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# Sensory Differences and Stereotyped Movements in Children with Autism

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Abstract

This study was designed to test whether there is a functional relationship between sensory stimulation and stereotyped movements (SM). Four children with autism and intellectual disability (according to DSM IV criteria) who showed stereotyped movements were studied. The Short Sensory Profile was used to define whether a child perceived stimulation within each sensory modality as aversive, attractive, or neutral. The Stereotyped and Self-Injurious Movements Interview was used to identify each child's repetitive movements. Children were then exposed to sensory stimuli that were neutral, aversive, or attractive. Results indicate that children: (a) initiate or increase stereotyped movements immediately following the onset of an aversive stimulus; (b) terminate or decrease stereotyped movements following the onset of an attractive stimulus; and (c) initiate or increase stereotyped movements during periods of neutral stimulation. We conclude that stereotyped movements are functionally related to sensory stimulation; individuals who frequently engage in stereotyped movements may do so in order to cope with under-stimulation and aversive over-stimulation.

Key words: Stereotyped movements, sensory sensitivity, autism, intellectual disability

Stereotyped movements (SM), or stereotypies, are patterned repetitive movements that share at least three characteristics: a high frequency of repetition, an invariant form, and an inappropriate or odd manifestation such that the movement lacks an obvious goal. Typical SM include rhythmic body rocking, head bobbing, arm or hand flapping, eye rolling, finger wiggling, finger waving (in front of the face), and hair twirling (Schopler, 1995).

Stereotyped movements are a feature of normal behaviour, especially during infancy. Among adults, they are especially evident when a person is bored or anxious (de Lissavoy, 1961; Thelen, 1979). More commonly, SM appear in captive animals, in persons who have mental illness or a disability, and in persons given stimulant drugs (Mason, 1991). Most commonly, SM are observed in individuals with autism—whether or not the person is also intellectually disabled (Bartak & Rutter, 1976). Among individuals with autism and profound intellectual disability, elaborate motor routines may be the only way of expressing the restrictive repertoire of activities and interests that contribute to the diagnosis of autism (Schopler & Mesibov, 1995; Gillberg & Colleman, 1992). Among individuals with autism who are less intellectually disabled, repetitive movements may include lining objects, flicking light switches, or showing attachment to and manipulating an object like a string, a rubber tube, or a toy (Schopler, 1995).

By definition, SM lack an obvious goal or function, but there is evidence that SM are in fact rewarding (Mason & Turner, 1993). For example, some SM are difficult to abolish by punishment or by the differential reinforcement of alternative behaviour. These stereotypies so engage a child’s attention that the child is unlikely to notice alternative pursuits and, if noticed, the SM are more attractive than the alternatives (Wing, 1976). Individuals will perform other work in order to gain an

opportunity to perform some SM (Berkson & Mason, 1964). People with autism who engage in SM seem 'driven' to carry out the activity in a certain way. When SM are interfered with, the person usually becomes anxious and unhappy which, in turn, often precipitates a range of problem behaviours (Schopler & Mesibov, 1995). If stopped from performing one stereotypy, individuals will sometimes perform an alternative one.

Although the goal of SM is not obvious, close study suggests that they are reinforcing and that their function is the amelioration of a sub-optimal environment (Mason, 1991). According to Mason (1991), SM can be used to inhibit central nervous system activity. The SM of people with autism are accompanied by increased heart rate *variability*, a response that is associated with REM sleep and other states of low stimulus input (Hutt & Hutt, 1978). Leg swinging is associated with *reduced* heart rate in normal children who tend to perform these movements in association with tasks, such as abstract school work, which are not engaging (Soussignan & Koch, 1985). Stone claimed that the SM of blind retarded children are accompanied by brain waves typical of drowsiness (Stone, 1964). In other words, SM may lower a person's responsiveness to external stimuli (Odberg, 1978) or inner stimuli such as pain (de Lissavoy, 1961) and focus attention away from the source of conflict (Wiepkema, 1987) and frustration (Dantzer, 1986). SM may reflect the activation of the lower brain structures controlling motor behaviour in the absence of normal inhibitory control by higher nervous functions (Dantzer, 1986).

Dantzer (1989) proposes that SM gain strength because of the positive feedback effect of sensory stimulation on their underlying control system, which leads to a progressive sensitisation of these neural systems and a more optimal level of arousal. SM have been associated with barren and restrictive environments that are

regarded as sub-optimal for an individual's basic arousal needs (Toates, 1983). In these situations the proprioceptive and other sensory input are thought to be reinforcing in a dull, unstimulating environment (Mason & Turner, 1993).

