Course of maternal prosodic incitation (motherese) during early development in autism

An exploratory home movie study

Raquel S. Cassel[1,5], Catherine Saint-Georges[1,2], Ammar Mahdhaoui[2], Mohamed Chetouani[2], Marie Christine Laznik[3], Filippo Muratori[4], Jean-Louis Adrien[5] & David Cohen[1,2]

[1]Department of Child and Adolescent Psychiatry, Université Pierre et Marie Curie
[2]Institut des Systèmes Intelligents et de Robotique, Université Pierre et Marie Curie
[3]Department of Child and Adolescent Psychiatry, Association Santé Mentale du 13ème
[4]Scientific Institute Stella Maris, University of Pisa
[5]Laboratoire de Psychopathologie et Processus de Santé (LPPS, EA 4057), Institut de Psychologie de l'Université Paris Descartes Paris

We examined the course of caregiver (CG) motherese and the course of the infant's response based on home movies from two single cases: a boy with typical development (TD) and a boy with autistic development (AD). We first blindly assessed infant CG interaction using the Observer computer-based coding procedure, then analyzed speech CG production using a computerized algorithm. Finally we fused the two procedures and filtered for co-occurrence. In this exploratory study we found that the course of CG parentese differed based on gender (father vs. mother) and child status (TD vs. AD). The course of an infant's response to CG vocalization differed according to the type of speech (motherese vs. other speech) and child status (TD vs. AD). Mothers spent more time interacting with infants, and fathers appeared to interact with their child preferentially between 12 and 18 months in the TD boy, but not in the AD boy. The TD boy responded equally well to motherese compared to other speech after 1 year of age. For the AD boy, the responses to both types of speech were lower than in the boy with TD and decreased from the second to the third semester.

Keywords: Autism – motherese – early interaction – computational methods

Interaction Studies 14:3 (2014), **480–496**. DOI 10.1075/is.14.3.08cas
ISSN 1572–0373 / E-ISSN 1572–0381

1. Introduction

Autism is a developmental disorder characterized by the presence of abnormalities in reciprocal social interactions, in patterns of communications, and by a restricted, stereotyped, repetitive repertoire of behavior, interest, and activities (ICD 10; DSM IV). Although autism manifestations are extremely variable, a child's inability to develop any sociability or to communicate is at the core of this pathologic developmental process.

Symptoms, such as speech delay and stereotyped behavior, are often evident in the second and third year, but these clearly are not the initial manifestations of autism (Stone, Hoffman, Lewis & Ousley 1994). Retrospective studies on early home videos (for a review, see Saint-Georges et al. 2010) and data from parental interviews (e.g. Adrien et al. 1993; Werner, Dawson, Osterling & Dinno 2000) have revealed atypical developmental tendencies in infants who were later diagnosed with autism spectrum disorders (ASD). In addition, prospective studies based on siblings of ASD children have reported various behavioral markers that, in part, predict a subsequent diagnosis of autism (Zwaigenbaum 2005). The first signs are abnormalities in eye contact, social behavior, joint attention, orienting to name, and body language. These behaviors constitute important prerequisites for communication and social competencies; however, whether these first signs impact the interactive process between an infant and its parents and whether such signs influence the development of the infant himself remain two complex issues.

However, very few studies have addressed the importance of infant caregiver synchrony and reciprocity in early interactions (Feldman 2003). In typically developing children the quality of social interaction depends on an active dialogue between the parent and the child based on the infant's early competencies and the parent's capacity to be attuned (Braarud & Stormark 2008; Crown, Feldstein, Jasnow, Beebe & Jaffe 2002). Numerous studies have emphasized the importance of synchrony and the co-modality of these early interactions for an infant's development.

Social interactions also have an important impact on language learning (Bloom 1975; Goldstein, King & West 2003). Simple exposure to language does not explain phonetic learning. Features inherent in the social setting, such as interactivity and contingency, are critical for language learning (Kuhl 2007). Since the description of Victor the wild boy of Aveyron by Jean-Marc Gaspard Itard, we have known that a complete lack of social interaction has devastating impacts on human language learning (Carrey 1995). Rutter's adoption studies (Croft et al. 2007; Rutter et al. 2007) show the dramatic damage following severe early deprivation and its heterogeneity in outcomes, including cognitive deficits, attachment problems and quasi-autistic patterns.

Researchers in language acquisition and in early social interactions have demonstrated that adult vocal behavior is a fundamental factor that affects the language and social development of infants. A special type of speech that is directed towards infants, called 'motherese' or 'parentese' (or infant-directed speech), which is characterized by higher pitch, slower tempo, and exaggerated intonation contours (Fernald 1985), seems to play an important role in both social interaction and in language development. This particular prosody may be responsible for attracting infants' attention, conveying emotional affect and providing language-specific phonological information (Fernald 1985; Fernald & Kuhl 1987). A mother's infant-directed speech was found to depend on the quality of the infant's responsiveness, suggesting that infants are actively involved in the course of motherese (Braarud & Stormark 2008; Saint-Georges, C., Cassel, R.S., Mahdhaoui, A., Chetouani, M., Muratori, F., Laznik, M.C., Cohen, D., submitted). It has been shown to be present also in fathers and other caregivers when addressing an infant (Fernald et al. 1989; Fernald 1991; Niwano & Sugai 2003; Shute & Wheldall 1999).

