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Individual mentalizing ability boosts flexibility toward a linguistic marker of social distance: An ERP investigation

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A R T I C L E I N F O

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A B S T R A C T

Sentence-final particles (SFPs) as bound morphemes in Japanese have no obvious effect on the truth conditions of a sentence. However, they encompass a diverse range of usages, from typical to atypical, according to the context and the interpersonal relationships in the specific situation. The most frequent particle, *-ne*, is typically used after addressee-oriented propositions for information sharing, while another frequent particle, *-yo*, is typically used after addresser-oriented propositions to elicit a sense of strength. This study sheds light on individual differences among native speakers in flexibly understanding such linguistic markers based on their mentalizing ability (i.e., the ability to infer the mental states of others). Two experiments employing electroencephalography (EEG) consistently showed enhanced early posterior negativities (EPN) for atypical SFP usage compared to typical usage, especially when understanding *-ne* compared to *-yo*, in both an SFP appropriateness judgment task and a content comprehension task. Importantly, the amplitude of the EPN for atypical usages of *-ne* was significantly higher in participants with *lower mentalizing ability* than in those with a *higher mentalizing ability*. This effect plausibly reflects low-ability mentalizers' stronger sense of strangeness toward atypical *-ne* usage. While high-ability mentalizers may aptly perceive others' attitudes via their various usages of *-ne*, low-ability mentalizers seem to adopt a more stereotypical understanding. These results attest to the greater degree of difficulty low-ability mentalizers have in establishing a smooth regulation of interpersonal distance during social encounters.

1. Introduction

Many people are sensitive to subtle cues in the behavior of others and can use those cues to flexibly recognize *social distance*, or shared psychological space with others. However, those without this sensitivity often fail to accomplish this delicate regulation, which might cause awkward or even unpleasant feelings toward others. These individuals may therefore experience a certain sense of discomfort when creating interpersonal relationships. Indeed, there seem to be inter-individual differences in the sensitivity to others' cues that typically manifest in nonverbal behavior, such as facial expressions (e.g., John & Gross, 2004) and gestures (e.g., Rosip & Hall, 2004).

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In addition to nonverbal behavior, language also plays a key role in controlling interpersonal distance. This seems particularly evident in (spoken) Japanese, which has sentence-final particles (SFPs) as bound morphemes such as *-ne* and *-yo* that uniquely serve to indicate the interpersonal distance between addresser and addressee (Kamio, 1994; Katagiri, 2007). It is not uncommon for some East and South-East Asian languages, like Mandarin Chinese (Li & Thompson, 1989), Cantonese (Matthews & Yip, 1994), Korean (Koo & Rhee, 2013), and Malay (Neeleman & Szendröi, 2007), to have SFPs that can be attached after a predicate to specify the addresser's attitude to the proposition to yield various discourse functions.

In Japanese, SFPs as function words have no obvious effect on the truth conditions of a sentence (Davis, 2009), but they encompass a complicated and diverse range of usages, from typical to atypical, according to the context and the interpersonal relationships (Tanaka, 2000). The most frequent SFP, *-ne*, indicates the addresser's attitude that the stated proposition before the SFP belongs to or is under the control of the addressee, while the second most frequent SFP, *-yo*, indicates that said proposition is under the control of the addresser (Takiura, 2008). Accordingly, it is typical to attach *-ne* to sentences with addressee-oriented propositions to communicate information shared with the addressee, and to use *-yo* for addresser-oriented propositions to elicit a sense of strength or insistence (e.g., Kamio, 1994; Davis, 2009; see Table 1 for examples). Nevertheless, the opposite combinations, namely, an addresser-oriented *-ne* and an addressee-oriented *-yo*, are still grammatical and sporadically used, even though they are mostly atypical. In an atypical usage of the addresser-oriented *-ne*, the addresser would create a somewhat “unfriendly attitude,” as if leaving the given proposition to the addressee (Takiura, 2008). Participants in Japanese conversations are expected to detect these fluid and delicate senses intended by addressers through the use of SFPs, which are said to have *chameleon-like qualities* (Tanaka, 2000).

Several linguists studying Japanese SFPs (e.g., Cook, 1990, 1992; Maynard, 1994, 1997; Mizutani & Mizutani, 1987, among many others) have pointed out that *-ne*, being an addressee-oriented particle, typically plays an *emotional role* in that it helps to build a rapport between the addresser and the addressee as it achieves information sharing. In contrast, the addresser-oriented function of *-yo*, meant to elicit a sense of strength, serves to emphasize the addresser's will or judgment. With these basic functions, Japanese SFPs can arouse both pleasant and unpleasant emotions in the addressee. For example, an addressee would typically have a pleasant emotion if a favorable addresser used *-ne* to create empathy with the addressee because, in this case, the use of *-ne* would agree with the addressee's expectation of closeness to the addresser. However, if a disliked person used *-ne* in succession, the addressee might have an unpleasant emotion because, in this case, the addresser would give the impression of being overly familiar with or too dependent on the addressee, who does not want to create empathy with the addresser. Indeed, Japanese SFPs are predominantly used in informal face-to-face conversations and hardly appear in formal situations, such as court sessions and press reports, in which addressers are not supposed to convey any emotion in order to stay neutral and objective with their message in front of an unspecified audience. In sum, indications of interpersonal relationships through SFPs can unintentionally evoke various emotional reactions.

