. As a result, its design removes an important obstacle for persons with motor difficulties. A user with the motor skills to use it can access a wealth of possibilities in terms of learning and occupations. Applications designed for minimal precision of movement can be used by a larger number of people.

Size and space for approach and use: *Appropriate size and space is provided for approach, reach, manipulation and use regardless of user's body size, posture or mobility.* MTs offer possible alternatives for those with major disabilities. Thus, TMs are available in several formats (iPad™, iPad mini™, iPhone™, iPod™ and others) and, thanks to Wi-Fi and size, it can be used in different places - at home, school, work or elsewhere (classroom, recreational area, bedroom, living room sofa, etc.).

Other technological tools, such as switch access scanning, also offer iPad™ access to persons with major disabilities.

On the whole, many elements cited by the experts or in the literature consulted are consistent with the principles of universal design, such as usability, perceptible information, flexibility and others. A number of specific characteristics are highlighted as well, including the motivating aspect of these tools or the notion of *kairos*. Generally speaking, MTs can contribute to the development and autonomy of persons with disabilities. They have the potential to reduce constraints and obstacles and facilitate these persons' participation in a number of occupations.

DISCUSSION

This chapter began by reporting on the state of current knowledge of sensory-motor disorders and their impacts in relation to persons with ASD. It then looked at interventions that could prove effective for this clientele. The effectiveness of interventions using the environment and mobile technologies in particular was analyzed based on three sources of data: expert consultations, scientific research and case studies. The characteristics of the tablet and other MTs were then discussed in function of the principles of universal design.

Thus, this study and its accompanying discussion explain how tools like the tablet and other MTs can be beneficial. Generally speaking, they respond to the principles of universal design and support the main targets for developing a sense of self-efficacy. More specifically, the tablet reduces the effort required to write or manipulate, leaving greater room for learning, reasoning and other cognitive functions. It thereby avoids memory overload, notably for dyspraxic individuals who have difficulty automatizing movements (Barendse et al., 2013; Chukoskie, Townsend and Westerfield, 2013). It is a captivating tool for young people that can increase their motivation, attention and productive work time. It makes learning fun, which is a gauge of success.

Tablets and other MTs also offer various tools for developing motor imitation, a type of intervention that has been shown to be effective. Thus, a particular advantage is that the video, the camera and the applications that simplify a montage are combined into a single apparatus when video modeling is used for a specific objective or learning activity. Many applications are even designed to provide various scenarios (Dumont, 2013). Video modeling with the direct use of the tablet has also been the focus of several studies demonstrating the relevance of this type of intervention (Cardon, 2012; Mintz, 2013; Mintz, Branch, March and Lerman, 2012; Murdock, Ganz and Crittendon, 2013; Vandermeer, Beamish, Milford and Lang, 2013).

Thanks to MTs, the desired model or scenario can thus be easily created in the person's environment with participants he knows or with himself as a participant. MTs can also be transported to the venue for learning or activities at the right time and the right place (*kairos*).

As regards play, MTs offer various and often unique possibilities that can benefit children with disabilities (Helps and Herzberg, 2013). Indeed, the tablet offers panoply of applications for children with sensory-motor difficulties that would be difficult or impossible to play with traditional toys (dolls, trucks, puzzles, blocks, computers, consoles, etc.).

Computer technologies also serve as intermediaries that facilitate communication or interactions in diverse situations including play (Cardon and Azuma, 2012; Glenwright and Agbayewa, 2012; Hopkins et al., 2011; Kenworthy, Yerys, Antony and Wallace, 2008). In interaction with an adult, the tablet can thus contribute to the development of play in children, an essential element in their evolution.

What about the question of free play, more specifically? In free play, the child decides what to do with objects without adult guidance. Ferland (2005) explains that free play favours the child's imagination, fantasy and creativity. All the child's competencies (intellectual, motor, relational, sensory…) are exercised in play and the pleasure derived from it. During group activities, children learn to conduct themselves socially, decide on the meaning of their relationship to the other and resolve conflicts. In free play, they practice decision-making, evolve at their own rate, discover their own interests and, finally, engage fully in the activities they wish to pursue. Although there has been little scientific writing on the subject, free play as an outdoor physical activity can potentially improve numerous aspects of physical and emotional well-being by reducing anxiety, depression, aggressiveness and sleeping problems (Burdette and Whitaker, 2005; Janssen and Leblanc, 2010).

Free play using the tablet or another MT is a different matter. In this instance, the child is confined to a rather sedentary and sometimes solitary activity. Some game activities used with young ASD persons risk increasing repetitive behaviours or causing overstimulation (Arthanat, Curtin and Knotak, 2013). Thus, when children use MTs, it's important to exercise a certain control, particularly in the choice of applications they can access.

Because MTs have the pitfalls described in the list above, certain conditions must be observed to obtain conclusive results. Another factor to consider is that the simple fact of owning a tablet or MT is not necessarily a benefit in itself. Furthermore, the teacher or the therapist who wishes to use these tools must plan to spend a certain amount of time becoming familiar with them, notably with the many settings that can facilitate its use for persons with impaired functioning, as proposed in the iPad™'s access options. Knowledge of the applications appropriate for a situation based on the user's capacities and targeted objectives also calls for investing time. Thousands of applications are available for different learning activities or situations. Several directories of applications have, moreover, been created to support the work of users in this regard (Dumont, 2013). Applications must present the just right challenge, i.e. a level of difficulty conducive to success in a challenge that is adjusted according to the person's capacities with a view to improving sense of self-efficacy. Those that are too easy do not allow for progress; those that are too difficult lead to failure and frustration. As a result, applications that include settings for levels of difficulty and are designed for teaching or rehabilitation should be privileged. Generally speaking, to obtain meaningful results, one must know the person's capacities and preferences, target relevant objectives, make a judicious choice of applications and structure their use within certain routines, whether in therapy, as part of a teaching program in class, or at home.

The tablet can thus be recommended for ASD persons at home, in therapy, or at school. An inclusive school should be able to offer the use of this tool, notably as a compensatory aid, especially for persons with sensory-motor difficulties that impede writing or using a computer (Karsenti and Fiévez, 2014; Rousseau and Angelucci, 2014).

Overall, MTs are components of an inclusive environment that, when used properly, have the potential to develop aptitudes (shared attention, memory, reasoning, fine motor skills…), foster accomplishment of occupations - including play - and facilitate various types of learning. They can be of particular benefit for persons with sensory-motor difficulties that impede the achievement of activities.

CONCLUSION

The evolution of knowledge allows for improved understanding of the deficits of ASD individuals and their sensory-motor, neurological or cognitive particularities. These persons may be assisted not only by attempts to reduce deficiencies, but also by acting on environmental factors to foster their participation in social life based on their aptitudes. It is not possible, of course, to cure autism and/or eliminate its associated deficiencies, but their impact can nevertheless be mitigated by encouraging ASD persons to participate using appropriate tools in an inclusive environment.

Their sometimes exceptional aptitudes may be put to further use if strategies are found that allow them to express these aptitudes. A notable way to accomplish this may be to simplify sensory-motor requirements.

In this text, the masculine gender is used solely for convenience and includes the feminine.

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