The link between social interaction and language learning theories of autism and the study of motherese in early interactions of infants who become autistic may provide cues for understanding the development of communication skills in children with autism. In a previous work, we extensively described our hypotheses (Mahdhaoui et al. 2011) concerning this relationship between early interaction, language learning and autism. Summarizing them, we postulated that if learning depends on normal social interest in people and the signals they produce, children with autism, who lack social interest, may be at a cumulative disadvantage in language learning. Their poor response to parental incitation may impair both parental incitation and motherese production over time. As a consequence, this impairment will reinforce social withdrawal and language acquisition delay.

1.1 Aims of the study

In this exploratory study, we tested the use of a computerized algorithm created for the detection of motherese speech (Mahdhaoui et al. 2011) and focus on parent's vocalizations and infants' responses simultaneously using home movies from two single cases: a boy with typical development (TD) and a boy with autistic development (AD). This manuscript will provide the methodological process that will be used to assess a large database of home movies and that maybe used in siblings studies. We propose the following hypotheses. (1) As motherese amplification is bidirectional and AD children lack social interest, a caregiver's motherese towards the AD boy should decrease over time; this is a decrease that will likely be greater than that seen in a caregiver's motherese towards the TD

boy. (2) However, the AD boy should be capable of interacting and responding to motherese specifically at the start of life as motherese appears to enhance infant attention and learning.

2. Methods

2.1 Participants

We studied the home movies of two boys from the Pisa Home Movie (HM) database during the first 18 months of life using the following criteria: the first was diagnosed with autism and the second was a typical developing (TD) comparison boy. The two cases were selected according to the audio band quality of the videos and the fact that they had the largest number of video sequences. An editor, who was blind to the children's diagnoses, selected among the HM of each child all segments running for at least 40 seconds where the infant was visible and could be involved in human interaction (standard situations). For each infant, the sequences were organized into three 6 month age periods (≤6 month; 6< age ≤12 months; >12 months). All scenes showing a situation in which social interaction could occur (i.e. all scenes with an infant and an adult) were extracted and, if necessary, segmented into short sequences for scoring (for a complete description of the Pisa Home Movie database see (Muratori, Apicella, Muratori & Maestro 2011; Maestro et al. 2005). We excluded all video sequences with poor audio quality (background noise such as loud music, outdoor sequences, birthday parties or baptism celebrations).

Case 1 is a boy with early onset autism that was diagnosed at age 5 by a psychiatrist based on DSM-IV criteria. Parents received the Autism Diagnostic Interview-Revised to confirm the diagnosis: ADI-R scores were 23 for social domain (cutoff = 10), 20 for communication domain (cutoff = 8), and 6 for limited interest (cutoff = 3) domain (Rutter, Le Couteur & Lord 2003). The Childhood Autism Rating Scale was used to assess the severity of autistic symptoms (CARS score = 36.5; threshold = 30; maximum score = 60) (Schopler, Reichler & Renner 1988). The child also received an Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2000) (ADOS module 1 scores = 5, 9, 14, 3, 4 for communication, social interaction, total, play and limited interests, respectively). IQ score was 83, based on the Leiter scale. Case 2 involves a boy with a history of typical development (TD) and no psychiatric and/or developmental symptoms, as confirmed with the Child Behavior Check List: i.e. all scores were below the clinical threshold (Achenbach & Rescoria 2000) and did not correspond to the autistic profile as described in Muratori et al. (2011).

2.2 Procedures

We used two separate, blind analyses to assess first infant caregiver (CG) interaction using computer-based coding procedure; speech and motherese CG production were then analyzed using a computerized algorithm for motherese detection. Then an interaction analysis was conducted based on time after fusing the two procedures and filtering for co-occurrence using a time window of 3 seconds (see below).

The Observer 4.0® was configured for the application of the Infant Caregiver Behavior Scale (ICBS) to the video media file-material. The ICBS is composed of 29 items that reference the ability of the infant to engage in interactions and 8 items describing CG solicitation or stimulation toward the infant to obtain his attention (details of the grid can be found in Muratori et al. 2011; Saint-Georges et al. 2011). All target behaviors were described as Events, which occurred at a specific instant. Four coders were trained to use the computer-based coding system until they achieved satisfactory agreement (Cohen's Kappa ≥ 0.7). The standard situations derived from the HM were mixed, and each HM case was rated by one trained coder who was blind to diagnosis. For continuous verification of inter-rater agreement, 25% of standard situations were randomized and independently rated by two coders. The final inter-rater reliability, calculated directly by the Observer, showed a satisfactory Cohen-κ mean value ranging from 0.75 to 0.77.

To extract the caregiver's vocalizations from the video segments, we performed a manual segmentation of CG vocalizations with The Observer 4.0®. We used Sound Forge 9.0 to extract the vocal segments from each video sequence. Vocal segments that presented poor audio quality or were imperceptible to the ear were excluded. Manual segmentation provided us with a database of speech segments, separated by case (AD, TD) and by semester (S1, S2 and S3). In addition, manual segmentation allowed us to identify the following: the number/frequency of vocal segments, the duration of segments in each sequence of movie, and the identity of who was speaking to the child (i.e. mother, father, other CG).