Japanese SFPs, therefore, seem to function as a set of inherent, pre-lexical interactional markers for native Japanese speakers, independent of understanding the proposition itself. This is supported by the observation that typically developing Japanese children begin to utter *-ne* at the age of two (i.e., the very earliest stage of language acquisition, during which children begin to make two-word utterances) without explicit guidance from adults (Kajikawa, Amano, & Kondo, 2004; Shirai, Shirai, & Furuta, 2000). They even occasionally utter *-ne* by itself just to create empathy, even when they do not understand what the adult addresser is saying.

If SFPs' emotional function proceeds through the link with interpersonal distance, the understanding of Japanese SFPs likely depends on the individual addressee's ability to imagine the addresser's thoughts and feelings. This can be referred to as a “theory of mind” (ToM) or a “mentalizing” ability (Baron-Cohen, 1995). While mentalizing ability predicts others' behavior based on their mental states, its more advanced features include knowledge about the emotional experience of others (e.g., Hooker, Verosky, Germine, Knight, & D'Esposito, 2008). Although most native speakers seem to naturally acquire a sense of SFPs (Shirai et al., 2000), Japanese children with high-functioning autism, who experience the greatest difficulty in solving mentalizing problems, seldom use the rapport-creating SFP *-ne* (Watamaki, 1997). This observation is consistent with autistic children's pervasive pragmatic deficits, which can be characterized in terms of a lack of ability to share information or difficulty with differentiating addresser-addressee roles (Baltaxe, 1977). Baron-Cohen (1988) argues that the pragmatic deficits in autism derive from an innate inability to engage emotionally with others, as well as an impairment of the meta-representation of attributing others' beliefs to their behavior. Among typical speakers, it could also be assumed that those with a lower mentalizing ability are more deficient in understanding the SFP *-ne*, since the degree of mentalization ability follows a continuous distribution across the general population (Constantino & Todd, 2003). To our knowledge, however, there is only limited experimental evidence available concerning how native Japanese speakers can flexibly recognize the large variety of usages that these SFPs allow, and to what extent the cognitive and affective aspects of an individual's mentalizing ability are associated with this flexibility.

To elucidate the correlation between the flexibility to successfully understand SFPs and an individual's mentalizing ability, physiological indices such as event-related potentials (ERPs) are informative, as they have been found to disclose some of the course of the involuntary processes of mentalization (see: Abell, Happé, & Frith, 2000). From a neurolinguistic perspective, one could expect an N400 component (a negativity between 250 and 500 ms after stimulus onset in the centroparietal regions) to emerge in response to an atypical usage of SFP *-ne*, as opposed to its typical usage. Since Kutas and Hillyard (1980) first reported the effect, numerous other studies (see Kutas & Federmeier, 2011 for a review) have shown that the classical index occurs in response to anomalies during the integration of semantic information presented in sentence and discourse context. A similar N400 effect has already been shown in discourse comprehension in Japanese (Hirotani & Schumacher, 2011) and in pragmatic function words such as/cai2/and/jiu4/in spoken Chinese (Liu, Jin, Li, Li, & Wang, 2009). Moreover, a correlation between the pragmatic N400 effect and individual mentalizing ability is discernible (Nieuwland, Ditman, & Kuperberg, 2010), with high-ability mentalizers showing a larger N400 amplitude in response to under-informative statements than to informative statements.

However, we must note that the Japanese SFP *-ne* is qualitatively different from pragmatic function words (Liu et al., 2009) and

Table 1
Example usages of Japanese sentence-final particles ***-ne*** and ***-yo***.

Typicality	Content orientation	First turn	Second turn
Typical *-ne* (Atypical *-yo*)	Addressee	*Kondo Satou-san-tati-to onsen-ni iku-n-da.* soon Mr. Satou-others-with spa-DAT go-NMLZ-COP '(I)'m going to the spa with Mr. Satou and others soon.'	*Hontooni onsen-ga suki-da-**ne*** (***-yo***). really spa-NOM like-COP-SFP '(You) really like the spa.'
Typical *-yo* (Atypical *-ne*)	Addresser	*Moo ohirugohan tabe-ta?* already lunch eat-PST 'Did (you) already eat lunch?'	*Kinjo-de udon tabe-ta-**yo*** (***-ne***). nearby-LOC noodle eat-PST-SFP '(I) ate noodles nearby.'

Notes: The abbreviations represent the following: DAT [Dative case marker], NMLZ [Nominalizer], COP [Copula], NOM [Nominative case marker], SFP [Sentence-final particle], PST [Past], LOC [Locative case marker]. Atypical markers appear between parentheses.

discourse comprehension (Hirotani & Schumacher, 2011; Nieuwland et al., 2010), which have been shown to induce an N400 effect. As discussed earlier, Japanese SFPs are considered to be more emotionally arousing linguistic markers of interpersonal distance, unlike discourse markers such as the Chinese function words/cai2/and/jiu4/, which were examined by Liu et al. (2009).

