Turn-taking in Children with Autism Spectrum Disorder: Discussion regarding *Ne* and Backchannel Interjections

YUKO YOSHIMURA
Kanazawa University

KOJI KAWAHARA
Nagoya University of Foreign Studies

MITSURU KIKUCHI
Kanazawa University

1 Introduction

Autism spectrum disorder (ASD) is one of the most common childhood neurodevelopmental disorders and is characterized by impaired social cognition and communication and by repetitive and/or obsessive behavior and interests (American Psychiatric Association 2013). The purpose of this paper is to introduce a neuroimaging analysis of ASD and raise the possibility that the different brain responses between children with ASD and typically developing (TD) children lead to different behavior in real conversations. The paper consists of two major parts. Section 2 discusses the neuroimaging analysis of children with ASD and TD children, showing what happens in the brain when they hear a human voice. Section 3 provides a corpus analysis of these children, showing that children with ASD are not observed to utilize an important conversational function. We will argue that a different brain response can be 'a' reason for unsocial communication by children with ASD. Finally, Section 4 concludes the discussion.

Japanese/Korean Linguistics 26. Edited byShoichi Iwasaki, Susan Strauss, Shin Fukuda, Sun-Ah Jun, Sung-Ock Sohn, and Kie Zuraw.

2 Brains and ASD

2.1 Neurophysiological Studies Using Magnetoencephalography (MEG) in Children with ASD

Recent neurophysiological studies suggest that atypical brain function regarding processing sound and voice is related to a social and communication disorder in children with autism. Therefore, atypical processing of voice stimuli in the brain cortex is thought to be involved in the impairment of social behavior in individuals with autism (Cardy et al. 2004). Yoshimura and Kikuchi have focused on the development of auditory processing in early childhood by employing auditory evoked magnetic field (AEF) using child-customized MEG. We reported the characteristics of the auditory response in TD preschool children and children with ASD. In particular, to investigate brain function related to social information, we have used the syllable sound /ne/, which is often used in Japanese mother-child conversations and expresses the speaker's request for acknowledgement or empathy from the listener (Ponton et al. 2002; Kajikawa et al. 2004). Some previous studies have reported that the most prominent feature of sound and voice processing that occurs in children aged 1-10 years old is a component that appears at approximately 100 ms after auditory stimulus (Ponton et al. 2002; Cardy et al. 2004; Gilley et al. 2005). We have labeled this first most prominent component after auditory stimuli P1m and conducted cross-sectional (Yoshimura et al. 2013) and longitudinal studies (Yoshimura et al. 2014, 2016) on the maturational process of the magnitude of the current density of the current source for children aged 2 to 10 years. Intriguingly, our previous studies have demonstrated that the magnitude of the P1m component in the left hemisphere is positively correlated with language performance in young preschool children (2-5 years old)) (See Figure 1 below).

The result of this experiment indicated that the left hemisphere becomes predominant in language processing by 5 years of age. A previous study provided evidence that P1m is sensitive to the place-of-articulation features of speech and their coarticulatory processes (Tavabi et al. 2007). Furthermore, P1m evoked in the left hemisphere may already be involved in a long-range brain network that contributes to language performance, as previous physiological studies indicate that the link between auditory perception and vocal production is quite rapid and connects within quite short periods. For example, Howard et al. (2000); Brugge et al. (2003) and Greenlee et al. (2004) use depth electrode stimulation, and electrophysiological recording in neurosurgical patients to explore the evoked responses and connectivity in a circuit involving the primary auditory cortex, posterior lateral superior temporal, inferior frontal gyrus and orofacial motor cortex. Their studies suggest that, within 40 ms of stimulus onset, a sound already has an impact on neural activity in the orofacial motor cortex through the posterior lateral superior temporal and inferior frontal gyrus. These rapid linkages among language-related brain areas are consistent with previous anatomical studies, indicating the intimate connections among these areas (Pandya and Seltzer 1982; Seltzer

