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Exploratory behaviour and adaptation to novelty in preschool children with autism – a preliminary report[1]

Abstract *The purpose of this study was to compare exploratory behaviours in children with autism and typically developing preschool children and the course of their adaptation to novelty. A series of five repeated trials was conducted, during which children were allowed to freely explore the experimental room. The results revealed differences between study groups in the overall rate of exploratory activity, which was lower in children with autism. Patterns of time characteristics of exploratory activity showed both similarities and differences between the groups. In both groups, the rate of simple exploratory behaviours (i.e. looking at an object, touching the object, manipulating one object) decreased with time, while the levels of diversive exploration (i.e. touching the wall or floor) increased. Children with autism engaged in less complex object manipulation than their peers. Similarly, their adaptation and habituation to a novel environment proceeded in a different way in the low stimulation zone than in the high stimulation zone. In the low and medium stimulation zones, the rate of exploration decreased with time, while in the high stimulation zone it remained relatively constant. In typically developing children, habituation occurred in all stimulation zones. These results suggest the presence of some differences between the patterns of adaptation to novelty in the two groups, which emerge in a stimulation-rich environment. Due to the limitations of the study, in particular the small number of subjects, the present paper should be treated as a preliminary report.*

Key words*: autism, preschool children, exploratory behaviour, novelty, adaptation, habituation*

Curiosity and the associated exploration in preschool children are important aspects of building knowledge about the environment and learning (Evangelou, Dobbs-Oates & Bagiati, 2010). Exploratory behaviour provides children with information about their environment, as well as helps them learn about the properties of objects and examine the relationships between them (Williams, 2003). Gaining insight into these behaviours and the factors that affect them would bring us closer to the creation of supportive educational environments for preschool children.

In the case of children with autism, information obtained from research on exploratory activity may help shape their environment in a way which would promote their development and education. So far, little attention has been paid to this area of study, even though the characteristics of these children's development may have a significant impact on their exploratory activity. Studies on animal models of autism have pointed out the co-occurrence of deficits in social and exploratory behaviours (e.g. DeLorey et al., 2008; Meidenbauer et al., 2011). Moreover, limited exploration patterns may be associated with the core symptoms of autism, in particular with restricted patterns of interests (American Psychiatric Association, 2000). The structure of exploratory activity in people with autism can also be affected by the specifics of their cognitive functioning, especially by weak central coherence (Frith, 1989, 2003). Weak central coherence is associated with difficulty in integrating pieces of information and recognizing their overall meaning, as well as in using context to interpret stimuli. This could result in focusing on those elements of the environment to which typically developing individuals pay far less attention, recognizing them as unimportant for the overall significance of a situation. The specifics of sensory perception, which is an important problem in autism

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(e.g. Ben-Sasson et al., 2007; Cunningham & Schreibman, 2008; Tomchek & Dunn, 2007) may also affect exploratory activity.

When analysing the issue of exploration, it is worth taking into account the ideas of Berlyne (1963), who assumed that, apart from drive, which maintains the cerebral cortex at an optimum level of stimulation, an individual's motivation to engage in exploratory activity is shaped by their expectations with regard to the environment. Arousal results from the disparity between its expected and actual stimulatory properties. The greater the difference, the stronger is the individual's motivation to explore. We can assume that atypical sensory processing in individuals with autism may have a profound effect on the extent of that disparity.

Research findings to date suggest that exploratory activity in children with autism differs from that of their typically developing peers, both in terms of intensity of exploration and distribution of particular forms of exploratory behaviour. Children with autism demonstrate a much lower rate of environmental exploration (e.g. Baranek, 1999; O'Neill & Happé, 2000; Pierce & Courchesne, 2001). Differences in the intensity of exploratory behaviour between children with autism and typically developing children are noticeable already in the first year of life and may be an important predictor of developmental disabilities. In her study of children aged 9 to 12 months, Baranek (1999) analysed behaviours such as looking at objects, following objects with eyes and object manipulation. She found a relationship between the infants' exploratory activity and their later social functioning, demonstrating that early deficits in exploration may predict symptoms of autism. Children who were later diagnosed with autism looked at objects and manipulated them less often. In a prospective study, Ozonoff, Macari and Young (2008) also found that atypical object exploration may be a predictor of a later diagnosis of autism. At 12 months of age, children with autism spectrum disorders displayed significantly more spinning, rotating, and unusual visual exploration of objects than children with other delays or typically developing children. Similar information was reported for older children by Pierce and Courchesne (2001), who found that children with autism spent significantly less time than their typically developing peers on exploring containers placed in a large room, while demonstrating more stereotyped behaviours in this situation.

The above differences between children with autism and typically developing children in terms of visual exploration are associated with the characteristics of visual processing of novel and complex objects in autism (Brian et al., 2003; Deruelle et al., 2006; O'Riordan & Plaisted, 2001). Keehn and Joseph (2008) concluded that children with autism who performed visual search tasks required more time to process novel stimuli and demonstrated reduced sensitivity to novel onsets. In turn, Plaisted, O'Riordan and Baron-Cohen (1998) found that during a perceptual learning task that compared discrimination performance on familiar and novel stimuli, typically developing adults in comparison to adults with autism performed better in discriminating familiar objects than novel ones. No perceptual learning effect was observed in adults with autism, although they discriminated novel stimuli better than typically developing adults. Studies using event-related potential measurements have confirmed the difficulties in processing novel visual stimuli by children with autism (Kemner et al., 1999). Their problems are mainly associated with processing information on the relative positions of objects and may indicate the presence of deficits in contextual information processing. Visual exploration of a novel environment in people with autism may also be affected by problems with visual orienting (e.g. Elsabbagh et al., 2009).