Emotional processing and evaluation of interpersonal relationships could induce earlier ERP effects, especially in those with a lower mentalizing ability (or those with autistic traits; Orekhova & Stroganova, 2014; Perry, Levy-Gigi, Richter-Levin, & Shamay-Tsoory, 2015). Among early ERP components, an early posterior negativity (EPN) arising between 150 and 400 ms after stimulus onset over the occipito-parietal cortex has been reported to reflect autistic individuals' emotion recognition and perceptual attention (Faja, Dawson, Aylward, Wijsman, & Webb, 2016). Several previous investigations have identified this component as relevant to the comprehending of emotional words (e.g., Kissler & Herbert, 2013; Scott, O'Donnell, Leuthold, & Sereno, 2009; Zhang et al., 2014), as well as the processing of non-linguistic stimuli such as scenes, faces, and gestures (e.g., Junghöfer et al., 2004; Schacht & Sommer, 2009). EPN was initially linked to visual processing (see Schupp, Flaisch, Stockburger, & Junghöfer, 2006 for a review), but it has also been demonstrated within the auditory modality (e.g., Jaspers-Fayer, Ertl, Leicht, Leupelt, & Mulert, 2012; Schupp, Junghöfer, Weike, & Hamm, 2003). Specifically, Mittermeier et al. (2011) found an influence in the EPN of individual personality traits, on the scale of extraversion-introversion, during an auditory choice task that entailed emotional intonation, with extraverted participants having stronger EPN amplitudes for emotional words than for neutral words. This suggests that neural reactivity occurring in an earlier time window may reflect a pre-lexical attentional processing stage that facilitates subsequent semantic integration (Kissler & Herbert, 2013). This idea is also supported by behavioral evidence showing that lexical decisions are made more quickly for emotional words than for neutral words (Kousta, Vinson, & Vigliocco, 2009). Following this logic, understanding auditorily presented Japanese SFPs, which are emotionally arousing markers of interpersonal distance, may evoke some earlier potentials before N400.

So far, neural correlates of understanding SFPs with an individual's mentalizing ability have not been reported. Whatever the polarity, some earlier ERP effects might be induced, as the time course should be sensitive to the understanding of interpersonal relations through those markers. The predictions of this exploratory study are therefore that 1) the understanding of Japanese SFPs elicits a stronger EPN effect in atypical than in typical usages, and 2) an individual's mentalizing ability influences this effect. To examine these predictions, we investigated whether ERP amplitudes correlated with native Japanese speakers' mentalizing ability while understanding the auditorily presented SFPs *-ne* and *-yo* in typical and atypical usages. This was carried out while participants made judgments of SFP appropriateness (Experiment 1), and while attempting to comprehend the content of the dialog with no explicit instruction regarding SFPs (Experiment 2).

2. Experiment 1: SFP appropriateness judgment task

To examine native speakers' explicit judgments of sentences including Japanese SFPs, participants were required to judge whether a given SFP was appropriate or not in the various presented dialogs (in what will be referred to as the appropriateness judgment task).

2.1. Materials and methods

2.1.1. Participants

Twenty-one healthy right-handed graduate and undergraduate students (12 males; age range: 19-24, $M = 20.0$, $SD = 1.4$) participated in Experiment 1 after giving informed consent in accordance with the Declaration of Helsinki. All the participants were native Japanese speakers and reported to have no neurological problems. All of them were paid for their participation. This study was approved by the Ethical Committee of the Graduate School of Languages and Cultures, Nagoya University, Japan.

To assess the degree of each participant's mentalizing ability, participants were asked to complete the Japanese standardized version of the Autism-Spectrum Quotient (AQ; Wakabayashi, Baron-Cohen, Wheelwright, & Tojo, 2006). This questionnaire has been validated as an instrument for rapidly quantifying where an individual is situated along a continuum of autistic traits as diagnosed by the presence of repetitive behaviors and limited imagination of others' mental states (American Psychiatric Association, 2013) in adults with normal intelligence (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). We used AQ scores because they have been shown to represent mentalizing ability within the general population (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Nieuwland et al., 2010). The average AQ score (with higher scores indicating a lower mentalizing ability) among Japanese university students ($n = 1050$) has been reported to be 20.7 ($SD = 6.4$) out of the maximum score of 50 (Wakabayashi et al., 2006). For our participants in Experiment 1, the AQ total score ranged from 13 to 32 ($M = 20.3$, $SD = 5.2$), nearly equivalent to the overall average of Japanese university students as reported by Wakabayashi et al. (2006).

2.1.2. Materials

The stimulus materials were auditorily presented dialogs specifically created for this study. First, 176 dialogs between two people were prepared (i.e., small fragments of conversation as opposed to single sentences by one person), including the target SFPs *-ne* and *-yo*. To create the context necessary for judging the typicality of the SFP, each dialog consisted of two turns, with *-ne* or *-yo* at the end of the second turn. As shown in Table 1, the subject of each second turn was omitted, as Japanese is a pronoun-dropping (pro-drop) language (Iwasaki, 1993). We manipulated the typicality of *-ne* and *-yo* in terms of whether the second turn concerned addressee-oriented content (i.e., a typical *-ne* and an atypical *-yo*) or addresser-oriented content (i.e., a typical *-yo* and an atypical *-ne*). We also prepared 36 additional filler dialogs, which presented topics general to both persons (i.e., neutral topics such as the weather or topics pertaining to a third person). In these, either the grammatical combination *-yone* or the ungrammatical *-neyo* was used at the end of the second turn.