Paradoxically, SM have been thought to be rewarding not only because they provide sensory stimulation in under-stimulating environments but also because they lower responsivity to sensory stimuli in over-stimulating environments. For over three decades, researchers hypothesised that SM serve to reduce chronically high arousal levels, specifically in children with autism. This notion relies on the hypothesis that non-specific activity of the ascending reticular activating system is at a chronically high level in autism. The child with autism strives to lower it by engaging in SM which serve as displacement activities and block further sensory input relating to the arousing situation (Hutt & Hutt, 1965; Zentall & Zentall, 1983).

SM may be reinforcing under conditions of both over- and under-stimulation because they represent a coping mechanism that allows the person to maintain homeostasis, that is, an appropriate level of perceived stimulation (Fraser & Broom, 1990). Although perceived stimulation will often be a function of the number and intensity of stimuli in the objective environment, it will also be a function of a person's sensitivity or ability to access environmental stimuli (Wing & Wing, 1976). The ability to access stimuli is clearly limited in people with a sensory disability (for example hearing or vision impairment) and in people with various motor or cognitive dysfunctions. Alternatively, an individual may be over-sensitive to one or more categories of sensory stimulation.

Both ends of this sensory spectrum are commonly observed among people with autism. Higher functioning people with autism describe both hyper- and hypo-sensitivity to stimulation in various sensory modalities as well as unpredictable

fluctuation between hyper- and hypo-sensitivity (Cesaroni & Malcolm, 1991; Grandin, 1995; Stehli, 1997; Williams, 1992). Clinical descriptions of autism typically refer to unusual sensory reactions and interests (Demeyer, 1971). Wing and Wing (1976) suggest that children with autism typically have odd and contradictory responses to sensory input. Gillberg and Coleman (1992) argue that abnormal reactions to sound are common among young children with autism. Bettison (1994) reports that 65% of parents with a child with autism say that their child shows a distress reaction to some sounds or to other sensory stimulation. These parents also report that their children respond abnormally to pain, to heat or cold, and tend to have a withdrawal or squeal reaction to light touch. Abnormal responses to visual stimuli are probably present in a large majority of young children with autism, who often have difficulty recognising what they see (Gillberg & Coleman, 1992), are overly sensitive to light, especially bright, flashing, or blinking lights, and often have difficulties finding things due to visual overload (McMullen, 2001). Peculiarities of gaze, usually interpreted as a social deficit, may be taken as evidence of an abnormal perceptual response, as could the fascination with contrasts of light. Ornitz, Guthrie, and Farley (1977) and Volkmar, Cohen, and Paul (1986) found that 70% of children with autism are described as having disturbances of all sensory modalities. Both abnormal orienting and habituation responses to sensory stimuli were observed among subjects with autism in psychophysiological research (Dawson, 1989; James & Barry, 1980). In reviewing clinical studies, experimental studies, and firsthand accounts, O'Neill and Jones (1997) found that sensory-perceptual abnormalities are a feature of autism (cf. Greenspan & Weider, 1997) and contribute to the distress, fear, anxiety, and pain of people with autism.

Sensory-perceptual differences and stereotyped movements are both common to autism, but how these characteristics relate to each other has not been clearly established. Baranek, Foster and Berkson (1997) found that children with autism and related disabilities who also have high scores on measures of tactile defensiveness tended to show more stereotyped behaviour then children with autism who do not have a high level of tactile defensiveness. However, there are considerable differences between individuals in the extent to which they respond to a situation with stereotypy (Mason, 1991). If a stereotypy is a coping response, the extent to which it is performed will be influenced by the extent to which an individual perceives and is affected by sub-optimal aspects of the environment (Odberg, 1987). For example, individuals may differ in their optimal levels of arousal (Wood-Gush, Stolba, & Miller, 1983), or in the extent to which they can predict stressors (Dantzer, 1989), or in how frustrating they find specific situations. Therefore, before assessing the effectiveness of stereotypies as a coping mechanism, it is important to take into account specific individuals' differing sensitivities to the stereotypies' eliciting sensory stimuli. In other words, it will be essential to identify what factors might serve as stressors (stimuli to which an individual is oversensitive and which are experienced as aversive) and what factors might serve as incentives (stimuli to which an individual is undersensitive and which are experienced as enjoyable) for each individual.