The segments of speech were analyzed using a computerized classifier for motherese speech (infant-directed speech) or normal speech (adult-directed speech) categorization. Because the "manual" study of acoustic components (Laznik, Maestro, Muratori, Parlato 2005) of the voice is very costly in terms of human time and only allows for the study of very short voice segments, the realization of such an algorithm made it possible to conduct an extensive study of home movies based on their acoustic characteristics.

The whole system concept was described by Mahdhaoui et al. (2011). Here, we briefly describe the key components of this automatic system. Using classification techniques that are often used in speech and speaker recognition (GMM and K-nn), we developed a motherese detection system and first tested it on the mode

dependence of the speaker. The fusion of features and classifiers was also investigated. Given that home movies are not recorded by professionals and often contain adverse conditions (e.g. with regard to noise, the camera, or microphones), acoustic segmentation of home movies shows that segmental features play a major role in robustness (Schuller et al. 2007). Consequently, the utterances were characterized by both segmental (Mel Frequency Cepstrum Coefficients) and supra-segmental (e.g. statistics with regard to fundamental frequency, energy, and duration) features. We showed that segmental features alone contained much useful information for discrimination between motherese and adult-directed speech, as they outperformed the supra-segmental features. However, according to our detection results, prosodic features were also very promising. Based on the previous two conclusions, we combined classifiers that used segmental features with classifiers that used supra-segmental features and found that this combination improved the performance of our motherese detector considerably. In its most effective configuration, the novel detector had positive and negative predictive values of 90%. When we explored the motherese detector's performance on 200 sequences from 10 different speakers who were blindly validated by two psycholinguists, the performance of the detector (speaker-independent) remained very good (accuracy = 82%) (Mahdhaoui et al. 2011). For the purpose of the current study that aimed to also explore fatherese, we explored 100 sequences from each father that were blindly validated by two psycholinguists. Performance was good (accuracy = 74%). This level of prediction made it suitable for further studies of home videos.

For the interaction analysis, we first fused video coding and acoustic analysis. The computer-based coding system (The Observer) provided ".txt" files with the description of ICBS behaviors based on time. Vocalizations analyzed by the computerized system provided two new tags: motherese vocalization or other speech. These tags were reintegrated into the.txt file as CG "state events". Second, we extracted all infant responses to caregiver vocalizations co-occurring within a time window of 3 seconds using a Linux-based script. Any child behavior occurring within the 3 seconds following the caregiver vocalization was retained. The 3-second window was based on the available literature on synchrony (Feldman 2003) and on previous work on infant-caregiver interaction (Saint-Georges et al. 2011). Interactive behaviors were calculated by type (motherese or other speech), by semester (S1, S2 or S3) and by speaker (all CG, father or mother), in terms of frequency (number of events) and duration of CG vocalizations (in seconds).

3. Results

Table 1 summarizes the characteristics of the segments extracted for each case. Six sequences from the TD boy and 9 from the AD boy were excluded due to poor

audio quality. In total, we analyzed 87 sequences for a total duration of 10,330 seconds (≈172 minutes). The frequency of vocalization towards the TD or AD boy was similar when examined in terms of number of CG vocalizations per HM duration (seconds) and stable by semester around 0.2 (see Table 1, bottom). When examined in terms of CG vocalization duration per HM duration, some differences emerged. CG vocalization rate towards the AD boy was higher than towards the TD boy during S1 and S2 (0.33 and 0.36 vs. 0.19 and 0.13, respectively), but not in S3 (0.23 vs. 0.2). Taking these two results together, during S1 and S2, the duration of vocalizations towards the AD boy was longer.

Table 1. Characteristics of the movies for the typically developing (TD) and the autistic (AD) children

	TD				AD			
	S1	**S2**	**S3**	**Total**	**S1**	**S2**	**S3**	**Total**
N sequences	12	8	6	26	22	21	18	61
D sequences	1272	844	785	2901	2387	3031	2011	7429
N voc	214	124	150	488	472	670	350	1492
D voc	240	109	158	507	790	1101	471	2362
N MM	134	44	24	202	309	216	83	608
MM total D	155	43	25	223	516	359	125	1000
N voc mother	148	81	76	305	392	417	213	1022
D voc mother	166	75	78	319	689	744	313	1746
N MM mother	115	41	22	178	271	189	51	511
D MM mother	132	41	23	196	479	324	81	884
N voc father	66	42	74	182	77	77	62	216
D voc father	74	32	80	186	97	75	58	230
N MM father	19	3	2	24	38	13	4	55
D MM father	23	2	2	27	37	12	4	53
N voc/D sequences	0.17	0.15	0.19		0.20	0.22	0.17	
D voc/D sequences	0.19	0.13	0.20		0.33	0.36	0.23	

D = duration (seconds); N = number of events; S = semester; MM = motherese vocalization; voc = all vocalizations

Consistent with previous findings on parent-infant interactions, the mothers' vocalizations during S1 represented 81% of all vocalizations addressed to the AD boy and 69% to the TD boy. In the TD case, the mother's vocalizations remained constant during S2 (65%) and decreased during S3 (48%). For the AD case, the mother's vocalizations decreased earlier, i.e. between S1 and S2 (62% and 61% during S3). In contrast to the mothers, the father's vocalizations towards the TD

boy increased from S1 to S3 (30%, 34%, and 47%, respectively). This trend was not found for the father's vocalizations towards the AD boy for which it remained considerably low (16%, 11%, and 18% of all vocalizations addressed to the infant in S1, S2 and S3, respectively). In the TD boy, the father was absent in only 4 of the 26 sequences retained and spoke to the child in all other sequences, with the exception of 1 where he was just videotaping. In the AD boy, the father appears in 48 sequences but does not speak in 18 sequences. Regarding the parentese rate per vocalizations addressed to the infant and that of mother and father alone, the TD and AD cases show a comparable profile (Table 1). There was a decreasing course for both motherese and fatherese over time, and motherese rates were always higher than fatherese rates during all semesters.