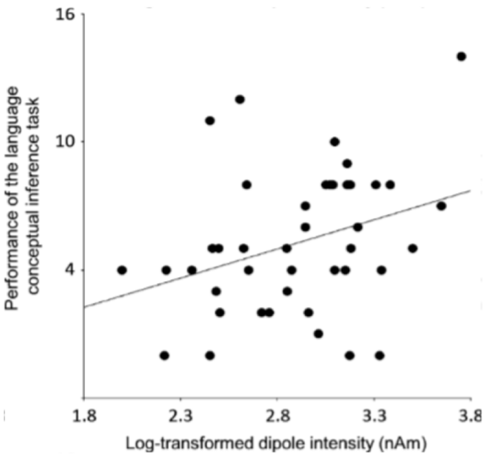

Figure 1: Scatterplot for the P1m intensity in the left hemisphere and language performance (Yoshimura et al. 2012)

and Pandya 1991; Yeterian and Pandya 1998; Petrides and Pandya 2002; Patterson and Johnsrude 2008). Therefore, the P1m component can be used for diagnosing whether the role of the left hemisphere in children with ASD is comparable to that of TD preschool children.[1]

The results of the experiment in Figure 2 show that 3- to 7-year-old children with ASD demonstrate less leftward lateralization in P1m magnitude in response to hearing a voice compared to typically developing control children.

This result indicates that the developmental processes of the auditory cortex, which matures through changes in biological indicators, such as myelination, ordinarily accompanying language acquisition, are not observed in children with ASD in early childhood. Auditory mismatch negativity (MMN), or its magnetic mismatch field (MMF), is quantified by subtracting the average waveform generated in response to standard stimuli from the average deviant waveform; MMN typically peaks between 100 to 250 ms from the onset of the stimulus change (Näätänen et al. 2007).

In previous studies in children, the MMN latency ranged between 100 ms and 400 ms, depending on the age, cognitive skill and stimulus type (Korpilahti et al. 2001; Pihko et al. 2005). MMN has been considered a suitable method for investigating speech development, even in infants, because MMN is elicited at all ages and is enhanced by native speech but demonstrates contrasts with unfamiliar speech beginning at the age of 6 months (Kuhl et al.

[1] According to Yohei Oseki (p.c.), the different activation of the left superior temporal gyrus only indicates that this part of the brain simply responds to the sound; the result does not indicate anything with respect to human language. We hope these studies are a reply to his comment.

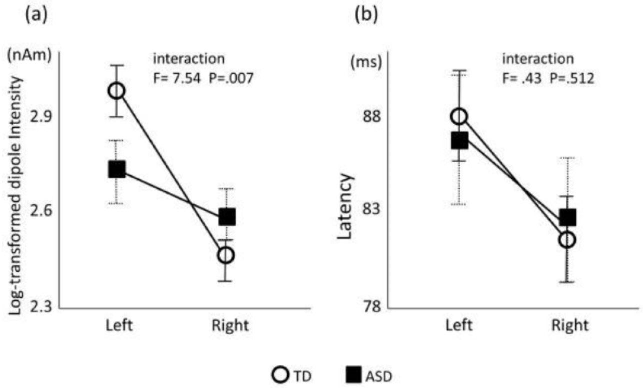

Figure 2: Intensity (a) and latency (b) of the P50m component. The open circles indicate typically developing children, and the closed squares indicate children with ASD. Note the significant interaction between the group and hemisphere (F= 7.54; p = 0.007) for the intensity values (a). (Yoshimura et al. 2013)

2005). Atypical MMN/MMF responses have been reported in populations with ASD (Kuhl et al. 2013). Yoshimura and Kikuchi have also investigated the MMF evoked by voice stimuli in 3- to 5-year-old typically developing (TD) children and children with ASD (Yoshimura et al. 2013). We have used typical oddball sequences consisting of standard stimuli (456 times, 83%) and deviant stimuli (90 times, 17%). The stimuli consisted of the Japanese syllable “ne” pronounced two different ways (Figure 3).