This study was designed to assess whether there is a functional relationship between SM and sensory stimulation in children with developmental disabilities. In particular, we were interested to assess whether a child's differential sensitivity to stimulation across sensory modalities covaries with SM responses to the onset of sensory stimulation. Three patterns of behaviour can be anticipated. First, a child may

be oversensitive to stimulation in one or more modalities. If the child experiences stimulation in this modality as aversive, that situation will increase arousal levels, and the child will try to control the effects of the stimulation by engaging in increased SM. Second, a child may not be able to access the stimuli that are objectively present in the environment if the stimuli are not presented directly to the child according to the child's needs. In such a neutral stimulation condition, the child will perceive the environment as barren, and will respond with increased SM in order to balance his/her deprived sensory system. Third, if a child is under-sensitive to stimulation in one or more modalities, the child may need intensive stimulation to achieve balanced arousal within this sensory modality. A situation that supports the child with the extra stimulation that the child needs would be experienced as attractive. In this case, we expect a decrease in SM following stimulation because the child would have no 'need' for the extra stimulation that the SM would otherwise provide.

## Method

### Participants

The participants were four intellectually disabled (IQ < 50) children with autism who showed stereotyped movements. Participants were two girls aged 7 and 14 and two boys aged 8 and 12. The children were recruited from a special education school in upstate New York. Diagnosis was based on DSM-IV criteria and was assessed using the Battelle Developmental Inventory (BDI; Newborg, Stock, & Wreck, 1984). Three of the four children were ambulatory and did not suffer from other health conditions. One child (Child "J") suffered from cerebral palsy and ambulated with the aid of a wheelchair or a walker. All children needed constant care and support in order successfully to complete daily activities. No child had a

diagnosed sensory impairment such as deafness or blindness, but all children were reported to show sensory sensitivity.

Instruments

Short Sensory Profile (SSP; Dunn, 1999). The SSP is designed to screen for impairments in sensory processing among children aged three to ten years, and includes 38 items of the 125 items in the original Sensory Profile. Retained items are those that best discriminate between children with and without disabilities, and that relate directly to sensory events. The SSP includes 7 sections: tactile sensitivity, taste/smell sensitivity, movement sensitivity, under responsive/seeks sensation, auditory filtering, low energy/weak, and visual/auditory sensitivity. Parents or educators use a 5-point Likert scale (1 = always: when presented with the opportunity, the child responds in the fashion described 100% of the time; 5 = never: when presented with the opportunity, the child responds in this fashion 0% of the time) to rate the frequency of responses. Internal reliability of the 'total' and 'section' scales ranges between 0.70 and 0.90. Inter-correlations of the SSP total and section scores range between 0.25 and 0.76. Children with abnormal skin conductance responses to sensory stimulation have significantly lower scores on all sections of the SSP than do children with normal skin conductance responses.

Stereotyped and Self-Injurious Movements Interview (SSIMI; Gal, Passmore & Dyck, 2001). The SSIMI, an adaptation of the Repetitive Behaviours Interview (Turner, 1999), is a 30-item structured interview that was designed to assess subtypes of repetitive movements, including stereotyped movements, stereotyped manipulation of objects, and self-injurious movements. SSIMI is still undergoing a process of validation.

Procedure

Each child was tested at his/her school in a small room, which included a mattress, a blanket, a rocking chair, a light board, an audio tape recorder and tapes, and a vacuum cleaner. The researcher was in the room, as was another person who videotaped the child. While in the room, each child was exposed to three stimulus conditions: neutral stimulation, aversive stimulation, and attractive stimulation. In the neutral stimulation condition, no stimuli additional to those already in the room were presented to the child. In the aversive stimulation condition, a stimulus to which the child had been rated as over-sensitive was presented. In each case, the aversive stimulus was something to which all children were frequently exposed in the ordinary course of their lives. In the attractive stimulation condition, a stimulus to which the child was not over-sensitive was presented. Each stimulus was presented for two minutes, beginning with the neutral stimulus, followed by the aversive stimulus, and then the attractive stimulus. The child's response to each condition was recorded on videotape. Within each condition, the appropriate video segment was analysed frame by frame for stereotyped movements during two minutes intervals. The total time, out of two minutes, spent engaging in one or more stereotyped movement was calculated. To ensure that coding was reliable, videotapes were coded by the same researcher on 3 occasions, each separated by 2 weeks. There was no disagreement between the second and third administrations, and these results were retained.

## Results

### Child "A"

A is a 14-year-old girl with an intellectual disability and autism. A was evaluated by the BDI and was shown to have social skills equivalent to 10 months of age, gross motor skills of 16 months, cognitive skills of 8 months. Her receptive language skills are equivalent to 21 months of age, however she is unable to talk and

uses the communication book for choice making. A is very social, smiles and displays affection to staff members and peers. She has poor balance, but she walks, she eats with minimal assistance, but needs assistance in toileting and dressing. According to the results of the SSP, A perceives loud noises as aversive, and shows sensitivity in the tactile and movement modalities. According to her classroom teacher, A reacts to loud noises by startling and having a fearful expression on her face. She reacts to being touched by pushing the toucher's hand away. She especially dislikes uncontrolled, surprising touch, and while she is willing to accept touch, she holds the person's hand in order to control it. A also becomes anxious and distressed when her feet leave the ground. Attractive stimuli were identified in the visual and taste/smell modalities. A enjoys and explores visual stimuli and loves to eat all sort of foods. Surprisingly, as it can be considered as a tactile stimulus, A's favorite sensory stimulus is flowing air from a hair dryer. She strongly prefers to control the machine herself rather than have it controlled by other people.