Some insight into the specifics of novel environment exploration is offered by information on the negative response of children with autism to novelty and their insistence on sameness. However, while there are published research reports on these issues (Green et al., 2006; Gustafsson & Papliński, 2004; Smith et al., 2009), very little is known about the adaptation of children with autism to novelty. Response to novelty in preschool children has been investigated by, among others, O'Neill and Happé (2000). In their study, children were shown identical toys in three consecutive trials, and in the fourth trial the object was replaced by an almost identical one, which differed in terms of one property (e.g., intact Teddy bear vs. Teddy bear without an ear, or small yellow plastic duck vs. big yellow plastic duck). Children with autism, similarly to children with Down syndrome and those with typical development, spent significantly more time exploring toys in sessions 1 and 4, i.e. when the novelty effect was present. They demonstrated reduced interest in the object when it was familiar, and the appearance of novelty prolonged exploration. However, even though the effect was statistically significant in children with autism, authors noted that the difference between times spent on exploring the toy in individual trials were very small in this group and amounted to 0.4 s.

As children become familiar with their environment, the level of interest drops and habituation develops. In his seminal work on habituation, Thorpe (1956) notes that it is the most basic form of learning or behaviour modification. Psychophysiological studies on habituation in children with autism have revealed the presence of unique patterns of sensory habituation to visual, tactile and auditory stimuli (Cf. Dunn, 2001; Miller et al., 2001; Rogers and Ozonoff, 2005). Slower habituation of such social stimuli as human faces was also demonstrated in toddlers with autism (Webb et al., 2010). This aspect of their overall functioning may affect their adaptation to novel environmental conditions. Still, it would be difficult to predict precisely how such adaptation proceeds based on the information currently available.

In the present study, exploratory behaviours of preschool children with autism and their typically developing peers in a novel environment were compared in an attempt to identify the course of adaptation to novelty in the two groups. For that purpose, using repeated measures, changes in the children's behaviour as they became more familiar with their environment were analysed. Taking into account the results of previous studies on exploration in children with autism, the following hypotheses were proposed:

1. Exploratory activity in children with autism will be less intensive than in typically developing children.
2. The patterns of time characteristics of overall exploratory activity in children with autism will differ from those of typically developing children.
3. Adaptation and habituation to a novel environment in children with autism will proceed differently in a low stimulation zone than in a high stimulation zone.

Method

Participants and sample selection procedure

Eighteen children participated in the study (age range 3-5 years), including 9 children with childhood autism (7 boys and 2 girls; mean age = 50.88 months, SD = 8.32) and 9 typically developing children (5 boys and 4 girls; mean age = 51.44 months, SD = 8.63). Childhood autism was diagnosed by a child psychiatrist with extensive experience in the assessment of young children. Clinical diagnoses of childhood autism were based on the criteria provided in the *International Statistical Classification of Diseases and Related Health Problems* (ICD 10, World Health Organization, 1992). The selection criteria to the group of children with autism were as follows: (1) chronological age between 36 and 60 months, (2) psychiatrist diagnosis of childhood autism, (3) absence of identified genetic or metabolic disorders and (4) absence of severe sensory or motor impairments. All children with autism had been diagnosed at least 6 months prior to participation. Typically developing children were matched with children with autism for chronological age. These children also had no severe sensory or motor impairments. All children were living in a large city in central Poland and attending kindergartens or early intervention centres. The demographics of the sample are shown in Tab. 1.

Parents of children with autism and typically developing children were contacted through several therapy centres, associations helping individuals with these conditions and kindergartens. A written announcement informing about the purpose of the study was used to recruit participants. Out of the initial group of 32 children with autism and 20 typically developing children, 17 children with autism and 15 typically developing children were selected using the criteria described above. Ultimately, 14 families withdrew from participation, mainly due to organisational difficulties or their children's health problems (e.g. viral infections).

Table 1. Demographic characteristics of the sample

Group	Children with autism			Typically developing children		
Age Mean in months (SD)	50.88 (8.32)			51.44 (8.63)		
Number of siblings	Only child	One sister or brother	Two siblings	Only child	One sister or brother	Two siblings
	3	5	1	0	6	3
Parents' education level	Primary	Secondary	Higher	Primary	Secondary	Higher
Mother	0	2	7	0	3	6
Father	1	3	5	0	4	5
Mean mother's age in years (SD)	35.11 (6.23)			34.78 (4.60)		
Mean father's age in years (SD)	37.56 (6.08)			36.56 (5.29)		

The parents were informed about the purpose and procedures of the study. The written consent of each participant was obtained. The research was conducted in accordance with legal and ethical regulations for scientific research in Poland.