To understand how motherese is correlated with positive interactions, we examined motherese speech and other CG speech in relation to infants' behaviors after extracting CG vocalizations occurring within a 3-second window including an infants' response. Any child behavior occurring within the 3 seconds following the caregiver vocalization was retained. As the results obtained by number of events (number of vocalizations) or duration did not differ, we decided to report only the number of events in this manuscript.

Figure 1 shows the role of CG motherese speech when addressing infants. Motherese speech was involved in 70% of the interactions in the TD case versus 61% in the AD case at S1. Even if the frequency of motherese was proportionally higher in the TD case compared to the AD case, this result highlights the fact that motherese is more effective for eliciting and maintaining infant attention and emotional responses than other speech (Papousek, Papousek & Symmes 1991). In the TD boy, the proportion of motherese speech followed by an infant response decreased linearly by 30% at each subsequent semester. In the AD boy, the use of motherese speech in interactions reduced by 24% from S1 to S2 and remained

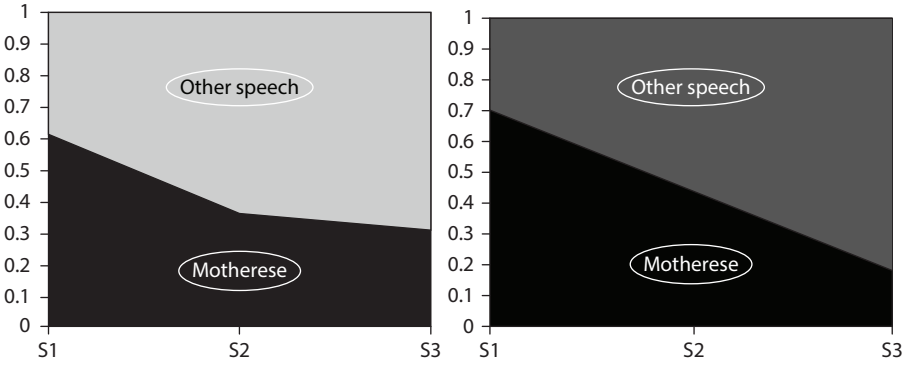

Figure 1. Contribution of motherese versus other speech to interaction according to child status: autism (left), typical development (right)

almost constant from S2 to S3. It is possible that AD caregivers, sensing the infant's social difficulty, adapt their language to continue arousing the infant's attention. To answer this question, we decided to examine the contribution of motherese speech on interactions by defining an index of efficacy for each type of speech (motherese vs. other speech): Number of sequences with Motherese (or other speech) followed by an interaction/Total Number of sequences with Motherese (or other speech).

The course of mother and father vocalization rates followed by a child response (or an interaction) (Figure 2, left) shows that the role of the TD boy's father appears to be more critical during the third semester. In contrast, the AD boy's father remained discrete. The efficacy of mother and father parentese (Figure 2, right) is increasingly important from S1 to S3 for the TD boy, reaching 100% efficacy for the fatherese during S3. Interestingly, the curve of effectiveness for all other speech addressed to the TD infant changed from 0.40 at S1 to 0.41 at S2, and reached 0.68 at S3. Therefore, the TD boy was capable of responding to all types of vocalizations, and this tendency increased over time. During S3, the TD boy responded equally well to motherese as to other speech. This is not the case for the AD boy. Comparatively, the AD boy responded less well than the TD boy to all types of speech at S1, S2 and S3 (data not shown). Motherese remained more effective at inducing an infant's response, but rates were quite low (maximum efficacy for all care givers = 0.52 at S2), despite some efficacy of the fatherese after the first year. Indeed, the AD boy responded to 75% of the fatherese versus 24% of his other speech.

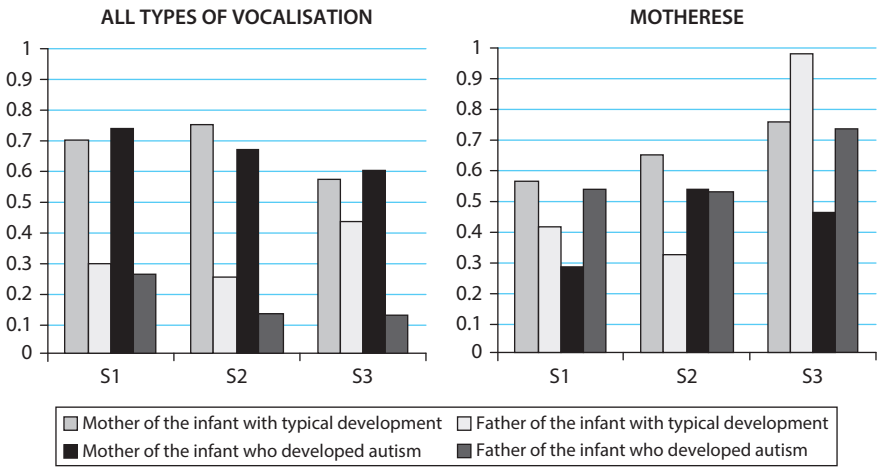

Figure 2. Summary: Mothers' and fathers' role when interacting with their child by semester (Left); Efficacy* of mother and father motherese by semester (Right)