All the stimulus dialog sets were recorded by a male (for the first turn) and a female (for the second turn) native speaker of Japanese, and they were saved as WAV sound files using PRAAT version 5.1.31 (Boersma, 2002). The recording was conducted turn by turn in as much of the same manner as possible, instead of splicing separately recorded parts of each turn, so that each turn would sound seamless and natural (Fig. 1). To verify whether SFP typicality was successfully manipulated in the auditory stimulus materials, 26 native Japanese speakers (16 males; age range: 19-23, $M = 20.0$, $SD = 1.2$), who did not take part in any of the EEG experiments, were randomly presented with the 176 candidate dialogs (including target and filler stimuli). These Japanese speakers rated the appropriateness of the SFPs presented in each dialog on a seven-point scale (1: very inappropriate to 7: very appropriate). Based on the results of the pilot test, we selected 80 dialogs, in which the mean difference between typical and atypical usage of a target turn was greater than two. The ratings of the selected items revealed that turns intended as typical usages of an SFP ($M = 6.32$, $SD = 0.37$) were significantly more appropriate than those intended as atypical usages ($M = 2.96$, $SD = 0.48$, $t_{78} = 34.529$, $p < .001$, $d = .423$). Another 36 filler dialogs with various content were included for the ERP experiments. All target and filler dialog sets (and their English translations) are provided as supplementary data.

To ensure that speech prosody was not significantly different between typical and atypical conditions, the acoustic waveforms were checked following Paulmann, Pell, and Kotz (2008). As shown in Table 2, no significant differences were found between typical/atypical conditions in terms of duration, highest and lowest pitch, or intensity of *-ne* and *-yo* (all p's *ns.*). Additionally, the lengths of the entire target turns, including the SFPs in the target dialogs, were not significantly different between typical ($M = 2036$ ms, $SD = 218$) and atypical usages ($M = 1932$ ms, $SD = 272$; $t_{78} = 1.851$, $p = .068$, $d = .051$). The sound files for an example stimulus dialog set can be found at http://skiyama.com/research.

2.1.3. Procedure

The participants completed an appropriateness judgment task while their EEGs were recorded in a sound-attenuated room. They were seated in front of a monitor and were shown a fixation mark (+) in the center of the monitor for 2000 ms before they heard the stimulus dialog through a set of loudspeakers. We then presented another fixation (+) for 3000 ms, after which the participants were asked to indicate via button press whether the use of the SFP(s) at the end of each dialog was appropriate or not as soon as the instruction appeared in the monitor (Fig. 2). We inserted a long inter-stimulus interval (ISI) before asking for the judgment to prevent possible muscle activity caused by the button press. Before the experiment proper started, the participants were given 16 practice trials to get familiarized with the task. The volume was adjusted if needed. The participants were asked to minimize eye blinking while listening to the dialogs. The experiment consisted of 4 blocks, with a small break between each block. At the beginning of each block, which contained 58 proper trials and took about 10 min, 3 warm-up trials were included. The stimulus dialogs were presented in random order during the blocks. Each participant listened to both typical and atypical usages of the same dialog, but one of the two usages was always given within the first two blocks, while the other was contained in the second two blocks, in order to minimize a potential repetition effect. Within both the first and the second two blocks, items were presented in random order. On average, the procedure took approximately 50 min for the task itself, without preparation for EEG recording. The presentation of stimuli and the obtaining of behavioral data were conducted with E-Prime 2.0 (Psychology Software Tools, Pittsburgh, PA).

2.1.4. Electrophysiological data acquisition and processing

The EEG signal was continuously recorded at a sampling rate of 512 Hz from 32 active Ag-Cl electrodes at standard positions of the international 10-20 system using a BioSemi ActiveTwo amplifier system (BioSemi B.V., Amsterdam, the Netherlands). The signal was referenced offline by tin electrodes attached to the left and right mastoids. Eye blinks were measured with tin electrodes placed one above and another underneath the left eye. Horizontal eye movements were measured with two electrodes, one on the external canthus of each eye. Automatic rejections on a participant-by-participant basis were performed to discard artifacts from blinks, movements, or technical malfunctions (amounting to the exclusion of 8.35% of the trials). The EEG data were corrected for eye-blink artifacts using the Gratton, Coles, and Donchin (1983) algorithm. For non-ocular artifacts, we removed trials with amplitudes below −200 μV and above +200 μV. Furthermore, trials that produced a 100 μV or greater voltage step within 200 ms were removed from the analysis. Filters (high-pass: 0.01 Hz/24 dB and low-pass: 40 Hz/24 dB) were applied for the data analyses, and a baseline correction was applied with a pre-response interval from −200 to 0 ms. Epochs of 800 ms were computed with a 200 ms pre-stimulus