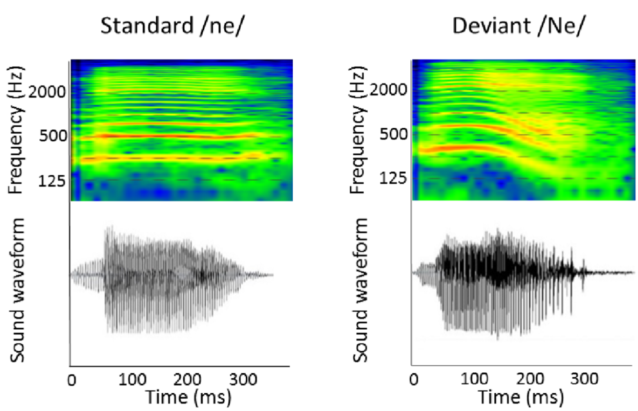

Figure 3: Spectral and temporal characteristics of the stimulus items standard /ne/ and deviant /Ne/ (Yoshimura et al. 2017)

A repetitive series of utterances of "ne" pronounced with a flat tone (/ne/) was used as a standard. This stimulus carries no intonational information. As a deviant stimulus, we used "ne" pronounced with a high falling tone (/Ne/), which carries intonational information (e.g., attention-seeking, emotional, declarative, or interrogative intonation). Children with ASD exhibited significantly decreased activation in the left superior temporal gyrus compared to TD children, as determined via the MMF amplitude (Figure 4).

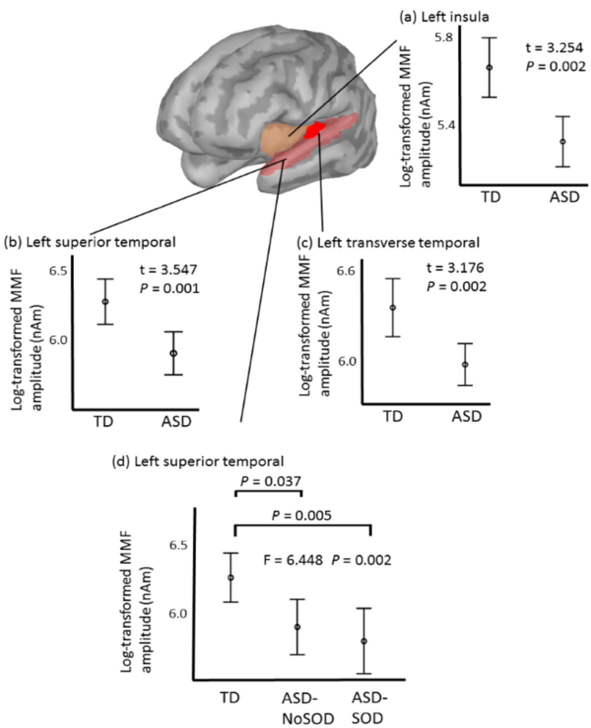

Figure 4: Comparison of the MMF source amplitude in the 100-200 ms time window. Significant differences were identified in the left superior temporal gyrus (a) and the left transverse temporal gyrus (b) between TD children and children with ASD. There was a significant difference in the left superior temporal gyrus (c) and between TD children and ASD children with and without speech onset delay (SOD) (Yoshimura et al. 2017)

Dividing children with ASD according to the presence of a speech onset delay (ASD-SOD and ASD-NoSOD, respectively) and comparing them with TD children, both the ASD groups exhibited decreased activation in the left superior temporal gyrus compared to the TD children. In contrast, the ASD-

SOD group exhibited increased activity in the left frontal cortex (i.e., pars orbitalis) compared to the other groups (Figure 5).

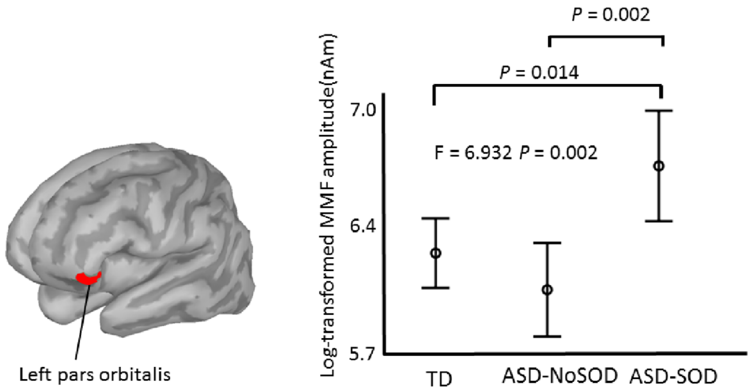

Figure 5: Comparison of the MMF amplitudes in the left pars orbitalis during the 200-350 ms time window among the three groups (Yoshimura et al. 2017).

