European Journal of Educational and Development Psychology
Vol.8, No.4, pp.1-16, December 2020
Published by ECRTD-UK
Print ISSN: 2055-0170(Print), Online ISSN: 2055-0189(Online)

ATYPICAL PATTERNS OF RHYTHMICAL MOTHER-CHILD INTERACTION AS AN EARLY SIGN OF AUTISM SPECTRUM DISORDER

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ABSTRACT: *Face-to-face interactions are organized in a clear rhythmic structure. This study examined how the rhythmic patterns of behaviors during mother-child interactions differentiate children with Autism Spectrum Disorder (ASD) from Typically Developing (TD) children. Ten children with ASD and ten TD children, matched for mental age, were videotaped in naturalistic play sessions with their mothers. The microanalytic approach applied, focused on a qualitative axis (type of behavior), and a quantitative axis (duration of behaviors). Results demonstrated that children with ASD rarely initiate an episode of interaction with their mother, prefer solitary play and use less communicative behaviors. Overall, they exhibit an atypical rhythmic patter of interaction, which is interpreted by their deficient motive for intersubjective communication*.
KEYWORDS: autism spectrum disorder, rhythm, mother-child interaction, intersubjectivity, microanalysis

INTRODUCTION

Infants are born with an innate urge and ability to participate in human interactions (Trevarthen & Aitken 2001). Even a few weeks after birth, infants begin to communicate face-to-face with their caregiver and show a precocious sense of rhythm in the interactions with their mother. The early development of rhythmical interactions is based on physiological rhythms and the infant's ability to perceive temporal regularities (Bobin-Begue, 2019). Rhythm enables anticipation and flow, and carries within it the intent of the interaction (Gill, 2012). Both rhythm and timing in early mother-child interaction play a fundamental role to the child's social development (Bornstein & Bruner, 2014; Rabinowitch & Knafo-Noam, 2015) and provide a structure for temporal expectancies (Harrist & Waugh, 2002).

During rhythmic interaction, infant and caregiver mirror each other's behavior and emotion. Infants, like adults move with rhythmic gestures that express motive states and changes of emotion and mood (Trevarthen, 2008). The development of intentions, mutual reciprocity, and cooperative understanding of others' intentions requires mother-child interactions that are

characterized by rhythm and structure (Trevarthen & Daniel 2005). Successful interactions depend on the temporal organization of interactional behaviors both within and between individuals (Schirmer et al., 2016).

What happens, however, when the temporal patterns in mother-child interaction are disturbed due to a developmental disorder of the child, such as Autism Spectrum Disorder (ASD). ASD is a neurodevelopmental disorder characterized by social communication deficits and a restricted range of activities and interests (American Psychiatric Association 2013). ASD is considered a heritable (Sandin et al., 2014), life-long disorder which interferes with the person's ability to communicate and relate to others (Elsabbagh et al., 2012). It affects the child's interaction with the physical and social environment and disturbs the development of interpersonal communication and collaborative action (Trevarthen & Daniel, 2005).

According to the most recent estimates from CDC, about 1 in 54 children has been identified with ASD (Maenner et al., 2020). Due to the rapid increase of this condition, understanding and identifying ASD characteristics and early signs is considered imperative. Identification of atypical features early in development would help understand how ASD unfolds from birth, facilitate timely diagnosis and contribute to early intervention (Elder et al., 2017; Suma et al., 2016; Vivanti et al., 2017; Zwaigenbaum et al., 2019).

One of the earliest domains where difficulties and atypicalities in children's behavior can become evident is during parent-child interaction (Peper et al., 2016). In their seminal research, Trevarthen and Daniel (2005) reported disorganized rhythm and synchrony in the dyadic interaction of an 11-month-old infant with Rett Syndrome, who was diagnosed with ASD at the age of two years, and her father. Their interactional analysis revealed that the infant showed little eye contact, absence of co-regulation, weak emotional expression and lack of anticipation, making the interaction asynchronous. From his part, the father tried to stimulate the child with repeated and more directive invitations. Rhythm and synchrony during the interaction are one of the earliest signs that can potentially provide valuable indications for ASD.