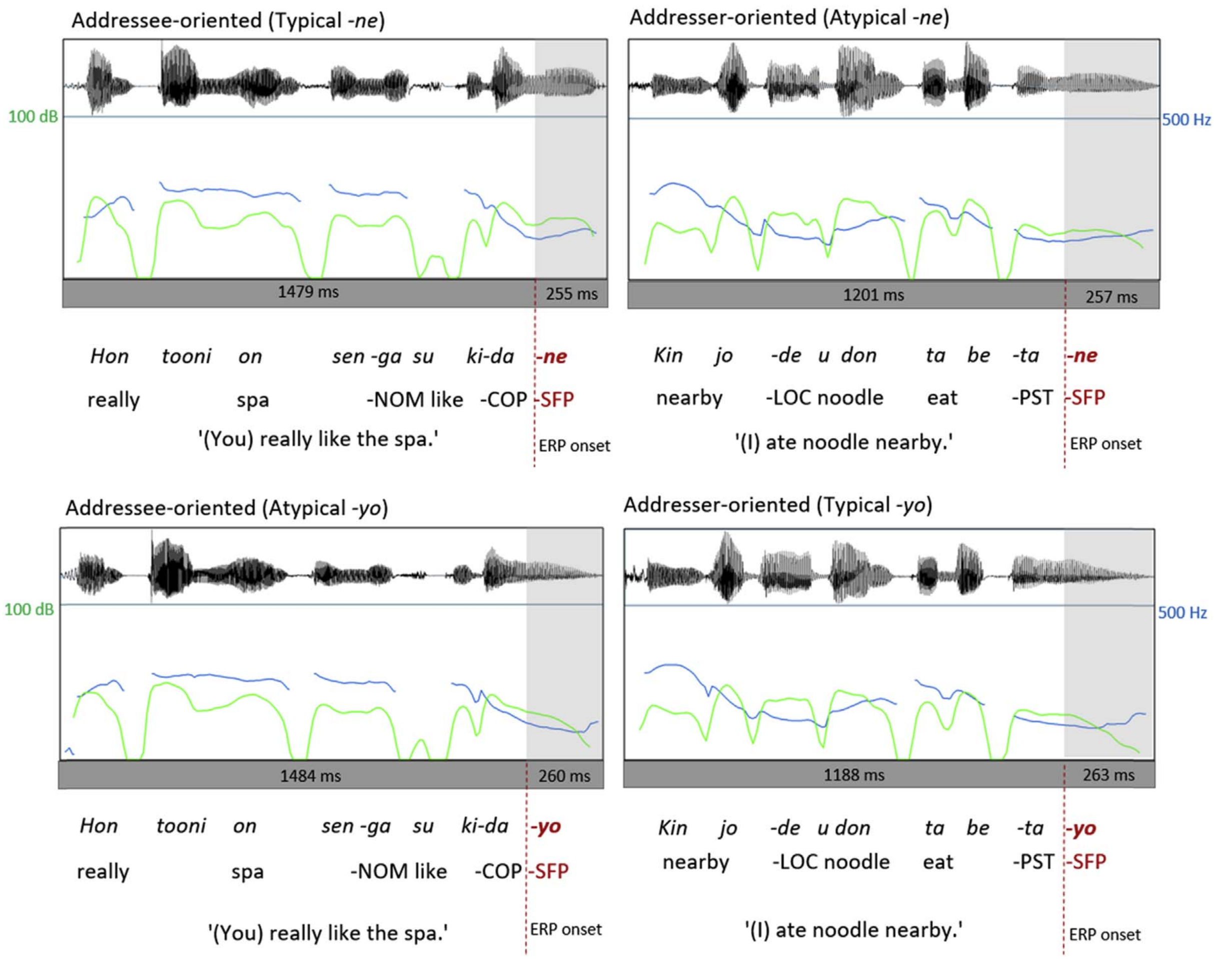

Fig. 1. Example of sound wave of a stimulus turn ending with Japanese SFPs ***-ne*** and ***-yo***.
Notes: The blue contour and the green contour represent pitch and intensity, respectively. The abbreviations represent the following: COP [Copula], NOM [Nominative case marker], PST [Past].

baseline. ERP onset was triggered at the beginning of the SFP presentation (Fig. 1). We used E-Prime 2.0 to write marker data onto the continuous EEG signal as well as for stimulus presentation.

2.1.5. Statistical analysis

The purpose of this study was to detect individual differences in mentalizing ability among the general population, and not to make a group comparison of autistic people (i.e., extremely low-ability mentalizers) versus healthy controls. To examine the effect of each individual's mentalizing ability on ERP components and the sensitivity to Japanese SFPs as linguistic markers of interpersonal distance, we performed a linear mixed effects (LME) modeling (e.g., Baayen, 2008) based on the maximum-likelihood method. This was done instead of grand-averaging ERP components by dividing participant groups into high- and low-ability mentalizers. The LME method estimates the effects of fixed variables (both continuous and categorical, or within- and between-participant variables together) that are of interest in the study over random effects that can be assumed to be randomly sampled from the population (e.g., Baayen, Davidson, & Bates, 2008; Davidson & Indefrey, 2007; Locker, Hoffman, & Bovaird, 2007; Moratti, Clementz, Gao, Oritz, & Keil, 2007). We used this technique for the ERP data as well as for behavioral data analysis. The application of LME modeling to ERP data analysis has been validated by several recent neurolinguistic studies (e.g., Newman, Tremblay, Nichols, Neville, & Ullman, 2012; Wang, Verdonschot, & Yang, 2016) that examined how individual differences such as foreign language ability scores (i.e., continuous variables) and other categorical independent variables interact to influence ERP components. The model estimation was conducted using the lme4 (Bates, Mächler, Bolker, & Walker, 2014a) and lmerTest (Kuznetsova, Brockhoff, & Christensen, 2014) packages implemented in R version 3.0.2. The alpha level was set at .05 for all statistical tests in this study. All continuous variables were scaled before analysis to obtain standardized fixed-effect parameters.