According to the SSIMI, A shows rocking in a sitting position, object twiddling, teeth grinding and repetitive vocalization. These behaviours are shown very often, especially when she is not engaged in any other activity, but also during classroom activities.

For the experiment, the aversive stimulus was the sound of a vacuum cleaner (selected because it did not require a direct, very aversive touch by another person). The attractive stimulus was the hair dryer; the hair dryer was held by the researcher and manipulated by A who directed the researcher's hand. During the experiment, A showed two stereotyped movements: twiddling objects, and rocking in a sitting position. Both behaviours were observed during the neutral stimulus condition when A rocked for 28 seconds and flipped an object for 17 seconds (out of 120 seconds; see

Figure 1). The rocking movements intensified during presentation of the aversive stimulus to 40/120 seconds. Finally, during presentation of the attractive stimulus, no flapping was observed and rocking decreased to 7 movements, or 7/120 seconds.

Child "J"

J is a 12-year-old boy with multiple disabilities including autism and intellectual disability. J was assessed (BDI) to have social skills, adaptive behaviour and gross motor equivalent to the age of 28 months, and cognitive skills equivalent to 16 months of age. He needs assistance with toileting, cleanliness, and dressing as well as hand over hand assistance with most activities. He has unintelligible articulation skills and limited verbal understanding. J had multiple ear infections earlier in childhood, and at times appeared deaf to people who worked with him. As a child, he developed self-injurious behaviours such as ear hitting and finger biting, which he performed both as a response to his surroundings or for no apparent reason. J's SSP revealed visual sensitivity: he seems to be distressed by sudden visual changes and by intensive movement around him. He reacts to these situations with stereotyped and self-injurious movements or by shutting down. For J, attractive stimuli are concentrated in the taste, vestibular and auditory modes. He loves loud and/or monotonous music, food, and slow movement. He often chooses to spend his free time on a swing. For the experiment, the aversive stimulus was in the visual domain: various objects were flipped or rolled in front of his eyes. The attractive stimulus that was chosen was in the auditory domain: loud music. As Figure 2 shows, J performed several stereotyped movements during the experiment. Very few SM were evident during the attractive stimulus condition (4/120 seconds), but were prominent in both the neutral (49/120 seconds) and aversive (68/120 seconds) stimulus conditions.

Child "M"

M is a 7-year-old girl with multiple disabilities including autism and an intellectual disability. According to BDI results, her social skills are equivalent to 11 months of age, her gross motor skills to 22 months of age and her cognitive ability to 8 months. She is ambulatory, she can scoop to feed herself and retrieve her cup to drink, but is dependent upon adults for all other daily living skills. She is non verbal, but laughs at times of interactive play. Her receptive language is equivalent to 20 months of age. M is usually in constant movement; it is rare to see her sit still. Because she frequently takes objects in order to flip them, her therapist tied a string around her belt so that something was always available for her to flip. This intervention reduced M's distractibility, but did not change the frequency of the flipping behaviour.

According to her SSP, M loves movement and visual stimulation. She loves to swing and is attracted to the light switch, which she flicks repetitively. M does not like loud noises or a gentle touch. The SSIMI revealed that M's most common repetitive behaviours are object flipping, rocking in both sitting and standing positions, and head and neck movements. For the experiment, the aversive stimulus was loud music, and the attractive stimulus was exposure to a light board (a board with textures and flickering lights, which can be used either by manipulating/touching, or visually only). M's most common SM was rocking in a standing position.

M reacted to the aversive stimulus with intensive rocking (98/120 seconds), during which she sometimes also flipped her string (see Figure 3). Rocking movements were evident only during the aversive stimulus condition. All SM were much less common during the attractive stimulation (4/120 seconds) and neutral stimulation (8/120 seconds) conditions. It was noted that in comparison to the other

children who hardly approached the environment if it was not presented to them, M initiated interaction with stimuli around the room. Because she was able to use the environment for her benefit more then the other children (because of an ability to initiate interaction and curiosity about her environment rather than because of physical ability), it can be assumed that the environment was not perceived by M as a barren one during the "neutral" stimulus, which may explain the relatively small number of stereotyped movements during this condition.