Irrespective of SOD, all the children with ASD have a significant negative correlation between the MMF amplitude in the left pars orbitalis and language performance. The left inferior frontal cortex may play an important role in the detection of rapid pitch changes in subjects with ASD at the cost of language performance. We had shown that the brain responses with respect to the interjection /ne/ are different between TD children and children with ASD. The next question to be discussed is how the difference in the brain activity leads to real conversations. We will argue that children with ASD are responsive enough to a conversational turn with the interjection /ne/ but that they will not make use of a sentence that requires a collaborative activity.

3 Unrepaired Conversations by Children with ASD

3.1 Background to the Difficulty with Turn-Taking Communication in ASD

As one of the core and common symptoms in individuals with ASD, numerous reports have been made about the difficulties with functional language and failure of social communication. The skill of using language for interpersonal communication is called “pragmatics”; a failure in social communication is one of the earliest signs of autism (Baron-Cohen 1988; Tager-Flusberg et al. 2009).

With respect to social communication, children with ASD neither show the use of words to look for joint attention nor refer to the cognition (i.e. belief, intention) in words that represent the state of the person’s mind. The ability to infer and predict the intentions, thoughts, desires, intuitions, behavioral reactions, plans, and beliefs of others is called “the theory of mind” (Frith and

Frith 2012). Many previous studies have suggested that the lack of pragmatics in children with ASD is due to an impairment in the 'theory of mind' (Mathersul et al. 2013; Baron-Cohen et al. 1985). In the case of TD children, joint attention emerges at approximately 9 months, and TD children acquire words and concepts for expressing one's state of mind at approximately 2 years old. Furthermore, they are able to distinguish between their own beliefs and the beliefs of others when they are approximately 4 years old. However, it has been pointed out that children with ASD show abnormalities in these developments. Based on this background, we have compared the conversations of children with ASD and of TD children as a control.

3.2 Conversation Analysis

We focused on the backchannel use of /ne/ that triggers confirmation or joint-attention in conversations. The turn initial /ne/ used as an attention getter is mainly involved in joint attention. Although it can also be used in a sentence final position but the main focus in this paper is on a single-use of /ne/ that corresponds to the turn initial /ne/ and is fairly frequent in Japanese conversations.[2] Based on traditional conversation analysis, we used informal face-to-face conversational data (Sacks et al. 1974; Schegloff et al. 1977). Language in context helps us understand how it is shaped by, and for, interaction. We focused on the role of the interjection /ne/ in real conversations (Tanaka 2000). We used the four video corpora and four samples in the TalkBank system, which is available for sharing and studying conversational interactions (MacWhinney 2000). The age of participants varied from 3 to 7 years old. Data collection was based on naturally occurring conversations between an experimenter and a subject and families and friends, following established methods of conversation analysis. Participants often engaged in additional activities during these conversations. The interjection /ne/ is used in a variety of positions in a sentence: the initial, internal and final positions. It is used for summoning, confirmation, inviting affiliation, repair initiation and so forth. All of the conversations were naturally occurring, social conversations in Japanese and social conversations. We counted the number of /ne/ that had some conversational function in the material and counted the reduplicated form, such as "nee nee," as a single unit.

We have investigated whether children with ASD are responsive in conversations and are willing to attract attention or make a request. Kajikawa et al. (2004) point out that by 3;3 years of age, turn-taking is fairly smooth, and frequent overlaps are observed between mother-child conversations. Based on the video corpora, we counted the number of the turn management /ne/. We found that, although children with ASD responded as quickly as TD children (Stivers et al. 2009), if they were asked by using /ne/ and were told something beginning with /ne/. However, there was no single statement made by children with ASD using /ne/ to make a request or to confirm; this result was pointed out previously by Watanuki (1997) in a study that evaluated in

---

[2] We thank some comments by the reviewer(s).

	A (5;00)	**B (5;00)**	**C (3;08)**	**D (3;01)**
Time of corpus	74:58	80:57	52:30	45:49
/ne/	18	51	10	29
Once Per Second	46.4	95.2	315.2	94.8

TABLE 2: TD Male Children Summary

an hour-long conversation. We also found that there was no time lag in the conversations between children with ASD and the examiner as far as the interjection is concerned. This applied to TD children in the control corpora.

However, children with ASD did not make use of /ne/ in the four corpora. The result of the production of /ne/ is summarized in TABLE 1 and 2.