To analyze the behavioral data in terms of accuracy rate (AR: the ratio of expected responses to the number of trials in each condition) and reaction time (RT), participants' AQ Scores, SFP (i.e., *-ne* and *-yo*), and Typicality (i.e., Typical and Atypical usages of each SFP) were set as fixed factors in the modeling, combined with Stimulus Dialog and Participant as random variables. The RT data

Table 2
Acoustic characteristics of the stimulus target turns including Japanese SFPs ***-ne*** and ***-yo***.

	-ne				*-yo*			
	Typical	Atypical	*t*	*p*	Typical	Atypical	*t*	*p*
	M (SD)	*M (SD)*			*M (SD)*	*M (SD)*		
Duration (ms)	285 (49)	297 (45)	1.664	*ns.*	298 (46)	285 (49)	−1.288	*ns.*
Highest pitch (Hz)	228 (20)	226 (20)	−.299	*ns.*	195 (21)	195 (17)	−.037	*ns.*
Lowest pitch (Hz)	184 (26)	190 (29)	1.040	*ns.*	128 (33)	131 (37)	.346	*ns.*
Intensity (dB)	67 (2)	67 (3)	−.378	*ns.*	63 (4)	65 (4)	1.334	*ns.*

was trimmed at 2.5 SDs above the mean of each condition for each participant, and responses outside of 2.5 SDs at both high and low ranges were replaced by boundaries indicated by 2.5 SDs from the individual means of participants in each condition (2.8% of the data were changed). The model used in the behavioral data analysis was [AR/RT ~ Typicality * SFP * AQ + (1|Dialog) + (1|Participant)], which is a standard formula for LME (using the lme4 package), in which the dependent variable presented before the tilde sign (~) is described by a statistical model specified using fixed effects (variables without parentheses) and random effects (variables between parentheses, expressed as 1| < factor >). A plus (+) indicates an addition to the model, and an asterisk (*) indicates an interaction as well as each main effect (see Bates, Mächler, Bolker, & Walker, 2014b for a comprehensive overview). Using this formula, either AR with the function *glmer()* or RT with the function *lmer()* was predicted by the three fixed factors of SFP, Typicality (categorical, within-participant variables), and AQ (continuous, between-participant variable), their interaction effects (denoted by asterisks), as well as two random factors for each item (i.e., stimulus dialog) and each participant.

For ERP data analysis, we used the model [ERP ~ Typicality * ROI * SFP * AQ + (1|Participant) + (1|Electrode)], in which the obtained ERP was predicted by the fixed factors of Typicality, Region of Interest (ROI; i.e., anterior, central, and posterior regions of the brain), SFP, AQ Score, the interaction terms of these four factors, as well as Participant and Electrode as random factors. We extracted ERP data for each condition of typical/atypical usage of *-ne* and *-yo* during the time window of 150–400 ms (following Faja et al., 2016, who examined this EPN component in relation to emotion recognition and perceptual attention in autism). To set up the ROI, we assigned channels FP1/2, AF3/4, Fz, F3/4, F7/8 for the anterior region, Cz, C3/4, T7/8, CP1/2, and CP5/6 for the central region, and Pz, P3/4, P7/8, PO3/4, Oz, and O1/2 for the posterior region.

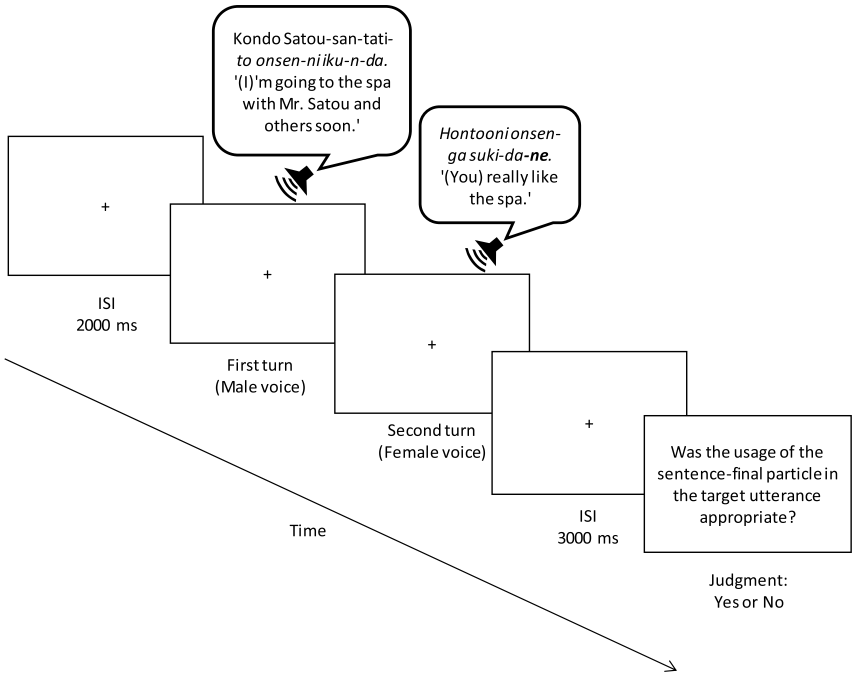

Fig. 2. Experimental trial for SFP appropriateness judgement task in Experiment 1.
Note: Everything was presented in Japanese for the actual experiment.