*Efficacy means the relative frequency of motherese sequences that were followed by a response from the child among the total sequences of motherese

4. Discussion

We hypothesized (1) Caregiver's motherese towards the AD boy should decrease over time more dramatically than that seen in caregiver's motherese towards the TD boy. (2) The AD boy should be capable of interacting and responding to motherese specifically at the start of life. Before confronting the hypotheses and the results, there are several limitations to the current study: (i) it is a single case study that precludes generalization; (ii) the lack of standardization in home movies (e.g. context, others present, location, parental characteristics) can influence parent-child interaction; (iii) although we selected the case in each group that had the largest number of sequences, Table 1 shows that there were twice as many HM sequences and duration for the AD than the TD dyads; (iv) we had no child with intellectual disability (ID) to determine the impact of cognitive impairment on the parent-child interactions before 1 year of age. Therefore, discussion should be done in the context of these limitations to develop a new hypothesis and directions for future research.

In a previous research based on the whole Pisa Home Movie database, Saint-Georges et al. (2011) studied caregivers' responses to infants' behaviors in three different groups (TD, AD and ID) and showed that their responses to the child differed little and consequently their ability to be adequate parents was preserved. In the current exploratory study, we aimed to explore specific hypotheses regarding motherese and the possible use of a computerized algorithm classifying motherese vs other speech (Mahdhaoui et al. 2011). Although exploratory, this longitudinal case study supports our hypothesis. The course of an infant's response to CG vocalization differed according to the type of speech (motherese vs. other speech) and child status (TD vs. AD). Mothers spent more time interacting with infants, and fathers appeared to interact with their child preferentially between 12 and 18 months in the TD boy but not in the AD boy. TD boy responded equally well to motherese compared to other speech after 1 year of age. For the AD boy, the responses to both types of speech were lower than in the boy with TD and decreased from the second to the third semester.

Our analysis of mothers' and fathers' vocalizations during the first 18 months of life showed some differences that are worthy of consideration. In general, the focus within the literature tends to be solely on mothers in relation to their children with little attention paid to the fathers. To our knowledge, no longitudinal study on a pathologic group has considered the dynamic between mother and father when interacting with the infant. Consistent with previous studies (e.g. Rebelsky & Hanks 1971), mothers (as the primary caregiver) spend more time interacting with infants during the first year than fathers do. Mothers spend more time than fathers feeding, cleaning, and playing with infants and engaging in more affectionate displays and

verbal interactions than fathers do during this time period (e.g. Clarke-Stewart, 1978; Field 1978; Lamb 1977a; Parke & Sawin 1980). Fathers tend to engage in more active and stimulating interactions than mothers (e.g. Clarke-Stewart 1978; Lamb 1977b), which corresponds to the acquisition of autonomy (motor and language abilities) characteristics beyond the first year of life.

In terms of the course of motherese during the first three semesters of life, studies on parent-infant interactions highlight the universality of the intonation modification in adult speech to infants. Studies also emphasize the powerfulness and effectiveness of this special speech register for communicating with preverbal infants across different cultures (Fernald et al. 1989). Indeed, our exploratory study shows that motherese represents an important proportion of interactions between infants and caregivers during the first 6 months and that its predominance decreases over time. Together, the decrease in motherese and the effectiveness of motherese over time in the TD boy are likely the most important finding of this study. While the use of motherese by caregivers decreased over time, the TD boy's responses to motherese increased along with responses to other speech. After the first year, the TD child responded equally well to motherese speech as to other speech, which is not surprising. At the end of the first year, children start to deliberately create messages that have recognizable functions of language in communication with other people. Caregivers no longer need to speak in motherese to elicit the child's attention or to have a successful interaction with him/her.

Paradoxically, in the AD case, analyses of both the rates of interactions initiated by motherese and the efficacy of motherese based on semesters provides a different framework. The infant's response to both types of speech is not only lower than that of the TD child but decreases from S2 to S3. The quality of vocal emission (CG) is preserved, but not the quality of reception (BB). This result is consistent with findings from home movie studies, which show that the decrease in responses corresponds to the moment that the first signs of autism become more evident. Surprisingly, our study shows that during the same period the rate of motherese used in an interaction remains the same. Should we consider that the boy with AD prefers motherese speech as compared to other speech and that he requires it to keep interacting with CGs? It could also be that there are unconscious concerns on the caregivers' part when interacting with the infant that motivate them to maintain the infant's arousal by using motherese speech. Does this mean that the AD parent should be able to increase their parentese production to ameliorate interactions with their baby? The analysis of the efficacy of fatherese and motherese separately allow us to support this hypothesis in this specific case. Excluding the differences in the frequency of parentese production, we can hypothesize that the fatherese was more effective and stable than the motherese in all three semesters. Indeed, there is an important difference between the infant's responses

to the fatherese and normal speech. In the context of a single case study, interpretation may become speculation as literature on fatherese is very limited. The only study conducted on infants' responses to fatherese suggests that a lower quality of maternal stimulation induces a type of neophilia in infants, such that they preferentially seek out interactions with male social partners (Kaplan et al. 2004).