Contingent interactions and mutual coordination is a domain that causes significant difficulties in children with ASD (Farran et al., 2019). These difficulties may stem from their severe difficulties in creating expectancies and predicting the behavior of others (Sinha et al., 2014). In addition, timing and social timing deficits present in ASD may be a key characteristic, or cause of, some of the behavioral and cognitive impairments of the disorder (Casassus et al., 2019). Children with ASD exhibit a deficit in temporal processing, which might cause atypical social synchrony in their interactions with others and reduce the quality of social bonding, reciprocity and communication (Allman, 2011; Leclère et al., 2014).

Children with ASD manifest lower interpersonal synchrony (Bloch et al., 2019; McNaughton & Redcay, 2020; Xavier et al., 2018) and show marked deficits in sharing their motives, intentions, and emotions with others about topics in the environment (Trevarthen & Delafield-Butt, 2013). Deficits in joint attention skills are one of the core clinical feature of ASD (Charman, 2003; Naber et al., 2008; Nyström et al., 2019). In relation to responding to joint attention (RJA), children with ASD have lower rates of gaze following (Gillespie-Lynch, 2013; Vivanti et al., 2017). However, these difficulties are not as enduring as the difficulties in the

initiation of joint attention (IJA) (Franchini et al., 2019; Parsons et al., 2019). Children with ASD show reduced alternating gaze behaviors (Thorup et al., 2018), exhibit lower gesture rates (LeBarton & Iverson 2016; Ramos-Cabo et al., 2019; Watson et al., 2013) and produce fewer vocalizations than TD children (Patten et al., 2014).

As regards play activities, children with ASD avoid social play and prefer solitary actions and simple manipulation of objects (Elison et al., 2014). Children diagnosed with ASD engage in significantly more exploratory and relational play (Dominguez et al., 2006), while they exhibit particular difficulties in functional and symbolic play (Christensen et al., 2010; Papaeliou et al., 2019; Thiemann-Bourque et al., 2012; Williams et al., 2001).

All of the above mentioned characteristics make mothers of children with ASD adjust their behaviors accordingly during the interaction (Crowell et al., 2019; Meirsschaut et al., 2011). Compared to mothers of TD children, they use a more directive and intrusive style, gesture more frequently (Talbott et al., 2013), employ more attention-getting behaviors, spent more time initiating an activity (Blacher et al., 2013), use more nonverbal prompts and increase their physical proximity to their child (Doussard-Roosevelt et al., 2003).

Despite the evidence about the fundamental role of rhythm in mother-child interactions, to the best of our knowledge, there are relatively few studies examining rhythmic patterns in parent-child interactions in children with ASD and measuring simultaneously the behaviors of both partners during free play in a multimodal way (gaze, affect, actions, play). The aim of the present study is to compare the rhythmical patterns of interaction between TD and ASD children, during free play episodes with their mothers by employing a microanalytic approach.

METHODS

Participants

Two groups of mother-child dyads participated in this study. The first group consisted of 10 children with ASD (9 males), between the ages of 29 and 81 months (M = 55.11, SD = 21.03). All children in the clinical group had a diagnosis of ASD from a licensed professional. Diagnoses were confirmed through clinical judgment of two psychologists based on the DSM 5 criteria (APA, 2013) as well as through the Modified Checklist for Autism in Toddlers [M-CHAT] (Robins et al., 2001). ASD children were recruited from pediatric clinics, daycare centers, pediatric clinics and special schools. The second group consisted of 10 TD children (8 males), aged between 9 and 30 months (M = 16.96, SD = 5.82). The two groups were matched for visuospatial, fine motor, and linguistic abilities on the raw scores of the Mullen Scales of Early Learning (1995). All participants were from monolingual, Greek-speaking families. Demographic information is presented in Table 1.

Table 1: *Demographic information for children with Autism Spectrum Disorder (ASD) and Typically Developing (TD) children*

	ASD	TD
Chronological age (months)		
Mean	55.11	16.96
Range	29.00-81.28	12-35
Sd	21.03	5.82
Mother's age (years)		
Mean	36.90	36.20
Range	32-44	31-43
Sd	3.75	4.44
Fathers' age (years)		
Mean	37.80	37.50
Range	33-44	31-48
Sd	4.21	4.76
Maternal education (%)		
Compulsory education	10	0
High School or Technical Education	80	10
University degree	10	90
Paternal education (%)		
Compulsory education	20	0
High School or Technical Education	80	20
University degree	0	80
Family status (%)		
Parents live together	80	100
Parents are divorced	10	0
Single parent	10	0

As is apparent, groups were similar in terms of sex ratio, ethnicity, family status and parental age, but significant differences were observed in parents' education. In particular, the majority of mothers in the ASD group had graduated from High School or had a Technical education, while the majority of mothers in the TD group had a University degree (χ^2=13.24, p=.004). The same holds for fathers as well (χ^2=14.00, p=.007). A significant difference between the groups was also found in children's chronological age (F=33.23, $p < .001$).