Experimental room

The study was conducted in a 5 m x 5 m x 2.5 m experimental room. The room was divided into three experimental zones (Fig. 1). They were equipped with objects of varying profiles in terms of complexity of visual stimulation.

The zones were sectioned off by means of 95 cm-high wooden partitions. The whole floor was fitted with

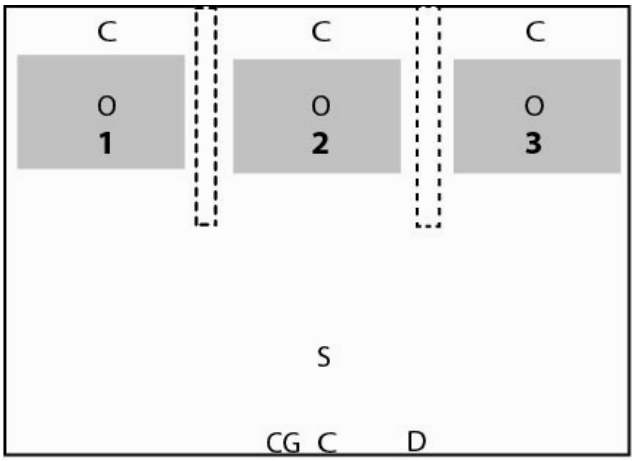

Fig. 1. Layout of the experimental room. Description of symbols: grey field – zone with objects; CG – caregiver chair, S – start point for children at the beginning of session, D – door, C – camera.

grey carpeting and windows were covered with laminated boards. At the centre of each zone was a table (77 cm x 55 cm x 48 cm). An analogous set of experimental objects were arranged on and around each table: four objects on the table and four objects on the floor. The objects were solid figures with identical shapes and dimensions in each set. They were made of 3 mm-thick transparent plastic. The

objects differed between zones in terms of visual stimulus complexity: in the first zone they were white, in the second their sides were painted in various colours (one yellow, one blue, one red), and in the third zone they were transparent and filled with multicoloured plastic, paper and metallic items permanently fixed inside each solid figure. The objects were unfamiliar and previously unseen for all children in the study. The experimental objects could not be disassembled, contained no detachable parts, and no two objects could be combined. Locations of individual zones with varying visual stimulation (right- or left-hand section of the room) were randomized for each tested child.

Procedure

The study was conducted according to a repeated measurement design. Five experimental trials were completed. Each trial was conducted on a different day in the course of one week.

During each experimental session, the child entered the experimental room with caregiver and experimenter. The caregiver sat in a designated chair, while the experimenter led the child to the starting point (see: Fig. 1). Then, the experimenter instructed the child to "Go and play", and left the room. The caregiver spent the entire session in the designated chair (he/she was asked not to initiate interaction with the child).

The children's behaviour was recorded with 4 video cameras. Three were positioned directly above zones 1-3, and one above the entrance to the experimental room. The set of four compact cameras was connected to a PC running Microsoft Windows XP Home Edition OS, equipped with a video recording card with 100 frames per second PAL resolution recording capability. The PC was located in an adjacent room, allowing the experimenter to follow sessions in real time. Recording started when the child reached the starting point.

Coding and reliability

Session videotapes of the children's behaviours in the experimental room were converted into digital format and coded to determine the frequency of each exploratory behaviour.

Based on analysis of the activity of 5 children in the first recording session, 41 behaviours demonstrated by children in the experimental room were identified. After discarding behaviours which were sporadic or demonstrated by only one participant, two categories of activity were extracted: behaviours aimed at exploring the environment and behaviours involving interaction with the caregiver. Behaviours related to interaction with the caregiver were analysed separately and are not reported in this paper. This article presents an analysis of behaviours aimed at exploring the environment. They comprise six behaviours identified on the basis of the initial analysis of recorded material and information from previous research on exploration in children (i.e. Bradley-Johnson et al., 2004; Pridham, Becker & Brown, 2000). The following behaviours were measured: (1) looking at an object (child looks at the experimental objects), (2) touching an object with hand or face (child touches the object with hands or face [cheek, mouth or tongue]), he/she may pick it up but there is no other manipulation), (3) manipulating one object (child throws the object, shakes it, moves it across the floor, drops it, turns it around, (4) manipulating multiple objects (child brings two objects together, groups at least two objects together, puts one object on top of another), (5) touching walls and floor (child touches the wall or floor with hand or face, (6) locomotion (child walks, runs, crawls).

The experimental sessions were coded independently from the same video recordings by two trained competent coders (psychologists), blinded to the diagnostic status of children, who were first trained in the behaviour coding procedure. They analysed the recording in 15-second intervals, marking the occurrence of the aforementioned behaviours on the monitoring sheet. The total number of analysed intervals for each child was 300, resulting in a total of 2700 intervals in the group of children with autism and 2700 intervals in the group of typically developing children. Interobserver reliability was assessed using average absolute agreement Intraclass Correlation Coefficients (McGraw & Wong, 1996). The alpha coefficients ranged from $r_{tt} = 0.79$ to $r_{tt} = 0.91$ (number of analysed time intervals N = 1080, i.e. 20 percent of the total number of intervals). Sessions coded for reliability were randomly selected.