Regarding further research that will explore the whole Pisa Home Movie database using the same methodology, the current case study shows that the course of parentese may differ according to gender (father vs. mother) and child status (TD vs. AD). The course of an infant's responsiveness to CG vocalization may also differ according to the type of speech (motherese vs. other speech) and child status (TD vs. AD). Therefore, to test our hypotheses we will need to distinguished mother vs father vs other CG in the Pisa Home Movie database before classifying vocalizations addressed to infants according to motherese or not.

References

Achenbach, T.M., & Rescorla, L.A. (2000). *Manual for the ASEBA preschool forms & profiles*. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families.

Adrien, J.L., Lenoir, P., Martineau, J., Perrot, A., Hameury, L., Larmande, C., & Sauvage, D. (1993). Blind ratings of early symptoms of autism based upon family home movies. *Journal of the American Academy of Child and Adolescent Psychiatry, 32*(3), 617–626.

Bloom, K. (1975). Social elicitation of infant vocal behavior. *Journal of Experimental Child Psychology, 20*(1), 51–58.

Braarud, H.C., & Stormark, K.M. (2008). Prosodic modification and vocal adjustments in mothers' speech during face-to-face interaction with their two- to four-month-old infants: A double video study. *Social Development, 17*(4), 1074–1084. doi: 10.1111/j.1467–9507.2007.00455.x

Carrey, N.J. (1995). Itard 1828 memoire on mutism caused by a lesion of the intellectual functions – a historical-analysis. *Journal of the American Academy of Child and Adolescent Psychiatry, 34*(12), 1655–1661.

Clarkestewart, K.A. (1978). Daddy makes 3 – fathers impact on mother and young-child. *Child Development, 49*(2), 466–478.

Croft, C., Beckett, C., Rutter, M., Castle, J., Colvert, E., Groothues, C., Hawkins, A., Kreppner, J., Stevens, S.E., & Sonuga-Barke, E.J.S. (2007). Early adolescent outcomes of institutionally-deprived and non-deprived adoptees. II: Language as a protective factor and a vulnerable outcome. *Journal of Child Psychology and Psychiatry, 48*(1), 31–44. doi: 10.1111/j.1469–7610.2006.01689.x

Crown, C.L., Feldstein, S., Jasnow, M.D., Beebe, B., & Jaffe, J. (2002). The cross-modal coordination of interpersonal timing: Six-week-olds infants' gaze with adults' vocal behavior. *Journal of Psycholinguistic Research, 31*(1), 1–23.

Feldman, R. (2003). Infant-mother and infant-father synchrony: The coregulation of positive arousal. *Infant Mental Health Journal, 24*(1), 1–23. doi: 10.1002/imhj.10041

Fernald, A. (1985). 4-month-old infants prefer to listen to motherese. *Infant Behavior & Development, 8*(2), 181–195.

Fernald, A. (1991). Prosody in speech to children: Prelinguistic and linguistic functions. In R. Vasta (Ed.), *Annals of child development* (Vol. 8, pp. 43–80). London, England: Jessica Kingsley Publishers.

Fernald, A., & Kuhl, P. (1987). Acoustic determinants of infant preference for motherese speech. *Infant Behavior & Development, 10*(3), 279–293.

Fernald, A., Taeschner, T., Dunn, J., Papousek, M., Deboyssonbardies, B., & Fukui, I. (1989). A cross-language study of prosodic modifications in mothers and fathers speech to preverbal infants. *Journal of Child Language, 16*(3), 477–501.

Field, T. (1978). Interaction behaviors of primary versus secondary caretaker fathers. *Developmental Psychology, 14*(2), 183–184.

Goldstein, M.H., King, A.P., & West, M.J. (2003). Social interaction shapes babbling: Testing parallels between birdsong and speech. *Proceedings of the National Academy of Sciences of the United States of America, 100*(13), 8030–8035. doi: 10.1073/pnas.1332441100

Kaplan, P.S., Dungan, J.K., & Zinser, M.C. (2004). Infants of chronically depressed mothers learn in response to male, but not female, infant-directed speech. *Developmental Psychology, 40*(2), 140–148. doi: 10.1037/0012–1649.40.2.140

Kuhl, P.K. (2007). Is speech learning 'gated' by the social brain? *Developmental Science, 10*(1), 110–120. doi: 10.1111/j.1467–7687.2007.00572.x

Lamb, M.E. (1977a). Development of mother-infant and father-infant attachments in 2nd year of life. *Developmental Psychology, 13*(6), 637–648.

Lamb, M.E. (1977b). Father-infant and mother-infant interaction in 1st year of life. *Child Development, 48*(1), 167–181.

Laznik, M.C., Maestro, S., Muratori, F., & Parlato, E. (2005). Les interactions sonores entre les bébés devenus autistes et leurs parents. In M.F. Castarede & G. Konopczynski (Eds.), *Au commencement était la voix* (pp. 171–181). Paris: Érès.