Measures

Mullen Scales of Early Learning (MSEL)

The MSEL (Mullen, 1995) was administered to all children in order to determine their developmental age and match the participants in terms of their cognitive, motor and language development. The Mullen is a standardized, examiner-administered developmental measure of cognitive functioning that yields age-equivalent and standard scores on various domains of cognitive development, including both verbal and nonverbal domains. It is administered in infants and preschool children and is commonly used in studies of children with developmental disorders (Klein-Tasman et al., 2007; Parladé & Iverson, 2015; Poon et al., 2012). Four of the five subscales assessed by the MSEL were used in the present study, namely visual reception,

fine motor, receptive language and expressive language. Children's performance on MSEL subscales is presented in Table 2.

Table 2: Performance on Mullen Scales of Early Learning

	ASD	TD	*F*	*p*
Visual reception				
Mean	20.9	21.6	.07	.782
Range	14 – 29	12 – 35		
Sd	4.22	6.63		
Fine motor				
Mean	20.8	20.2	.04	.832
Range	14 – 28	13 – 38		
Sd	5.51	6.84		
Receptive language				
Mean	15.6	19.5	1.82	.193
Range	6 – 23	10 – 33		
Sd	5.29	7.42		
Expressive language				
Mean	17.2	16.2	.15	.699
Range	8 – 29	13 – 29		
Sd	6.54	4.68		

*p < .05

Modified Checklist for Autism in Toddlers (M-CHAT)

The M-CHAT (Robins et al., 2001) is a brief parent report screening measure that detects cases of ASD. It consists of 23 yes/no questions evaluating the child's behavior, and includes items which identify sensory abnormalities, motor abnormalities, social interaction, early joint attention, playing ability, early language and communication abilities. Children fail the screener if they meet one of two or both M-CHAT cutoffs: receive a score of three or more items on the total measure or receive a score of two or more items out of the six identified critical items.

Coding System

The behavior coding system was intended to be concise, avoid redundancies and describe overt and mutually exclusive behaviors. The axes included in the annotation were gaze direction, action on object, action on partner and affect. At an initial level, behaviors were coded separately for the mother and the child on a frame-by-frame basis and then their behaviors were combined in order to assess the interaction of the dyad in terms of rhythmical interaction. As described in Table 3, the categories of the combinatorial coding system followed the developmental process of engagement and communication and depicted the progressive nature of intersubjectivity.

Table 3: *Combinatorial coding system*

Categories	Description
Solitary action	behavior used in order to learn and explore the environment. It does not involve any kind of communication or interaction between the mother and the child
Interpersonal communication	behavior focused on dyadic communication between the child and the mother without the use of any toys or objects
Converging interest	communicative partners express interest at the same object but they do not communicate between them about that object
Joint attention	communicative partners coordinate their attention to an object in order to share their experience. Achieved through the use of alternating gaze (looking back and forth between the partner and an object) and/or communicative gestures (pointing, showing, offering)
Functional play	conventional use of objects according to their function

A pilot application of the coding system in a sample of four children revealed that the category of converging interest was too broad and included heterogeneous cases of mutual attention to an object. In particular, it included cases of partners who spontaneously focused their attention to an object that simultaneously was the focus of attention of the other partner (without the other partner acknowledging it) and partners who attended to an object under direction or urge of the other partner. For this purpose, the category of converging interest was divided into imposed and spontaneous converging interest.

The innovation of the current coding system lies on the grouping of the separate behaviors observed in mothers and children into the above-mentioned categories. This research also demonstrates the way these categories are alternated during the interaction which produces a distinct rhythmical pattern for each group of participants.

Reliability

To assess inter-rater and intra-rater reliability, 6 videotapes (30% of the sample; 3 ASD, 3 TD) were chosen at random and independently scored by 2 raters. For inter-rater reliability Cohen's kappa ranged from .77 to .87 and for intra-rater reliability kappa ranged from .78 to .91.