2.2. Results

2.2.1. Behavioral data

Generally, participants judged the typical usage of the SFP *-ne* to be appropriate in almost all the stimulus dialogs ($M = .960$, $SD = .195$ for *-ne*; $M = .973$, $SD = .032$ for *-yo*), while they tended to judge the atypical usage as inappropriate ($M = .774$, $SD = .418$ for *-ne*; $M = .744$, $SD = .208$ for *-yo*). The LME analysis indicated that the AR of the responses was significantly higher for typical usage than for atypical usage ($\beta = 2.615$, $z = 7.298$, $p < .001$). The main effects of the other independent variables, SFP ($\beta = -.193$, $z = -.685$, $p = .494$) and AQ ($\beta = -.256$, $z = -1.124$, $p = .261$), as well as any of their interaction effects, were not significant. The mean RT for the projected answers of this task was faster for typical usage ($M = 361$ ms, $SD = 191$ for *-ne*; $M = 404$ ms, $SD = 179$ for *-yo*) than for atypical usage ($M = 500$ ms, $SD = 189$ for *-ne*; $M = 520$ ms, $SD = 202$ for *-yo*; $\beta = -.368$, $t = -7.414$, $p < .001$). No significant influences of SFP ($\beta = .065$, $t = 1.242$, $p = .216$) and AQ ($\beta = -.027$, $t = -.237$, $p = .814$) or the interaction effects between the variables were found in the RT data. Note that it is difficult to derive strong conclusions from the RT data in any case given the large 3000 ms ISI.

2.2.2. Electrophysiological data

Preliminary visual inspection of the ERP waveforms on the grand average of all participants in response to the presentation of SFPs *-ne* and *-yo* (Figs. 3 and 4, respectively) suggested greater early negativity in the central and posterior regions (i.e., early posterior negativity: EPN) for the atypical than for the typical usage of SFPs. We then continued to examine, over the typical EPN time window of 150–400 ms (Faja et al., 2016) and utilizing LME, how individual mentalizing abilities affected the amplitude and scalp distribution. Table 3 summarizes the fixed effects of SFP, ROI, Typicality, AQ, and the two-way, three-way, and four-way interactions among these factors on ERP amplitudes. In all, we observed a significant interaction between Typicality (typical vs. atypical usage) and ROI (anterior vs. posterior regions; $\beta = -.320$, $t = -3.241$, $p = .001$), generally indicating a greater negativity between 150 and 400 ms in the posterior region in comparison with the anterior region for atypical SFP usage (both with *-ne* and *-yo*) than for typical usage. This effect is greater for *-ne* than for *-yo* based on the three-way interaction ($\beta = .292$, $t = 2.095$, $p = .036$). Further, a significant four-way interaction between Typicality, ROI (anterior vs. posterior), SFP, and AQ revealed that participants with higher AQ scores (i.e., lower mentalizing ability) expressed a greater negativity in the posterior region compared with the anterior region in response to atypical SFP usage than its typical counterpart, especially with *-ne* as opposed to *-yo*. The inter-individual differences in terms of AQ score on the ERP effects for atypical SFP usage are shown in Fig. 5.

2.3. Discussion

Native Japanese speakers in general seem to display some uncertainty when understanding atypical usages of the SFPs *-ne* and *-yo*, as they took a longer time to make appropriate judgments for atypical than for typical usages. This tendency may relate to some salient feature of sentence processing in Japanese as a pro-drop language. That is, the stimulus dialogs created for this study lacked the subject when it was a pronoun, as this is common and natural in spoken Japanese (e.g., Iwasaki, 1993; Sakamoto, 2002). Utilizing diversified usages of Japanese sentences with and without SFPs, Tamaoka, Matsuoka, and Sakamoto (2007) demonstrated that SFPs generally interfere with identification of the referent of subject-lacking sentences compared with subject-including sentences. It could thus be surmised that the observed response delay in SFP understanding may especially originate from atypical SFP usage rather than typical usage based on the present behavioral data, even though the delay could be obscured by the long ISI (i.e., 3000 ms) before the judgment.

The electrophysiological findings of Experiment 1 represent the neural activity expressed when native Japanese speakers paid explicit attention to whether the presented SFPs *-ne* and *-yo* were appropriate in a given dialog. We observed a greater EPN for the atypical usage in comparison with the typical usage in participants with higher AQ scores (i.e., lower mentalization ability) than in those with lower scores, and this effect was greater for *-ne* than for *-yo*. The result suggests that low-ability mentalizers have a stronger sense of strangeness toward atypical usage of the SFP *-ne*. One plausible reason for this could be that, as the SFP *-ne* encompasses a complicated and diverse range of usages depending on the context and interpersonal relationships, the addressee of *-ne* is required to flexibly interpret the addresser's attitude in a given situation. The greater EPN in low-ability mentalizers, who are impaired when it comes to forming the meta-representation of attributing others' beliefs to their behavior, and are hence are not tolerant enough to the dynamic and often chaotic changes in social interactions (Baron-Cohen, 1995), might reflect a more irregular ERP pattern in response to atypical usage of the SFP *-ne*.