Child "K"

K is an 8-year-old boy with autism and an intellectual disability. According to BDI results, K's social skills are equivalent to 19 months of age, his gross motor and cognitive skills are equivalent to 22 months. K is non verbal, and usually seems to lack motivation and ability to communicate his needs and wants to others. He uses a communication book accurately when he is thirsty. His receptive language is equivalent to 22 months, and he usually responds to directions. K is ambulatory and he can feed and dress himself. Like M, K is in constant movement. He becomes upset when he is required to remain still. When allowed to move freely, he is usually a content, smiling child. K's SSP revealed that he responds positively to movement, touch (especially firm or vibrating stimulation), and smell/taste. K does not like loud noises. What is most aversive to him is to be "prevented from moving." The SSIMI revealed that K performs various SM including pacing or moving around the room, rocking, spinning, finger movements, leg and feet movements, and noise-making, and some self injurious behaviours such as self slapping and biting. For the experiment, the attractive stimulus was a vibrator toy that was applied along his body. The aversive stimulus was the sound of the vacuum cleaner.

During the neutral stimulus condition (see Figure 4), K walked to the rocking chair and rocked himself (62/120 seconds). Although rocking in a rocking chair is usually an appropriate activity, K spent most of the time rocking on his knees, and for this reason his rocking activity was categorised as a stereotyped movement. During the aversive stimulus condition, K originally showed intensive rocking movements in a sitting position, then he covered himself and lay down while moving his legs. After approximately 35 seconds (30/120 seconds), he calmed down, and looked content, but he remained lying down, well-covered, until the end of the aversive stimulus. During the attractive stimulus condition, K did not show any SM.

## Discussion

The purpose of this study was to assess whether there is a functional relationship between stereotyped movements and sensory stimulation in children with autism and intellectual disability. In particular, we were interested to assess whether a child's differential sensitivity to stimulation across sensory modalities covaries with SM responses to the onset of sensory stimulation. The results of this study provide strong evidence for a functional relationship between SM and sensory stimulation. The presentation of sensory stimulation that had been categorised as 'attractive' consistently resulted in a reduction in SM, and the presentation of sensory stimulation categorised as 'aversive' consistently resulted in an increase in SM. The effects of 'neutral' sensory stimulation more closely resembled those of aversive than attractive stimulation in 3 of the 4 children. The implication of these results is that stereotyped movements are adaptive behaviours that help individuals with autism to regulate their level of arousal.

### Sensation and Movement

The relationship between SM and arousal has been discussed for some 40 years, usually in contradictory terms. According to one view, SM serve to relieve under-arousal caused by too little environmental stimulation (Goodall & Corbett, 1982; Schopler, 1965). According to an alternative view, SM are a product of over-stimulation and serve as a displacement activity to block sensory input and to reduce arousal (Hutt & Hutt, 1965). Our results are consistent with both views, but they also indicate that in order to determine whether a given environment will be under-stimulating or over-stimulating, it is necessary to assess how a person responds to different categories of sensory stimulation. The sensory modality in which a person is stimulated may be more important than the objective intensity of a stimulus in determining whether too little or too much stimulation is available.

One reason why SM have been thought to lack goal direction is that often there is no obvious connection between the form of the stereotypy and the available stimuli. Most of the SM that were observed in this study were not congruent in form with the mode of stimulation. For example, when Child A was exposed to an aversive *auditory* stimulus, she responded by covering her *eyes* while rocking. Rather than indicating a lack of connection between sensory stimulus and motor response, this relationship may illustrate what high functioning adults with autism describe as multi-channel perception (Cesaroni & Malcolm, 1991). Some people with autism perceive stimuli from one sensory modality as if they originate in a different sensory system. The person responds according to what has been perceived rather than according to what has been objectively presented. Alternatively, the lack of congruence in the form of the SM with the mode of stimulation may imply that SM function to regulate arousal within a general sensory system rather than to regulate arousal within a specific sensory modality

Functional Heterogeneity of Stereotyped Movements

As the frequency of SM varies systematically according to whether a stimulus is attractive, aversive or neutral, there is reason to believe that the relationship between SM and sensory stimulation is a functional one, and that one of the functions of the SM is to help a person cope with an environment that provides too little stimulation or too much stimulation. This coping mechanism may compensate for the lack of environmental or self-based stimulation in the case of a 'neutral' situation, or, alternatively, it might serve to release anxiety and sensory over-stimulation by discharging tension during 'aversive stimulation'.