Lord, C., Risi, S., Lambrecht, L., Cook, E.H., Leventhal, B.L., DiLavore, P.C., Pickles, A., & Rutter, M. (2000). The autism diagnostic observation schedule-generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders, 30*(3), 205–223.

Maestro, S., Muratori, F., Cesari, A., Cavallaro, M.C., Paziente, A., Pecini, C., Grassi, C., Manfredi, A., & Sommario, C. (2005). Course of autism signs in the first year of life. *Psychopathology, 38*(1), 26–31. doi: 10.1159/000083967

Mahdhaoui, A., Chetouani, M., Cassel, R.S., Saint-Georges, C., Parlato, E., Laznik, M.C., Apicella, F., Muratori, F., Maestro, S., & Cohen, D. (2011). Computerized home video detection for motherese may help to study impaired interaction between infants who become autistic and their parents. *International Journal of Methods in Psychiatric Research, 20*(1), e6-e18. doi: 10.1002/mpr.332

Muratori, F. Narzisi, A., Tancredi, R. Cosenza, A., Calugi, S., Saviozzi, I., Santocchi, E., & Calderoni, S. (2001). The CBCL 1.5–5 and the identification of preschoolers with autism in Italy. *Epidemiology and Psychiatric Sciences*, doi: 10.1017/S204579601100045X

Muratori, F., Apicella, F., Muratori, P., & Maestro, S. (2011). Intersubjective disruptions and caregiver-infant interaction in early autistic disorder. *Research in Autism Spectrum Disorders, 5*(1), 408–417. doi: 10.1016/j.rasd.2010.06.003

Niwano, K., & Sugai, K. (2003). Pitch characteristics of speech during mother-infant and father-infant vocal interactions. *Japanese Journal of Special Education, 40*(6), 663–674.

Papousek, M., Papousek, H., & Symmes, D. (1991). The meanings of melodies in motherese in tone and stress languages. *Infant Behavior & Development, 14*(4), 415–440.

Parke, R.D., & Sawin, D.B. (1980). The family in early infancy: Social interactional and attitudinal analyses. In F.A. Pedersen (Ed.), *The father-infant relationship. Observational studies in the family setting* (pp. 44–67). New York: Praeger.

Rebelsky, F., & Hanks, C. (1971). Fathers verbal interaction with infants in first 3 months of life. *Child Development, 42*(1), 63–68.

Rutter, M., Le Couteur, A., & Lord, C. (2003). *ADI-R: The autism diagnostic interview-revised.* Los Angeles: Western Psychological Services. doi: 10.1111/j.1469–7610.2006.01688.x

Rutter, M., Kreppner, J., Croft, C., Murin, M., Colvert, E., Beckett, C., Castle, J., & Sonuga-Barke, E. (2007a). Early adolescent outcomes of institutionally deprived and non-deprived adoptees. III. Quasi-autism. *Journal of Child Psychology and Psychiatry, 48*(12), 1200–1207. doi: 10.1111/j.1469–7610.2007.01792.x

Saint-Georges, C., Cassel, R.S., Cohen, D., Chetouani, M., Laznik, M.C., Maestro, S., & Muratori, F. (2010). What studies of family home movies can teach us about autistic infants: A literature review. *Research in Autism Spectrum Disorders, 4*(3), 355–366. doi: 10.1016/j.rasd.2009.10.017

Saint-Georges, C., Mahdhaoui, A., Chetouani, M., Cassel, R., Laznik, M.C., Apicella, F., Muratori, P., Maestro, S., Muratori, F., & Cohen, D. (2011). Do parents recognize autistic deviant behavior long before diagnosis? Taking into account interaction using computational methods. *PlosOne* 6(7): e22393.

Saint-Georges, C., Cassel, R.S., Mahdhaoui, A., Chetouani, M., Muratori, F., Laznik, M.C., & Cohen, D. (submitted). Motherese, variations and effects: A literature review.

Schopler, E., Reichler, R.J., & Renner, B.R. (1988). *The childhood autism rating scale*. Los Angeles: Western Psychological Services.

Schuller, B., Batliner, A., Seppi, D., Steidl, S., Vogt, T., Wagner, J., Devillers, L., Vidrascu, L.,Amir, N., Kessous, L., & Aharonson, V. (2007). The relevance of feature type for the automatic classification of emotional user states: Low level descriptors and functionals. *Interspeech 2007 8th Annual Conference of the International Speech Communication Association* (Vols 1–4), 881–884.

Shute, B., & Wheldall, K. (1999). Fundamental frequency and temporal modifications in the speech of British fathers to their children. Educational Psychology, 19, 221–233.

Stone, W.L., Hoffman, E.L., Lewis, S.E., & Ousley, O.Y. (1994). Early recognition of autism – parental reports vs clinical observation. *Archives of Pediatrics & Adolescent Medicine*, *148*(2), 174–179.

Werner, E., Dawson, G., Osterling, J., & Dinno, N. (2000). Brief report: Recognition of autism spectrum disorder before one year of age: A retrospective study based on home videotapes. *Journal of Autism and Developmental Disorders, 30*(2), 157–162.