Procedure

Following informed consent procedures, all children were visited at home with a primary caregiver. During the first visit, the MSEL was administered to children by an experienced researcher, while parents completed the M-CHAT as well as a questionnaire on demographic information and the child's developmental background. In the following visits, children and their mothers were videorecorded during play sessions that took place in their homes. Compared to the unfamiliar laboratory setting, home environment was more appropriate for capturing the child's spontaneous behavior (Papaeliou et al., 2002).

Each session lasted approximately 35 minutes and was video recorded using a high quality camera, mounted on a tripod. According to the relevant literature, this is a common duration for video recordings, which provides adequate data and has been used in previous work, including children with ASD (Iverson & Fagan, 2004; Iverson & Wozniak, 2007).
During the session, the mother was asked to play with her child, as she would typically do, with a set of standard, age-appropriate toys. The set of toys included a car, two different-sized dolls, doll furniture, a tea set, a brush, a telephone, blocks, toy animals and a book. This set of toys allows for different play behaviors ranging from exploration to pretense and are commonly used in similar study designs (Bentenuto et al., 2016; Dominguez et al., 2006; Williams et al., 2001).

Data analysis
Dyadic microanalysis of mother-child interaction was considered the best method in order to study the joint behaviors of the communicative partners. Microanalysis operates like a "social microscope," since it permits the detailed identification of the instant-by-instant interactive events which are so fast and subtle that are often not quite perceptible in real time. In addition, microanalysis is a fine-grained and precise method that allows investigating durations and temporal sequences of behaviors and facilitates analyzing rhythm in different modalities of communication by revealing multiple coexisting behaviors in mother-child interaction (Beebe & Steele, 2013; Wan et al., 2012). The EUDICO Linguistic Annotator (ELAN), which is a professional tool for the creation of complex annotations on video and audio resources, was used for the microanalysis of the video recordings (Hellwig, 2014).

RESULTS

For the statistical analysis, IBM the Statistical Package for Social Sciences (IBM SPSS) was used. In order to assess between group differences an independent samples t-test or Analysis of Variance (ANOVA) was applied. Within group differences were measured with a paired samples t-test. The data were examined for normality. However, duration, which is the dependent variable, does not follow normal distribution. Therefore, data were transformed in order to conform to normality. Among the different types of transformations used to transform skewed data to conform to normality, the log transformation was selected as the most appropriate for the data of the present study (Field, 2013). In addition, because of the small sample size Cohen's d effect size was also calculated in order to measure the magnitude of the mean differences in cases where the null hypothesis was rejected.

Interaction initiation
The first analysis examined the relation between initiation of interaction (mother or child) and group category (ASD, TD). Because of the small sample size, 2 cells (50%) of the 2x2 table have expected count less than 5 (the minimum expected count is 2.29) and a Fisher's Exact Test had to be applied. Results showed that there was a significant nonrandom association between the two categorical variables (initiator and group category) and the number of mothers or children who initiated the interaction differed between the groups. Adjusted residuals in crosstabs cells were also calculated to account for the variation due to the small sample size (Sharpe, 2015). In the ASD group, in most cases it was the mothers who initiated the interaction (Ads res = 2.2), while in the TD group, it was the children who most often took the initiative for interaction (Ads res = 2.2).

Patterns of interaction

Figure 1 and 2 present the patterns of interaction for all children in the ASD and TD group respectively. Figures indicate the behaviors that dominate in each group as well as the duration of each behavior. Each bar represents the total duration of the episode. Inside each horizontal bar there is a note about the duration of each behavior. The temporal analogy of behaviors was taken into account, which means that the duration of each behavior was divided by the total duration of the episode. It is noted that there was not any statistically significant difference between the ASD dyad (M =10.95, SD = .77) and the TD dyad (M =11.049, SD = .90) in the total duration of the play episode $t(18) = -.242$, $p = .812$ and both groups dedicated similar time in order to play with a toy. However, as it is depicted graphically in Figures 1 and 2, noteworthy differences between the groups were observed in the type of play they engaged in as well as the quantity and quality of mother-child interaction. Moreover, the figures depict the succession of behaviors during the play episode, which produces a rhythmical sequence of behaviors and creates a pattern that characterizes the communication and interaction of each group.