Nonetheless, the hypothesis that SM function to regulate arousal is an incomplete hypothesis. It does not account for the specificity of the SM that are elicited under conditions of under- or over-arousal, or even for an individual's choice of stereotyped movements rather than, for example, behavioural apathy as a coping mechanism. In this study, children invariably performed more than one SM. In some cases, SM were specific to a stimulus, and in other cases were common across stimuli. Child M, for example, reacted with extreme rocking to an aversive stimulus but did not show this response to attractive or neutral stimuli. On the other hand, her string flipping behaviour was evident (if in varying degree) during all three stimulus conditions. These two SM appear to serve different functions for M and illustrate Turner's (1999) contention that SM are heterogeneous and have multiple subtracts.

Some SM appear to be chosen for their relaxing effects. In this study, the most common SM response to aversive stimulation was rocking—present in 3 of 4 children. Rocking is known to have a relaxing effect (Ayres, 1979) and it can be assumed that rocking helps the child establish homeostasis under conditions of over-stimulation. The presence of a particular SM, however, will also depend on other

factors, including whether a given SM is ‘developing’ or ‘established’ (Mason & Turner, 1993), on the ‘maturity’ of a person’s central nervous system (Thelen, 1979), and whether or not there are specific deficits in executive functioning (Turner, 1997). Mason (1991) distinguished ‘developing’ from ‘established’ SM because these forms differ qualitatively in their emotional and motivational correlates, in how they interact with medicines and interruptions, in the fixity of performance, and in the degree to which they are emancipated from their original eliciting stimuli. Established stereotypies are much more difficult to discourage or interrupt (Cronin, Wiepkema, & Hofstede, 1984). Whereas developing SM usually relate to a specific overwhelming situation, established SM are often performed outside the original eliciting situation (Odberg, 1978), and sometimes even in the absence of apparent conflict (Kennes, Odberg, Bouquuet, & de Rycke, 1988). The string flipping behaviour of Child M, which was observed across stimulus conditions, probably represents an established SM that is not closely bound to external stimulation.

The relationship between SM and maturation is illustrated by the fact that spontaneous, repetitive movements are a common feature in the normal development of infants, and are known to continue until about 12 months of age (Piek, 1995). Thelen (1979) suggests that characteristic rhythmical patterns are the precursors to particular stages of motor development, and argues that spontaneous movements are defined by the level of maturation of the CNS. She later suggested that infant spontaneous movements form the neuromuscular bases from which higher skills such as sitting and walking are built (Thelen, 1991). Sporns and Edelman (1993) argue that through successive selection, the infant will build up a stable repertoire of movements. Later in life, these movements are less common and appear only when a person is stressed (Soussignan & Koch, 1985). In other words, among healthy

individuals, SM appear to serve as a coping mechanism. It is possible to assume that in response to stress, inhibitory control by higher nervous structures is reduced, resulting in regression to more primitive forms of movement controlled by lower brain structures. The idea that SM are a normal response to stress is important because it implies that under conditions of abnormal stress perception (as a function of abnormal sensory processing in autism), SM are a normal response.

Finally, stereotypies may also be caused by brain abnormalities in systems that subserve executive functions (Turner, 1997). Research shows that children with autism have various deficits in executive functioning (Hughes, Russell, & Robbins, 1993; Turner, 1997). According to motor control theorists, human motor responding is based on the simultaneous integration and cooperation of many anatomical parts (Schmidt, 1988). The dynamic system approach to motor control (Gibson, 1979) suggests that action and perception mutually guide each other in a process that detects invariants which define the properties of events, objects and places. If SM are the product of a dynamic sensory-motor system, then a dysfunction in one or more parts of this system will lead to these movements. When neither the sensory nor motor system give the individual reliable information (as in autism and intellectual disability), an increase of SM is to be expected. Our research supports the view that SM are not solely a motor phenomenon, but are also strongly connected to the sensory system.

Limitations and Conclusions

Although our results are consistent with the observations of others and suggest a way of resolving apparent contradictory hypotheses about the function of SM, our small sample means that we must be cautious about generalising the results. We also recognise that failure to counterbalance the order in which stimuli were presented

means that we cannot exclude the possibility that our results are due, in part, to unanticipated order effects. In order to minimise the aversiveness of the study for the participants, we preferred to end the session with a pleasurable stimulus rather then an aversive one. A third limitation is the fact that the research environment was not objectively barren, which entailed that the 'neutral' stimulus condition was not, in fact, neutral for all participants: some children were able to initiate interaction with the objects in the room. We assume that use of an objectively barren environment would have increased the similarity in subjects' SM responses between the neutral and aversive stimulus conditions.