Results

To find out whether the intensity of exploratory activity in children with autism was lower than in typically developing children, the groups were compared in terms of the overall rate of exploratory activity, which was the sum of rates of all coded exploratory behaviours (i.e. looking at object, touching the object, manipulating one object, manipulating multiple objects, touching the walls or floor of the room and locomotion). The Mann-Whitney U-test results show a difference between the two groups ($Z=-13.89$; $p>0.05$). The intensity of exploratory activity in children with autism (M=11.60; SD=3.53) was lower than in typically developing children (M=20.36; SD=4.71).

In order to find out whether the exploratory behaviour of children with autism differed in terms of intensity from trial to trial compared with the same activity of their typically developing peers, the rate of exploratory activity calculated separately for each trial was analysed. Figure 2 presents the graph of the overall exploratory activity rates in both groups in each of the five trials.

The Friedman test was employed in order to find out whether there were differences in each group in terms of the rate of exploratory activity between individual trials. The differences proved to be significant ($p<0.01$) both in the children with autism group ($\chi^2=114.96$; M=11.61; SD=16.02), and in the typically developing children group ($\chi^2=183.46$;

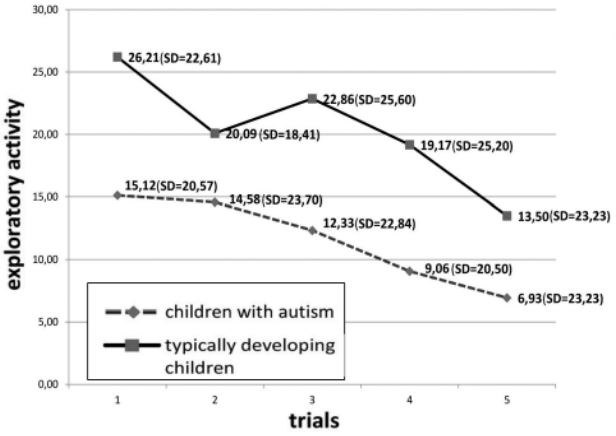

Figure 2. Mean rate of overall exploratory activity in individual trials in the groups of children with autism and typically developing children

Table 2. Comparison of overall exploratory activity in individual trials for each group separately – Wilcoxon test results

Trials compared	Children with autism	Typically developing children
Trial 1 and trial 2	Z=0.61	Z=6.58**
Trial 2 and trial 3	Z=3.14**	Z=2.95*
Trial 3 and trial 4	Z=4.66**	Z=4.09**
Trial 4 and trial 5	Z=1.91	Z=6.30**

** - p<0.01, *- p<0.05

M=20.34, SD=16.83). Next, a series of Wilcoxon tests were conducted for each group separately to determine between which trials there were differences (Tab. 2).

Each exploratory behaviour measured in the study was analysed in the same way. Descriptive statistics and Friedman test results are shown in Tab. 3.

Wilcoxon tests were conducted to find out which trials differed in terms of individual exploratory behaviours. Tab. 4 shows the results of these analyses in the group of children with autism.

Tab. 5 shows the results of comparisons of successive trials in the group of typically developing children.

Comparison of rates of exploratory behaviours in individual trials in the group of children with autism (see Tab. 4) revealed statistically significant changes in the following variables:

- Looking at object, Touching the object and Manipulating multiple objects: the rates of these behaviours decreased in the course of the study; Locomotion can also be classified with this group, as its intensity also decreased with the exception of trial 4, during which the rate of locomotion increased compared with trial 3;
- Touching the wall or floor of the room – rate increased during the course of the study;

Table 3. Mean standard deviation of rates of individual exploratory behaviours in successive trials and Friedman test results.

Exploratory behaviour	Group	Trial 1 M (SD)	Trial 2 M (SD)	Trial 3 M (SD)	Trial 4 M (SD)	Trial 5 M (SD)	χ^2
Looking at an object	A	25.55 (19.19)	23.44 (21.92)	18.88 (19.95)	13.22 (16.19)	10.77 (9.54)	155.82**
	TYP	41.66 (16.00)	28.33 (18.20)	46.33 (16.90)	38.88 (22.53)	31.66 (24.79)	347.11**
Touching an object with hand or face	A	30.22 (30.65)	30.22 (34.56)	21.33 (31.63)	14.66 (30.22)	8.66 (16.00)	173.23**
	TYP	38.33 (16.08)	23.55 (16.75)	42.22 (12.09)	39.44 (25.21)	31.44 (26.45)	169.95**
Touching walls and floor	A	7.33 (9.12)	5.00 (7.05)	9.44 (12.95)	13.11 (16.72)	13.11 (17.47)	26.35**
	TYP	0.22 (0.44)	3.00 (7.56)	3.88 (9.87)	0.11 (0.33)	2.66 (3.00)	60.52**
Manipulating one object	A	16.88 (16.80)	20.88 (31.54)	19.77 (34.71)	15.66 (31.60)	7.00 (7.53)	66.01**
	TYP	46.00 (19.60)	32.66 (22.21)	46.66 (23.35)	40.77 (29.57)	25.77 (21.93)	94.26**
Manipulating multiple objects	A	4.77 (7.15)	1.88 (4.64)	2.11 (5.62)	1.55 (4.66)	0.22 (0.66)	49.68**
	TYP	1.22 (2.38)	1.00 (1.22)	1.35 (2.06)	3.00 (5.31)	9.66 (11.94)	35.49**
Locomotion	A	27.88 (20.41)	22.66 (16.37)	12.55 (17.29)	16.44 (11.78)	19.11 (11.16)	29.87**
	TYP	14.77 (6.43)	19.44 (10.28)	31.44 (22.42)	21.66 (13.52)	30.88 (26.95)	22.52**