Zwaigenbaum, L., Bryson, S., Rogers, T., Roberts, W., Brian, J., & Szatmari, P. (2005). Behavioral manifestations of autism in the first year of life. *International Journal of Developmental Neuroscience, 23*(2–3), 143–152. doi: 10.1016/j.ijdevneu.2004.05.001

Authors' addresses

Raquel S. Cassel
Department of Child and
Adolescent Psychiatry, AP-HP,
Groupe Hospitalier Pitié-Salpêtrière,
Université Pierre et Marie Curie,
Paris, France

Laboratoire de Psychopathologie
et Processus de Santé (LPPS, EA 4057),
Institut de Psychologie
de l'Université Paris Descartes
Paris, France

Catherine Saint-Georges
Department of Child and
Adolescent Psychiatry, AP-HP,
Groupe Hospitalier Pitié-Salpêtrière,
Université Pierre et Marie Curie,
Paris, France

Institut des Systèmes Intelligents
et de Robotique, CNRS FRE 2507,
Université Pierre et Marie Curie,
Paris, France

Ammar Mahdhaoui
Institut des Systèmes Intelligents
et de Robotique, CNRS FRE 2507,
Université Pierre et Marie Curie,
Paris, France

Mohamed Chetouani
Institut des Systèmes Intelligents
et de Robotique, CNRS FRE 2507,
Université Pierre et Marie Curie,
Paris, France

Marie Christine Laznik
Department of Child and
Adolescent Psychiatry,
Association Santé Mentale du 13ème,
Paris, France

Filippo Muratori
Scientific Institute Stella Maris,
University of Pisa,
Italy

Jean-Louis Adrien
Laboratoire de Psychopathologie
et Processus de Santé (LPPS, EA 4057),
Institut de Psychologie
de l'Université Paris Descartes
Paris, France

David Cohen
Department of Child and
Adolescent Psychiatry, AP-HP,
Groupe Hospitalier Pitié-Salpêtrière,
Université Pierre et Marie Curie,
Paris, France

Institut des Systèmes Intelligents
et de Robotique, CNRS FRE 2507,
Université Pierre et Marie Curie,
Paris, France

david.cohen@psl.aphp.fr

Authors' biographical notes

Raquel Cassel is a clinical psychologist. She made her Ph.D. at the Institute of Intelligence System and Robotics from the Université Pierre et Marie Curie (CNRS UMR 7222). She focused on how motherese could be a moderator of successful early interaction in home movies. She is currently working as a therapist in the department of Child and Adolescent Psychiatry at La Salpêtrière hospital in Paris.

Catherine Saint-Georges is a child psychiatrist. She made her Ph.D. at the Institute of Intelligence System and Robotics from the Université Pierre et Marie Curie (CNRS UMR 7222). She focused on how computational methods could model successful early interaction in home movies. She is currently working as a psychiatrist specialized in autism in the CEREP day care hospital in Paris.

Ammar Mahdhaoui received a Bachelor degree in computer science from the University of Monastir (Tunisia) in 2006, and the Master degree in computer science from the University of Grenoble (France) in 2007. He received the Ph.D. degree for his studies on Machine Learning and Speech Processing in 2010, from the University Pierre et Marie Curie. He is a Research Engineer with France Telecom Orange-Labs. His research activities cover the areas of Pattern Recognition, Speech Processing and Human-Machine Interaction.

Mohamed Chetouani received a M.S. degree in Robotics and Intelligent Systems in 2001 and a Ph.D. degree in Speech Signal Processing in 2004 from the Université Pierre et Marie Curie. Then, he visited the Department of Computer Science and Mathematics of the University of Stirling (UK) and the Signal Processing Group of Escola Universitaria Politecnica de Mataro, Barcelona (Spain). He is currently Professor in Signal Processing and Pattern Recognition at the University Pierre and Marie Curie. His research activities cover the areas of non-linear speech processing, feature extraction and pattern classification for speech, speaker and language recognition.

Marie-Christine Laznick is clinical psychologist and psycho-analyst involved in early treatment of children with autism for many years. In the early 90ties, she looked for linked between neurosciences and psycho-analysis and was among the first to propose emotional engagement as a key variable in early interaction. Despite many clinical activities, she remains associated with several research projects focusing on early diagnosis of autism in both Brazil and France.

Filippo Muratori is neuro-psychiatrist, professor at the University of Pisa and head of the autism unit at the Fondazione Stella Maris in Pisa. His group runs research programs in the field of autism and other pervasive developmental disorder for several years both at the level of neurophysiology and early diagnosis and intervention. His expertise in home movie studies is recognized worldwide.

Jean Louis Adrien is developmental psychologist, professor at the Université René Descartes in Paris, and head of the autism team from the laboratory Psychopathology and health processes of the same university. His group runs research programs in the field of autism and other pervasive developmental disorder for several years both at the level of clinical assessment, diagnosis and intervention. He also published several teaching books on autism that are among the French best sellers.

David Cohen is professor at the Université Pierre et Marie Curie (UPMC) and head of the department of Child and Adolescent Psychiatry at La Salpêtrière hospital in Paris. His group runs research programs in the field of autism and other pervasive developmental disorder, severe mood disorder in adolescent and childhood onset schizophrenia and catatonia. He is a member of the laboratory Institute of Intelligence System and Robotics at UPMC (CNRS UMR 7222).