The ASD group

As it is depicted in Figure 1, solitary play is the most dominant category and is preceded or succeeded by instances of converging interest either imposed or spontaneous. A paired samples t-test showed that the duration of solitary play (M = 10.70, SD = .782) was statistically significantly longer, compared to the duration of imposed converging interest (M = 7.06, SD = 3.84), $t(9) = 3.061$, $p = .014$ and spontaneous converging interest (M = 5.11, SD = 4.45), $t(9)$ = 3.65, p = .005 (because there was a set of six pairs Bonferroni's correction was applied. Accordingly the α level of significance was adjusted to 0.016). No statistical significant differences were found in the duration of imposed and spontaneous converging interest. The categories of interpersonal communication and functional play were not observed in any child, while the category of joint attention appeared in only one child (participant: ASD_{10}) and therefore was not included in the statistical analysis.

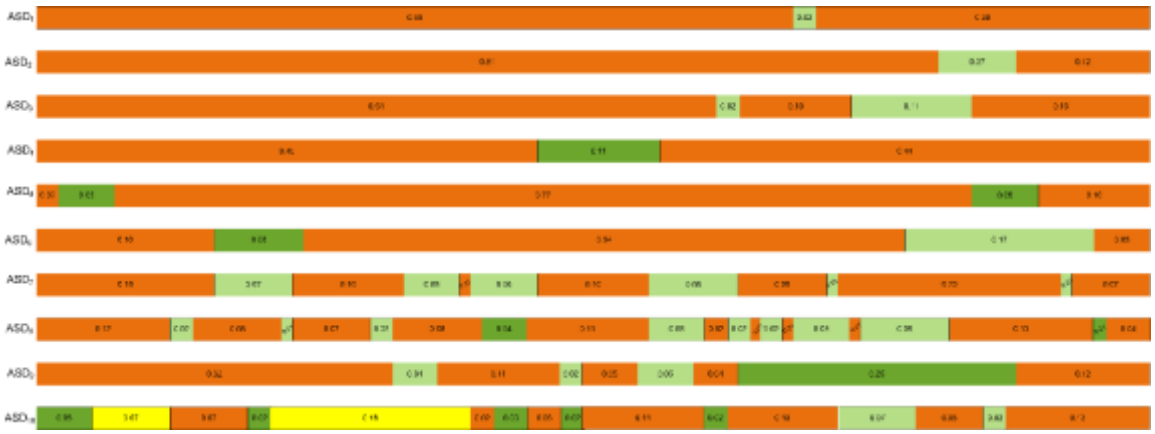

Figure 1. Rhythmic pattern for children with ASD

The TD group

As it is depicted in the respective figure for TD dyads (Figure 2), their pattern of interaction is characterized by greater diversity and quicker alternation of behaviors. A paired samples t-test showed that the duration of solitary play (M = 9.22, SD = 1.14) was statistically significantly shorter than the duration of functional play (M = 10.27, SD = .92), $t(8)$ = -3.04, p = .016. In addition, the duration of solitary play tended to be statistically significantly shorter than the duration of joint attention (M = 9.71, SD = .59), $t(9)$ = -2.61, p = .028. No statistical difference was found in the comparison of the duration of the other pairs. The category of imposed converging interest did not appear in the behavioral repertoire of the TD dyads.