	A (7;2)	**B (5;3)**	**C (5;2)**	**D (5;7)**
Time of corpus	73:39	56:56	45:20	46:25
/ne/	0	0	0	0

TABLE 1: Male Children with ASD Summary

Children with ASD were responsive to a conversational turn containing /ne/. This indicates that they actually heard the /ne/ sound and understand its function. What is intriguing is the fact that they did not utter the interjection /ne/, while they can pronounce a sound such as *nezumi* ‘mouse’.

In contrast, TD children often used the interjection /ne/ (twice per minute on average). As a result of the student’s t-test, there was a significant difference between TD children and children with ASD (t $= -3.035$, $p = 0.023$) in the instances of the interjection /ne/ produced.

In addition, children with ASD never repaired a conversation. In everyday social interaction, people ask each other for clarification once every 84 seconds on average (Dingemanse et al. 2015). Repair is ubiquitous and indispensable, that is, a key part of our communication system. Repair may be roughly divided into several subcategories: open requests, restricted requests, or restricted offers (Dingemanse and Enfield 2015). An open request that is initiated, such as *huh?* in English, asks for repetition or clarification, targeting the whole of a prior turn. A restricted request initiated, such as *who?* or *what?*, also asks for repetition or clarification, targeting some of the prior turn. A restricted offer is provided by a whole sentence, requesting confirmation and targeting some of the prior turn. Since a repair strategy is typical of normal conversations and is a major characteristic of collaborative conversations, the lack of repair by children with ASD should be a major target for analysis of their pragmatic abilities.

From these comparative studies, we conclude that children with ASD show no significant delay in response compared to TD children regarding turn taking. However, they are not willing to repair conversations. These are important strategies in conversations that prevent misunderstandings. A conclusion drawn from this research is that children with ASD have difficulties in conversations or social interactions because they are not willing to be involved in interactions, which is probably due to their atypical brain functioning. Therefore, the difference in brain function leads to production errors, not to receptive errors.

4 Conclusion

The purpose of this paper was twofold. First, the neuroimaging analysis of children with ASD exhibits significantly decreased activation in the left superior temporal gyrus compared to TD children for the MMF amplitude. For all the children with ASD, there was a significant negative correlation between the MMF amplitude in the left pars orbitalis and language performance. Second, in the comparative analysis of real conversations, we observed that children with ASD were receptive enough to a prior turn in turn-taking. However, they did not confirm or repair conversations. Specifically, the turn-management /ne/ was never used. This is important from a linguistic point of view because repair is ubiquitous and vital for preventing miscommunication. The next question is how and why the different brain responses lead to different attitudes in conversations. This awaits future research.

Acknowledgments

This study was supported by the Center of Innovation Program of the Japan Science and Technology Agency, JST, JSPS KAKENHI Grant Numbers JP18H05067, JP16K10247 and 18H05086. The authors wish to thank all of the participants who participated in this study and our colleagues for their assistance. The authors declare no competing financial interests.

References

American Psychiatric Association 2013. *Diagnostic and Statistical Manual of Mental Disorders: DSM-5*. Washington D.C.: Amercial Psychiatric Publishing.

Baron-Cohen, S. 1988. Social and Pragmatic Deficits in Autism: Cognitive or Affective? *Journal of Autism and Developmental Disorders 18*, 379–402.

Baron-Cohen, S., A. M. Leslie, and U. Frith 1985. Does the Autistic Child Have a "Theory of Mind"? *Cognition 21*, 37–46.

Brugge, J., I. Volkov, P. Garell, R. Reale, and M. Howard 2003. Functional Connections Between Auditory Cortex on Heschl's Gyrus and on the Lateral Superior Temporal Gyrus in Humans. *Journal of Neurophysiology 90*, 3750–3763.

Cardy, J. O., P. Ferrari, E. Flagg, W. Roberts, and T. Roberts 2004. Prominence of M50 Auditory Evoked Response Over M100 in Childhood and Autism. *NeuroReport 15*, 1867–1870.

Dingemanse, M. and N. J. Enfield 2015. Other-Initiated Repair Across Languages: Towards a Typology of Conversational Structures. *Open Linguistics 1*, 96–118.

Dingemanse, M., S. Roberts, J. Baranova, J. Blythe, P. Drew, S. Floyd, R. Gisladottir, K. Kendrick, S. Levinson, E. Manrique, G. Rossi, and N. J. Enfield 2015. Universal Principles in the Repair of Communication Problems. *PLoS One 10*(9), 1–15.