A – children with autism
TYP – typically developing children
** - p<0.01, *- p<0.05

Table. 4. Comparison of rates of individual exploratory behaviours in successive trials in the group of children with autism – Wilcoxon test results

Trials	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Trial 2	L: Z=1.45				
	TO: Z=0.11				
	M1: Z=3.92**				
	M2: Z=3.47**				
	TW: Z=1.09				
	LOC: Z=2.45*				
Trial 3	L: Z=4.65**	L: Z=3.47**			
	TO: Z=4.06**	TO: Z=4.57**			
	M1: Z=3.53**	M1: Z=0.56			
	M2: Z=3.09*	M2: Z=0.37			
	TW: Z=0.90	TW: Z=0.16			
	LOC: Z=3.00**	LOC: Z=0.56			
Trial 4	L: Z=7.82**	L: Z=7.01**	L: Z=4.38**		
	TO: Z=6.63**	TO: Z=7.05**	TO: Z=3.41**		
	M1: Z=1.25	M1: Z=2.67*	M1: Z=2.24*		
	M2: Z=3.84**	M2: Z=0.60	M2: Z=1.04		
	TW: Z=3.05*	TW: Z=3.90**	TW: Z=3.39**		
	LOC: Z=5.49**	LOC: Z=3.52**	LOC: Z=2.62*		
Trial 5	L: Z=9.24**	L: Z=8.31**	L: Z=5.68**	L: Z=5.18**	
	TO: Z=9.44**	TO: Z=9.33**	TO: Z=6.34**	TO: Z=3.72**	
	M1: Z=3.24**	M1: Z=5.79**	M1: Z=5.76**	M1: Z=3.58**	
	M2: Z=5.97**	M2: Z=3.44**	M2: Z=3.71**	M2: Z=3.46**	
	TW: Z=2.67*	TW: Z=3.57**	TW: Z=3.12*	TW: Z=1.00	
	LOC: Z=4.24**	LOC: Z=1.67	LOC: Z=1.14	LOC: Z=1.43	

L – Looking at an object, TO – Touching an object with hand or face, M1 – Manipulating one object, M2 - Manipulating multiple objects, TW - Touching walls and floor, LOC - Locomotion, ** - p<0.01, *- p<0.05

Table. 5. Comparison of rates of individual exploratory behaviours in successive trials in the group of typically developing children – Wilcoxon test results

Trials	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Trial 2	L: Z=7.41**				
	TO: Z= 2.87 **				
	M1: Z=6.00**				
	M2: Z=1.98				
	TW: Z=0.68				
	LOC: Z=1.87				
Trial 3	L: Z= 6.50 **	L: Z=1.83			
	TO: Z=0.88	TO: Z=1.78			
	M1: Z=3.03**	M1: Z=2.93*			
	M2: Z=1.67	M2: Z=4.32**			
	TW: Z=3.67**	TW: Z=2.96**			
	LOC: Z=1.73	LOC: Z=0.26			
Trial 4	L: Z=11.25 **	L: Z=5.46**	L: Z=7.83**		
	TO: Z=3.67**	TO: Z=0.96	TO: Z=3.19**		
	M1: Z=5.07**	M1: Z=0.45	M1: Z=2.60*		
	M2: Z=0.42	M2: Z=2.53	M2: Z=1.67		
	TW: Z=4.52**	TW: Z=4.12**	TW: Z=1.19		
	LOC: Z=1.30	LOC: Z=0.56	LOC: Z=0.33		
Trial 5	L: Z=13.87**	L: Z=9.70**	L: Z=10.59**	L: Z=5.18**	
	TO: Z=10.01**	TO: Z=8.17**	TO: Z=9.23**	TO: Z=6.91**	
	M1: Z=8.14**	M1: Z=3.06*	M1: Z=5.94**	M1: Z=3.76**	
	M2: Z=3.66**	M2: Z=1.51	M2: Z=4.81**	M2: Z=4.11**	
	TW: Z=2.33*	TW: Z=2.88*	TW: Z=5.20**	TW: Z=6.00**	
	LOC: Z=3.32**	LOC: Z=1.28	LOC: Z=1.62	LOC: Z=1.97	

L – Looking at an object, TO – Touching an object with hand or face, M1 – Manipulating one object, M2 - Manipulating multiple objects, TW - Touching walls and floor, LOC – Locomotion, ** - p<0.01, *- p<0.05

- Manipulating one object – rate fluctuated during the course of the study.

Comparison of trials 1 and 5 (the first and last) in the group of children with autism showed decreased rates in almost all exploratory behaviours. The only exception was Touching walls and floor, the rate of which increased.