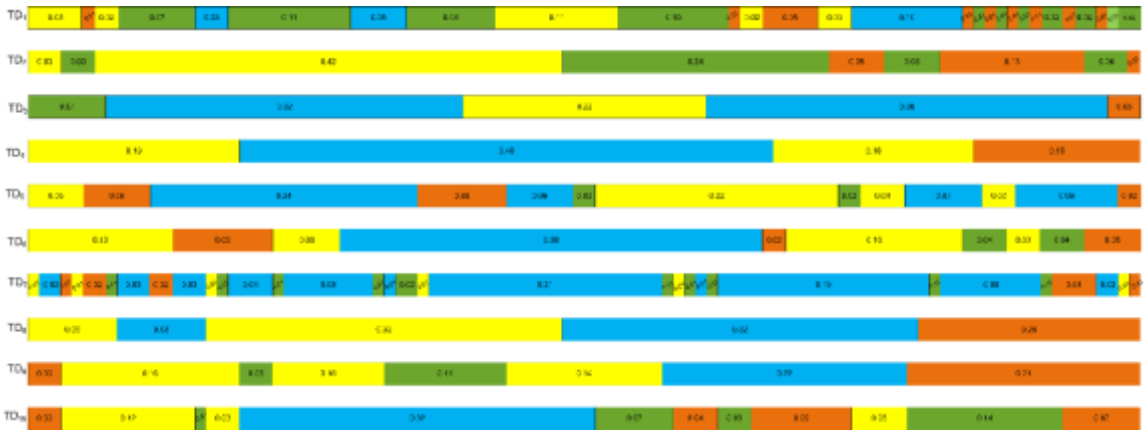

Figure 2. Rhythmic pattern for TD children

Between groups comparisons

As it was depicted above, the succession of behaviors during the play episode yielded two distinct patterns of interaction with great differentiations both qualitatively, in terms of the types of behaviors employed and the rhythm that is produced, and quantitatively, in terms of the duration of each behavior and the frequency of the alternations performed between the two groups. Figure 3 shows the mean duration of each category for the two groups. That is, the duration of each category is divided by the total duration of the episode of interaction and results are presented in the unit of time (1 min). This figure depicts the dominant behavior in each group as well as the differences in the durations of all categories between the groups.

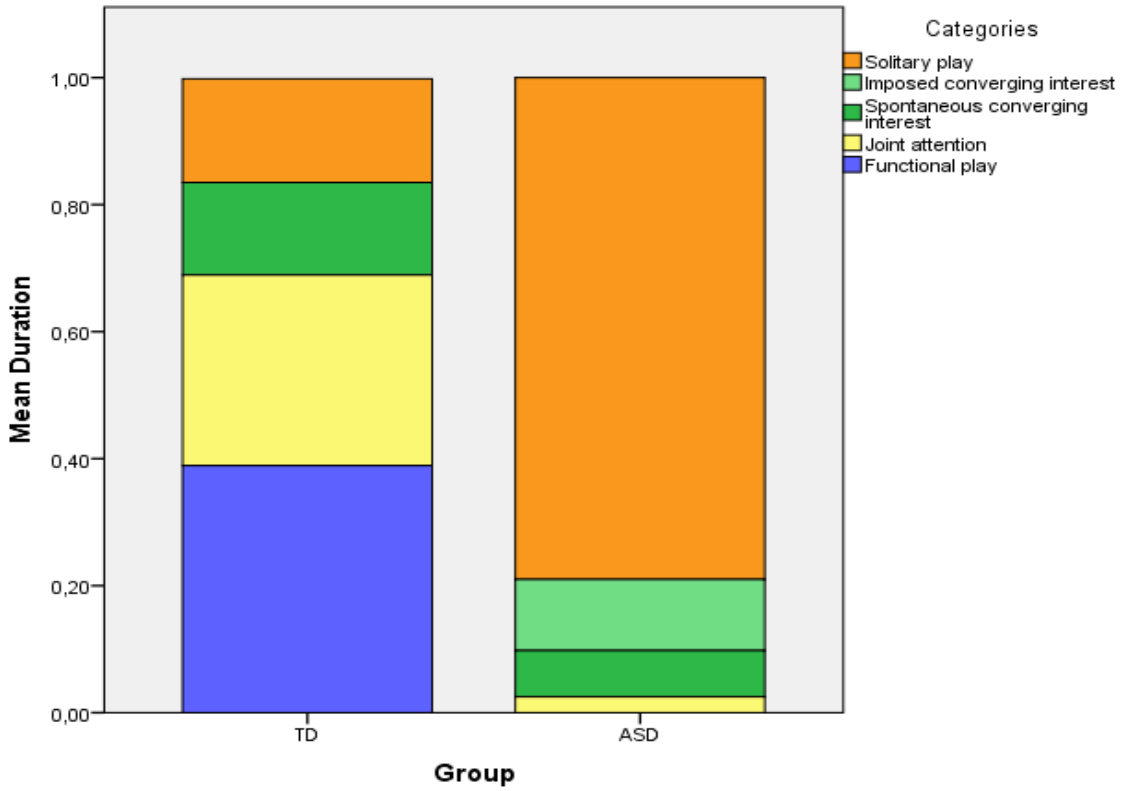

Figure 3. Analogical mean duration of categories

In particular, an independent samples t-test was performed in order to compare the mean duration of each category between the groups. Results showed that the mean duration of solitary play was statistically significantly longer in the ASD group (M = 10.70, SD = .78) than the TD group (M = 9.09, SD = 1.15), $t(18) = 3.650$, $p = .002$, $d = 1.63$. No significant difference between the groups was found for the category of spontaneous converging interest, while the category of joint attention was observed in one child only and therefore no statistical analysis was performed. The category of imposed converging interest was not observed in the TD group, while the category of functional play was not observed in the ASD group (Table 4).