Frith, C. D. and U. Frith 2012. Mechanisms of Social Cognition. *Annual Review of Psychology 63*, 287–313.

Gilley, P. M., A. Sharma, M. Dorman, and K. Martin 2005. Developmental Changes in Refractoriness of the Cortical Auditory Evoked Potential. *Clinical Neurophysiology 116*, 648–657.

Greenlee, J., H. Oya, H. Kawasaki, I. Volkov, O. Kaufman, C. Kovach, M. Howard, and J. Brugge 2004. A Functional Connection Between Inferior Frontal Gyrus and Orofacial Motor Cortex in Human. *Journal of Neurophysiology 92*, 1153–1164.

Howard, M., I. Volkov, R. Mirsky, P. Garell, M. Noh, M. Granner, M. Damasio, M. Steinschneider, R. Reale, J. Hind, and J. Brugge 2000. Auditory Cortex on the Human Posterior Superior Temporal Gyrus. *Journal of Comparative Neurology 416*, 79–92.

Kajikawa, S., S. Amano, and T. Kondo 2004. Speech Overlap in Japanese: Mother-Child Conversations. *Journal of Child Language 31*, 215–230.

Korpilahti, P., C. M. Krause, I. Holopainen, and A. Lang 2001. Negativity Elicited by Words and Speech-Like Stimuli in Children. *Brain and Language 76*, 332–339.

Kuhl, P. K., S. Coffey-Corina, D. Padden, and G. Dawson 2005. Links between Social and Linguistic Processing of Speech in Preschool Children with Autism: Behavioral and Electropysiological Measures. *Developmental Science 8*, 1–12.

Kuhl, P. K., S. Coffey-Corina, D. Padden, J. Munson, A. Estes, and G. Dawson 2013. Brain Responses to Words in 2-Year-Olds with Autism Predict Developmental Outcomes at Age 6. *PLoS ONE 8*(5), e64967.

MacWhinney, B. 2000. *The CHILDES Project: Tools for Analyzing Talk*. Mahwah, NJ: Lawrence Erlbaum Associates.

Mathersul, D., S. McDonald, and J. A. Rushby 2013. Understanding Advanced Theory of Mind and Empathy in High-Functioning Adults with Autism Spectrum Disorder. *Journal of Clinical and Experimental Neurophychology 35*, 655–668.

Näätänen, R., P. Paavilainen, T. Rinne, and A. Kimmo 2007. The Mismatch Negativity (MMN) in Basic Research of Central Auditory Processing: A Review. *Clinical Neurophysiology 118*, 2544–2590.

Pandya, D. and B. Seltzer 1982. Intrinsic Connections and Architectonics of Posterior Parietal Cortex in the Rhesus Monkeyonnections and architectonics of posterior parietal cortex in the rhesus monkey. *Journal of Comparative Neurology 204*, 196–210.

Patterson, R. and I. Johnsrude 2008. Functional Imaging of the Auditoryprocessing Applied to Speech Sounds. *Philosophical Transactions of the Royal Society B: Biological Sciences 363*, 1023–1035.

Petrides, M. and D. Pandya 2002. Comparative Cytoarchitectonic Analysis of the Human and the Macaque Ventrolateral Prefrontal Cortex and Corticocortical Connection Patterns in the Monkey. *European Journal of Neuroscience 16*, 291–310.

Pihko, E., T. Kujala, A. Mickos, H. Antell, P. Alku, R. Byring, and M. Korkman 2005. Magnetic Fields Evoked by Speech Sounds in Preschool Children. *Clinical Neurophysiology 16*(112-119).

Ponton, C., J. J. Eggermont, D. Khosla, B. Kwong, and M. Don 2002. Maturation of Human Central Auditory System Activity: Separating Auditory Evoked Potentials by Dopole Source Modeling. *Clinical Neurophysiology 113*, 407–420.

Sacks, H., E. Schegloff, and G. Jefferson 1974. A Simplest Systematics for the Organization of Turn-Taking for Conversation. *Language 50*, 696–735.

Schegloff, E., G. Jefferson, and H. Sacks 1977. The Preference for Self-Correction in the Organization of Repair in Conversation. *Language 53*(2), 361–382.