In the group of typically developing children only the rate of Manipulating multiple objects increased in successive trials. Locomotion was also higher in trial 5 compared with trial 1. The direction of changes for the other behaviours varied, as their rates fluctuated between successive trials. Comparison of trials 1 and 5 showed that the rate of looking at an object, touching an object with hand or face and manipulating one object decreased, while the frequency of manipulating multiple objects, touching walls and floor and locomotion increased.

The next stage of analysis verified whether there were differences in the study groups between trials with regard to the overall rate of exploratory activity in the experimental room zones with varying stimulation values. For this purpose the Friedman test was conducted separately for each group for each measurement zone (low, medium and high stimulation zones) (Tab. 6).

Table 6. Comparison of overall exploratory activity in five trials in the low, medium, and high stimulation zones for each study group separately – Friedman test

Stimulation zone	Children with autism	Typically developing children
Low stimulation zone	χ^2 = 88.38**; M=8.44 ; SD=13.21	χ^2= 33.63**; M=14.96; SD=10.42
Medium stimulation zone	χ^2= 82.73**; M=7.56 ; SD=13.87	χ^2 = 42.37**; M=8.67 ; SD=8.06
High stimulation zone	χ^2= 17.69*; M=5.02 ; SD=8.62	χ^2= 64.97**; M=11.36 ; SD=9.46

** - p<0.01, *- p<0.05

Table 7. Mean results and standard variations of the overall exploratory activity ratio in individual trials for zones with low, medium, and high stimulation values.

Trial	Children with autism M (SD)	Typically developing children M (SD)
Trial 1 M (SD)	Lz: 12.89 (15.68) Mz: 11.44 (14.93) Hz: 5.89 (7.64)	Lz: 17.11 (7.91) Mz: 10.89 (7.49) Hz: 14.78 (6.78)
Trial 2 M (SD)	Lz: 13.33 (17.45) Mz: 10.00 (18.89) Hz: 6.89 (9.44)	Lz: 14.67 (9.89) Mz: 7.78 (7.53) Hz: 14.11 (11.20)
Trial 3 M (SD)	Lz: 8.44 (15.33) Mz: 9.33 (16.05) Hz: 3.56 (4.69)	Lz: 18.89 (11.14) Mz: 9.89 (6.86) Hz: 12.33 (8.03)
Trial 4 M (SD)	Lz: 4.89 (8.02) Mz: 5.56 (11.66) Hz: 4.22 (10.92)	Lz: 12.56 (11.20) Mz: 10.89 (11.06) Hz: 11.11 (12.13)
Trial 5 M (SD)	Lz: 2.67 (3.04) Mz: 1.44 (3.36) Hz: 4.56 (10.62)	Lz: 11.56 (12.06) Mz: 3.89 (6.01) Hz: 4.44 (5.73)

** - p<0.01, *- p<0.05
Lz - Low stimulation zone; Mz - Medium stimulation zone; Hz - High stimulation zone;

Table 8. Comparison of rates of individual exploratory behaviours in successive trials in the group of children with autism and typically developing children for zones with varying stimulation values – Wilcoxon test results.

Trials	Group	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Trial 2	A	Lz: Z=0.32 Mz: Z=0.89 Hz: Z=0.81				
	TYP	Lz: Z=1.44 Mz: Z=2.27* Hz: Z=0.37				
Trial 3	A	Lz: Z=2.83** Mz: Z=1.53 Hz: Z=2.02*	Lz: Z=3.31** Mz: Z=0.64 Hz: Z=2.88**			
	TYP	Lz: Z=1.07 Mz: Z=0.69 Hz: Z=1.56	Lz: Z=2.32* Mz: Z=1.57 Hz: Z=1.14			
Trial 4	A	Lz: Z=4.86** Mz: Z=3.96** Hz: Z=1.02	Lz: Z=5.47** Mz: Z=3.20** Hz: Z=1.65	Lz: Z=2.73** Mz: Z=2.88** Hz: Z=0.72		
	TYP	Lz: Z=2.65** Mz: Z=0.01 Hz: Z=2.30*	Lz: Z=1.25 Mz: Z=2.28* Hz: Z=1.86	Lz: Z=3.70** Mz: Z=0.76 Hz: Z=0.83		
Trial 5	A	Lz: Z=6.67** Mz: Z=7.38** Hz: Z=0.84	Lz: Z=6.89** Mz: Z=6.91** Hz: Z=1.47	Lz: Z=4.37** Mz: Z=6.38** Hz: Z=0.99	Lz: Z=2.23* Mz: Z=3.81** Hz: Z=0.26	
	TYP	Lz: Z=3.33** Mz: Z=5.63** Hz: Z=7.22**	Lz: Z=1.83 Mz: Z=3.52** Hz: Z=6.39**	Lz: Z=4.28** Mz: Z=5.19** Hz: Z=5.76**	Lz: Z=0.63 Mz: Z=6.09** Hz: Z=5.03**	

** - p<0.01, *- p<0.05
A – children with autism; TYP – typically developing children; Lz - Low stimulation zone; Mz - Medium stimulation zone; Hz - High stimulation zone

As the results presented in Tab. 6 show, differences between successive trials were present in both study groups and in all stimulation zones. Therefore, a series of Wilcoxon tests were conducted for each zone in order to find out between which trials there were differences. Table 7 presents descriptive statistics for individual trials in each of the stimulation zones.