The results of this study support the hypothesis that SM are adaptive behaviours that help individuals with autism to regulate their arousal. The close relationship between sensory stimulation and SM observed in this study supports the view that "the distinction between sensory and motor functions has neglected the very essence of the problem, and that is sensory and motor functions, or alternatively perception-action-perception coupling is a cyclic phenomenon" (Glencross, 1995, p. 3). It is likely that future research that controls for individual differences in sensitivity to different categories of sensory stimulation will help us to understand the complex interactions that determine an individual's choice of specific SM in specific stimulus conditions.

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Figure 1

Time spent by Child “A” in stereotyped movement during each of three sensory stimulation conditions, by SM type and Total SM

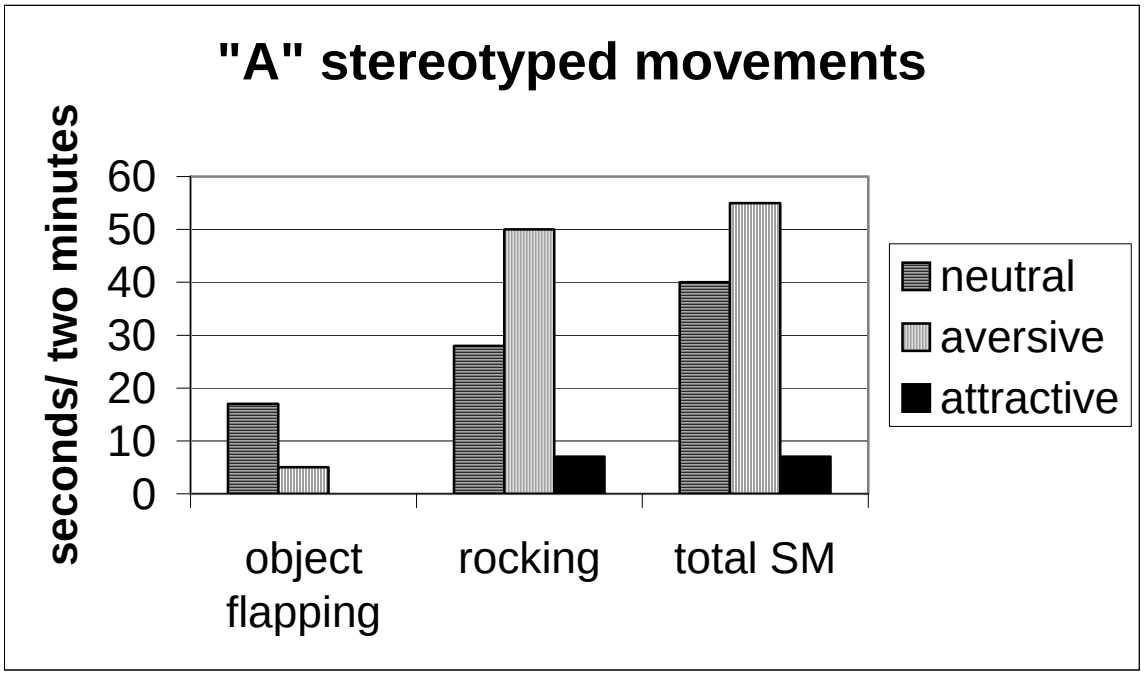

Figure 2

Time spent by Child “J” in stereotyped movement during each of three sensory stimulation conditions, by SM type and Total SM