Seltzer, B. and D. Pandya 1991. Post-Rolandic Cortical Projections of the Superior Temporal Sulcus in the Rhesus Monkey. *Journal of Comparative Neurology 312*, 625–640.

Stivers, T., N. J. Enfield, P. Brown, C. Englert, M. Hayashi, T. Heinemann, G. Hoymann, F. Rossano, J. P. d. Ruiter, K.-E. Yoon, and S. Levinson 2009. Universals and Cultural Variation in Turn-Taking in Conversation. In *Proceedings of the National Academy of Sciences of the United States of America*, Volume 106, pp. 10587–10592.

Tager-Flusberg, H., S. Rogers, J. Cooper, R. Landa, C. Lord, R. Paul, M. RIce, C. Stoel-Gammon, A. Wetherby, and P. Yoder 2009. Defining Spoken Language Benchmarks and Selective Measures of Expressive Language Development for Young Children with Autism Spectrum Disorders. *Journal of Speech, Language, and Hearing Research 52*, 643–652.

Tanaka, H. 2000. The Particle *ne* as a Turn-Management Device in Japanese Conversation. *Journal of Pragmatics 32*, 1135–1176.

Tavabi, K., J. Obleser, C. Dobel, and C. Pantev 2007. Auditory Evoked Fields Differentially Encode Speech Features: an MEG Investigation of the P50m and N100m Time Courses During Syllable Processing. *European Journal of Neuroscience 25*, 3155–3162.

Watanuki, T. 1997. Ziheisyoozi Niokeru Kyookan Kakutokuhyoogen *ne* Nosiyoono Ketuzyo (children with ASD do not Use /ne/ That Expresses Emphathy). *Hattatu syoogai kenkyuu (Japanese Journal on Developmental Disabilities) 19*, 146–157.

Yeterian, E. and D. Pandya 1998. Corticostriatal Connections of the Superior Temporal Region in Rhesus Monkeys. *Journal of Cognitive Neuroscience 399*(384-402).

Yoshimura, Y., M. Kikuchi, N. Hayashi, H. Hiraishi, C. Hasegawa, T. Takahashi, M. Oi, G. B. Remijn, T. Ikeda, D. Saito, H. Kumazaki, and Y. Manabe 2017. Altered Human Voice Processing in the Frontal Cortex and a Developmental Language Delay in 3-to 5-Year-Old Children with Autism Spectrum Disorder. *Scientific Reports 7*, 17116.

Yoshimura, Y., M. Kikuchi, H. Hiraishi, C. Hasegawa, T. Takahashi, G. B. Remijn, M. Oi, T. Munesue, H. Higashida, and Y. Minabe 2016. Synchrony of Auditory Brain Responses Predicts Behavioral Ability to Keep Still in Children with Autism Spectrum Disorder Auditory-Evoked Response in Children with Autism Spectrum Disorder. *NeuroImage: Clinical 12*, 300–305.

Yoshimura, Y., M. Kikuchi, K. Shitamichi, S. Ueno, T. Munesue, Y. Ono, T. Tsubokawa, Y. Haruta, M. Oi, Y. Niida, G. B. Remijn, T. Takahashi, M. Suzuki, H. Higashida, and Y. Minabe 2013. Atypical Brain Lateralisation in the Auditory Cortex and Language Performance in 3- to 7-Year-Old Children with High-Functioning Autism Spectrum Disorder: a Child-Customised Magnetoencephalography (MEG) Study. *Molecular Autism 4*(1), 38.

Yoshimura, Y., M. Kikuchi, K. Shitamichi, S. Ueno, G. B. Remijn, Y. Haruta, M. Oi, T. Munesue, T. Tsubokawa, H. Higashida, and Y. Minabe 2012. Language Perfromance and Auditory Evoked Fields in 2-to 5-Year-Old Children. *European Journal of Neuroscience 35*, 644–650.

Yoshimura, Y., M. Kikuchi, S. Ueno, K. Shitamichi, G. B. Remijn, H. Hiraishi, C. Hasegawa, N. Furutani, m. Oi, T. Munesue, T. Tsubokawa, H. Higashida, and Y. Minabe 2014. A Longitudinal Study of Auditory Evoked Field and Language Development in Young Children. *NeuroImage 101*, 440–447.