Tab. 8 presents the results of comparisons between trials in both study groups.

Comparison of exploratory activity in zones with different stimulation values in individual trials in the group of children with autism (see Tab. 8) revealed statistically significant differences between successive trials present in all stimulation zones. Exploratory activity in the low and medium stimulation zones decreased with each trial. In the high stimulation zone, the activity of this group of children for the most part remained constant.

In the group of typically developing children, the rates of exploratory behaviours decreased in all of the zones. Only in the case of activity in the low stimulation zone the rate of exploration increased from trial 2 to trial 3.

Discussion

The present study compared exploratory behaviours of preschool children with autism and typically developing children in a novel environment. The process of adaptation to novelty was also analysed by studying the behaviour of children in the same environment over five trials conducted on successive days.

On the basis of previous reports on exploratory behaviours (e.g. Libby et al., 1998; Sokhadze et al., 2009), as well as previous data on the characteristics of sensory processing in this population (e.g. Bölte et al., 2007; Leekam et al., 2007), three hypotheses were formulated with respect to exploratory activity. We expected the rate of exploratory activity to be lower in children with autism than in their typically developing peers. We also predicted that the patterns of time characteristics of exploratory activity in children with autism would differ from those of typically developing children and that the process of adaptation and habituation to a novel environment would occur in a different way in children with autism in the low stimulation zone than in the high stimulation zone.

The results of the present study have confirmed that exploratory activity was lower in children with autism than in typically developing children. The overall rate of that activity calculated as the sum of rates of individual exploratory behaviours was lower in children with autism than in their counterparts. This result confirmed our predictions, as well as previous findings of other researchers (e.g. Baranek, 1999; O'Neill & Happé, 2000; Pierce & Courchesne, 2001), who also reported lower intensity of exploratory behaviours in children with autism. It is also consistent with the accounts of clinicians who note lower and unusual activity of children with autism when exploring a novel environment (Cf. e.g. Olechnowicz, 2004). Our findings provide another confirmation of decreased exploratory activity in the clinical picture of autism. Since, as demonstrated by Baranek (1999), as well as Ozonoff et al. (2008), lower intensity of exploratory behaviour in infants is a predictor of poorer social development, the course of exploratory activity in children with autism calls for detailed analysis.

The results of the present study partly confirm the presence of differences in the patterns of time characteristics of exploratory activity between children with autism and typically developing children. The analyses conducted in both groups demonstrated changes in the overall exploratory activity from trial to trial in either group (Fig. 2, Tab. 2). In the case of typically developing children, these changes consisted in decreasing rates of exploration over time spent in the novel environment. These results are consistent with other findings on habituation and exploration of a novel environment by typically developing children (Bulf, Johnson & Valenza, 2010). By contrast, children with autism demonstrated decreased rates of overall exploratory activity in the middle trials; in trial 3 it was lower than in trial 2, and in trial 4 it was lower than in trial 3. No differences were found between sessions 1 and 2, and 4 and 5 in this group. These findings may suggest that the process of getting to know a novel environment in children with autism is slightly different than in typically developing children. It is possible that changes in the intensity of exploratory activity over time follow a different pattern in these children; although the rate of exploration decreases as well, the decline occurs later or is slower than in typically developing children. There are other reports in the literature which suggest that habituation in children with autism proceeds differently than in typically developing children (e.g. Kleinhans et al., 2009; Webb et al., 2010), with the main disparity being the dynamics of the process. Webb et al. (2010) studied social information processing and its relation to social and communicative symptoms in toddlers with Autism Spectrum Disorder (ASD) and their siblings. They demonstrated that the pace of habituation is slower in children with autism than their typically developing counterparts.

It should be noted, though, that the comparison of the first and last trial in children with autism showed a decrease in exploratory activity. The analysis of the graph of changes in the overall rate of exploratory activity over the entire study (Fig. 3) also indicates the presence of habituation in this group. These findings may confirm the observation of Rogers and Ozonoff (2005) that the hypothesised failure of habituation in autism has little confirmation in empirical data.

The analysis of rates of individual exploratory behaviours in both study groups demonstrated significant differences between successive trials. In children with autism, the rates of looking at an object, touching an object and manipulating multiple objects decreased with each session,

while the rate of touching the wall or floor increased. The most changes in successive trials were found between trials 3 and 4. They included looking at an object, touching the object and manipulating one object, as well as increased rate of touching the wall or floor and the intensity of locomotion. The comparison between the first and last measurement revealed statistically significant differences in all measured behaviours. The analysis of these data showed increased rates of touching the wall or floor and decreased rates of other behaviours. There was an increase in the rates of manipulating multiple objects and locomotion in typically developing children. Comparison of trials 1 and 5 revealed decreased rates of such behaviours as looking at an object, touching an object and manipulating one object. There was also increased locomotion, as well as greater frequency of such behaviours as manipulating multiple objects and touching the wall or floor of the room.