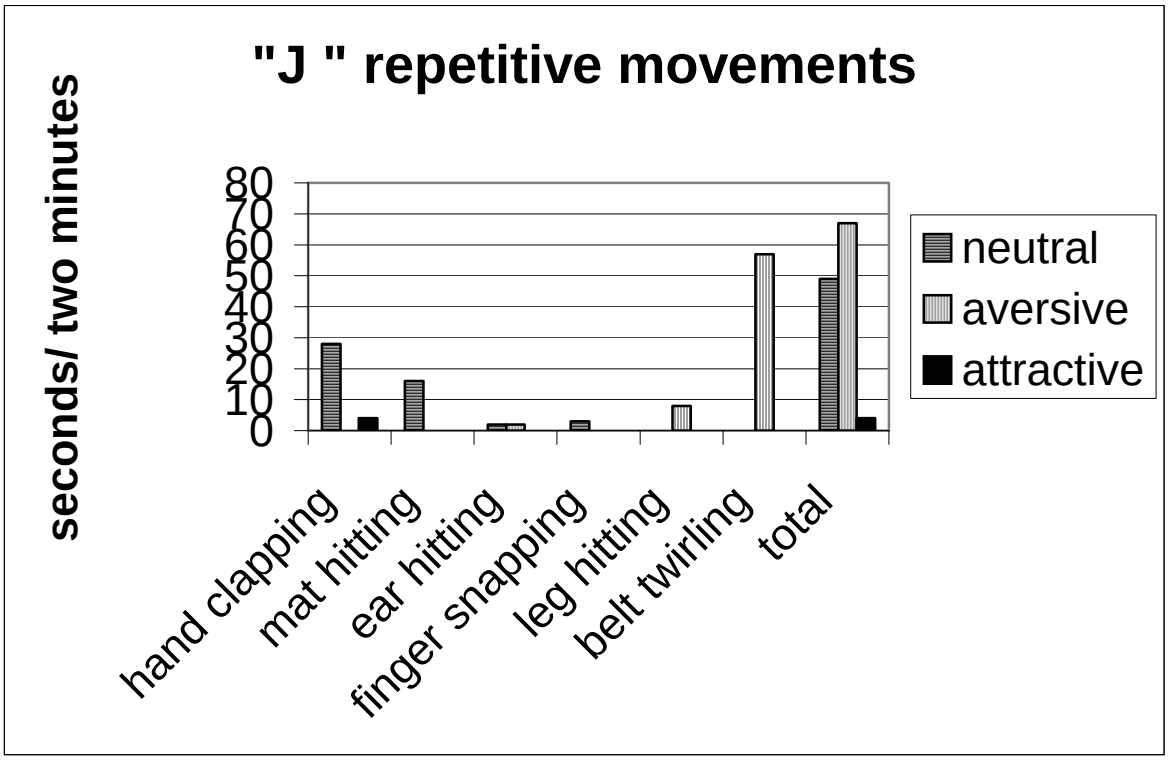

Figure 3

Time spent by Child “M” in stereotyped movement during each of three sensory stimulation conditions, by SM type and Total SM

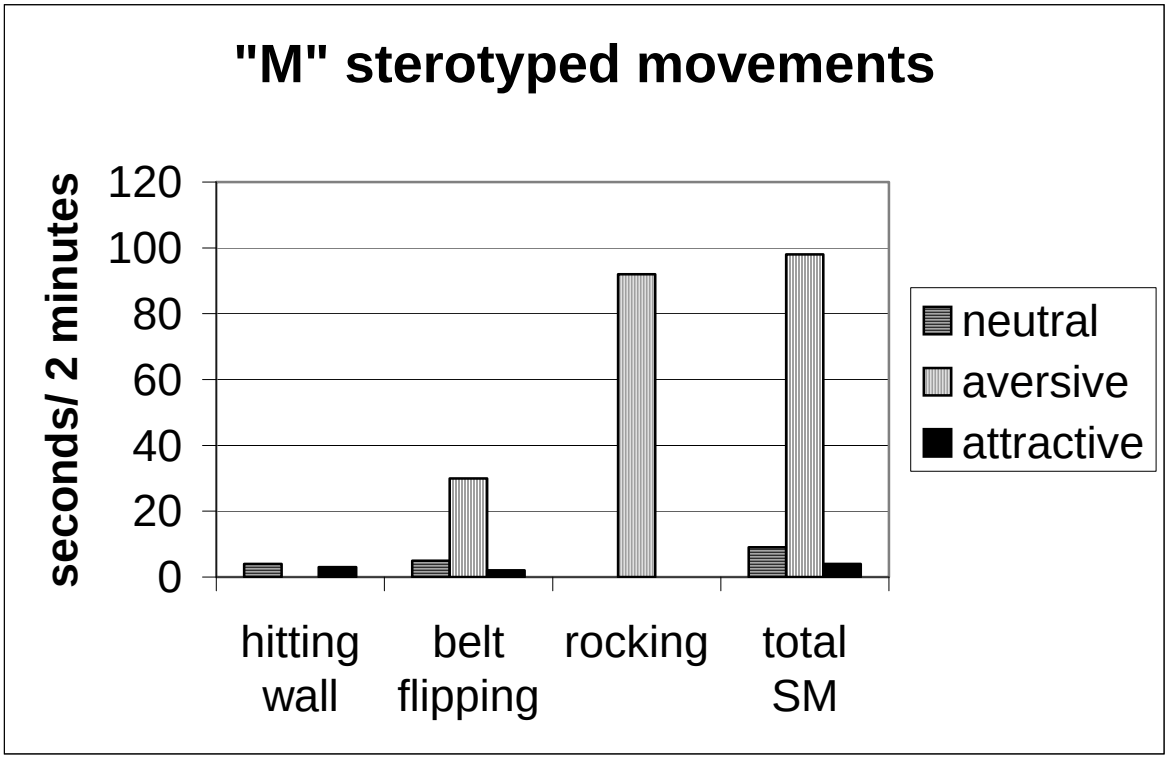

Figure 4

Time spent by Child “K” in stereotyped movement during each of three sensory stimulation conditions, by SM type and Total SM