Table 4: *Between group comparison in categories of interaction*

	M	SD	t	p
Solitary play			3.65	.002*
ASD	10.70	.78		
TD	9.09	1.15		
Spontaneous converging interest			-1.20	.245
ASD	5.11	4.45		
TD	7.38	4.00		
Joint attention			-8.64	<.001*
ASD	.99	3.13		
TD	9.71	.59		

*p < .05

DISCUSSION

Timing and rhythm are significant components of human life and constitute integral parts of the detection of intentional relations. Face-to-face interactions are organized in a clear rhythmic structure. Rhythm plays a pivotal role in mother-child interactions since it provides a structure for temporal expectancies that organizes the cognitive and affective experiences of the child (Deckner et al., 2003; Harrist & Waugh, 2002).

The aim of the present study was to compare children with ASD and TD in relation to their rhythmic communicative behavior, by examining a variety of modalities. Findings revealed two distinct rhythmic patterns that verified the hypothesis of disturbance or atypicality in rhythmic interactions between children with ASD and their mothers.

On contrary to the TD group, ASD children rarely initiate an episode of interaction with their mother. This finding agrees with other studies showing that children with ASD make fewer initiations (Hauck et al., 1995; Houghton et al., 2013). In their study, Freeman and Kasari (2013) found that parents of children with ASD suggested more play acts and had longer lasting parent-initiated schemes than parents of TD children.

As it was depicted in the rhythmic patterns of interaction, all children in the ASD sample preferred to engage alone with objects without seeking the participation of their mother. As a result, solitary actions were the most dominant behavior and their duration was prolonged. This evidence is consistent with the findings of Kasari et al. (2010) according to whom children with ASD tended to engage in object-focused interactions; that is, their attention was wholly focused on the object without involving another person in their play.

In relation to play, it is noteworthy that none of the children in the ASD sample exhibited functional play. Other studies have reported that children with ASD have difficulties in functional play (Jarrold et al., 1993; Williams et al., 2001). A recent study conducted by Wilson et al. (2017) reported that at 15-18 months, functional play acts were exhibited by 41% of the TD group, but only by 13% of the Developmental Disorders group and 9% of the ASD group. All of the above mentioned behaviors indicate children with ASD have difficulties in sharing their motives, intentions, and emotions with others about topics in the environment. These deficits in contingent interactions and mutual coordination with their mother (Papoulidi et al., 2017; Trevarthen & Delafield-Butt, 2013) may stem from their difficulties in creating expectancies and predicting the behavior of others (Sinha et al., 2014).

The results of the present study are interpreted on the basis of the developmental theory of Innate Intersubjectivity, according to which there is deficient motive for intersubjective communication in ASD, that is responsible for the deviant rhythmic interaction that these children exhibit. Trevarthen and Delafield-Butt (2013) describe ASD as a developmental disorder in intentional movement and affective engagement that can be explained by faults in the timing and integration capacities of the brainstem sensorimotor system.

In the same line of thought, Fuchs (2015) claims that ASD is a paradigmatic disorder of intersubjectivity. Children with ASD present difficulties in the transition from primary to secondary intersubjectivity (Hobson et al., 2004). Deficits in intersubjective behaviors are the best way to discriminate children with ASD from those with TD during the first year of life (Muratori & Maestro, 2007). The representative rhythmic patterns of interaction that were revealed in the present study could be used as a potential tool for early identification of children at risk of ASD well before other behaviors become fully manifested.

Limitations

Some of the limitations of the study should be acknowledged. The first is related to the small sample size and the heterogeneity of the ASD group. Children with ASD represented different levels of functioning and therefore a broad spectrum of difficulties. Moreover, some behaviors were observed for a very short time in either group, weakening any group comparisons. It would be interesting for a future research to examine these rhythmic interactions in more long-lasting episodes. Despite these limitations, the current study revealed the significance of rhythm during mother-child interactions, and indicated that an atypical rhythmic pattern can serve as an early sign of ASD. Early diagnosis can lead to early intervention, which is of paramount importance for the child's development and can alter the expression of the disorder.

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