There were some similarities in terms of changes in rates of individual exploratory behaviours in successive trials between the two study groups. The rates of looking at an object, touching an object and manipulating one object diminished in children with autism as well as their typically developing counterparts. This may suggest that there are no differences between the two groups in terms of more basic forms of exploration. Differences in exploration patterns may be present primarily in more complex exploratory activity. Pisula (2003) reported similar results.

When comparing changes in rates of individual exploratory behaviours between successive trials in children with autism and typically developing children, changes with respect to manipulating multiple objects are of particular interest. In children with autism, there is a tendency for the rate of this behaviour to decrease, while the opposite is the case with typically developing children: the rate of this behaviour increased with each trial. Changes in the behaviour of typically developing children in this respect can be described as activating a strategy enabling more complex exploration which goes beyond learning the basic properties of objects. As mentioned above, with the progress of the experiment these children demonstrated fewer and fewer simple exploratory behaviours (e.g. looking at an object, touching an object, manipulating one object), whose usefulness from the point of view of learning about the environment diminished, and they engaged in activity which was likely to reveal new, previously undiscovered properties of the environment. The frequency of simple exploratory behaviours decreased in children with autism as well, but that decrease was not associated with initiating more complex exploration. Instead, diversive exploration increased, as manifested in touching the wall or floor. The increase in the frequency of this last behaviour was also present in typically developing children, which indicates certain similarities between the two groups in the study in terms of how their strategy of exploring the environment developed as they spent more time in it.

Our results confirm the presence of the predicted differences between children with autism and typically developing children in terms of the dynamics of changes in exploratory activity in zones with varied stimulation values. In children with autism, the changes were mostly observed with respect to rates of exploration in low and medium stimulation zones. The overall exploration rate in those zones decreased over time, while the activity in the high stimulation zone remained relatively constant. By contrast, in typically developing children the rate of exploratory behaviours decreased with each trial in all stimulation zones. It seems to suggest that the effect of stimulation intensity on the course of habituation is greater in children with autism than in their typically developing peers. It is possible that if the study were longer, the exploratory behaviour of children with autism in this zone would also diminish. Perhaps atypical processing of visual input in these children meant that complex visual stimuli helped maintain exploratory activity at a similar level over the course of all 5 trials. After all, these children may have taken longer to get familiar with complex stimuli than typically developing children. It is worth noting that the experimental setting in which the children were observed provided them with relatively little stimulation. The three separate zones containing experimental objects introduced some variety, but both the type of stimuli used (stationary objects which produced no sounds and featured smooth surfaces), as well as lack of other stimulation (e.g. social or auditory) together resulted in low stimulation conditions. In those circumstances, the high stimulation zone may have been the most interesting, especially considering the fact that children with autism rarely engaged in complex object manipulation and were usually satisfied with simpler forms of exploration. When interpreting the behaviour of children with autism in that zone, we should remember that, although the intensity of exploration remained constant, the frequency of exploratory behaviours was relatively low. Thus, although this zone was more stimulating for children with autism in the later trials than other zones, the intensity of exploration was limited.

Any interpretation of the present results must take into account their limitations. The most important ones are the small size of study groups and their internal heterogeneity in terms of exploratory activity. Substantial individual differences in levels of activity are typical in the autistic population (Lane, Young, Baker & Angley, 2011). It includes individuals with very low levels of activity, bordering on extreme passivity, as well as people who are constantly on the move. This differentiation was reflected in the results of the study and affected the statistics in such a way that the differences in rates of certain behaviours were not significant, even though the means seemed varied. In order to obtain more reliable data, similar assessments would need to be repeated on a larger group of participants.

Furthermore, even though the age range of children in the study was quite narrow (3-5 years), given the small sample, age differences may still have affected intra-group variance. Another possible improvement would be to match the mental age of children in both groups.

The study employed purpose-designed and custom-produced experimental objects. The reason for doing so was to avoid a situation in which children would have differing levels of experience in playing with particular objects prior to the study. On the one hand, this was a definite strong point of the procedure, but on the other, it was difficult to predict how the type of objects would affect the children's behaviour. Ultimately, the objects proved to provide little incentive towards complex manipulation.

The above limitations mean that the present paper should be treated as a preliminary report. Still, the findings are interesting in that they constitute a novel approach to the analysis of changes that occur in the behaviours of children with autism as they spend more time in a novel environment. A particular challenge in this type of research is that a series of measurements must be obtained in the experimental setting on the same group of children. It is difficult to recruit a large and relatively homogeneous group of individuals with autism. In the present study, the group of children with autism was relatively homogeneous; all participants had been diagnosed with childhood autism and had no additional significant motor or sensory disorders.

A strong point of the study was the microanalysis of behaviour, which made it possible to count individual acts accurately. The same methodology is often used in such studies as those on the interactions of children with autism with others (e.g. Libby, Powell, Messer & Jordan, 1998).

There is no doubt that the specifics of exploratory behaviour in children with autism remains an inspiring research subject. Identifying the factors that influence this form of activity and the course of adaptation to novelty is all the more important due to the consequences of these issues for social development and communication in children with autism spectrum disorders (Munson et al., 2008). Further investigation of changes in these children's activity in the course of getting used to a novel environment may have significant relevance for clinical practice, because it can improve our understanding of their adaptation to environmental conditions and help support their development in that area.

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