However, we should hesitate to immediately conclude that the findings represent a full and accurate reflection of neural activity in actual person-to-person encounters. In real encounters, most Japanese speakers would not pay specific attention to SFP usage and to judging its appropriateness, but rather involuntarily perceive the addresser's attitude toward interpersonal relationships through SFP usage in the discourse. This being the case, we conducted another experiment to replicate the findings from Experiment 1, making use of a content comprehension task. In this experiment, participants were not required to make any judgment concerning SFPs. Instead, they simply had to comprehend what information was exchanged in the given stimulus dialogs. We believe this task is more similar to an actual person-to-person encounter.

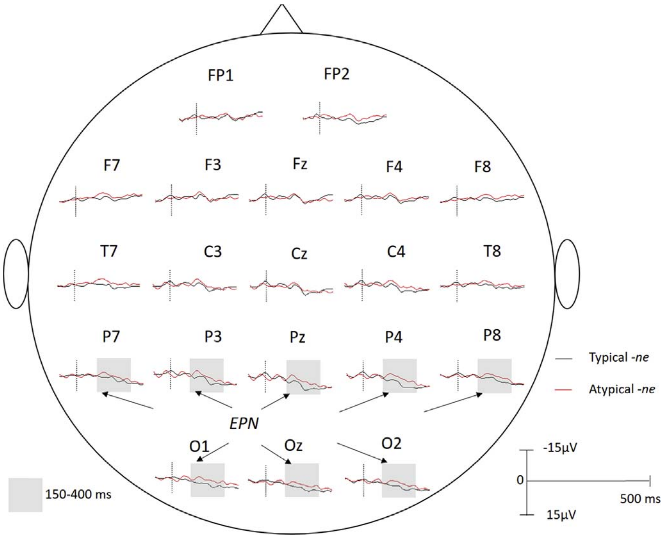

Fig. 3. Grand averaged ERPs time-locked to the onset of Japanese SFP *-ne* during the appropriateness judgment task. EPN: early posterior negativity.

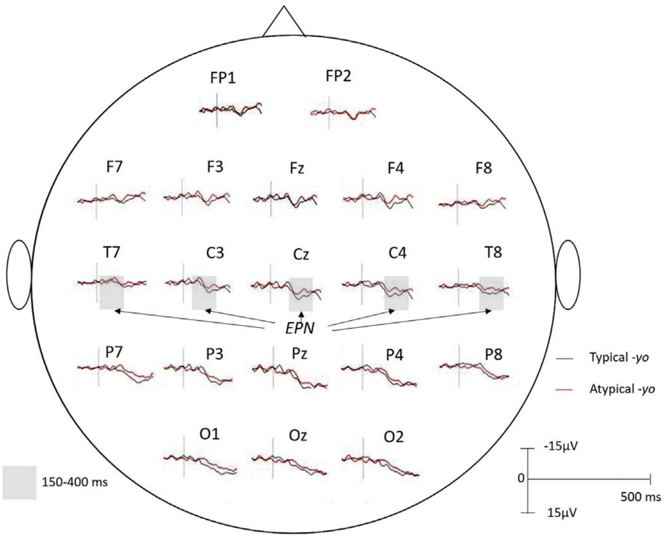

Fig. 4. Grand averaged ERPs time-locked to the onset of Japanese SFP *-yo* during the appropriateness judgment task. EPN: early posterior negativity.

3. Experiment 2: understanding SFPs during a content comprehension task

In Experiment 2, we administered a content comprehension task to investigate whether similar ERP patterns could be observed when native speakers listened to SFPs without explicit instruction concerning SFPs.

3.1. Materials and methods

3.1.1. Participants

Twenty-two healthy right-handed graduate and undergraduate students (8 males; age range: 19-30, $M = 21.2$, $SD = 2.5$) who participated in neither Experiment 1 nor the pilot manipulation check participated in this experiment. They were administered the Japanese version of the AQ test (Wakabayashi et al., 2006) and scored from 11 to 36 ($M = 22.5$, $SD = 6.4$). They gave informed consent and received financial compensation for participation.

3.1.2. Materials

The stimulus dialogs that included the SFPs (both target and filler) were identical to those in Experiment 1.

Table 3
Fixed effects of LME analysis on ERP amplitude in the 150–400 ms time window during the appropriateness judgment task of Japanese SFP ***-ne***.

Contrast	Estimate: β	*t*	*p*
(intercept)	−.387 [−.628, −-.146]	−3.235	.002
Typical vs. Atypical	−.046 [−.174, .081]	−.711	.477
Anterior vs. Central	.529 [.326, .731]	5.191	< .001
Anterior vs. Posterior	1.077 [.881, 1.273]	10.904	< .001
-ne vs. *-yo*	.266 [.138, .393]	4.083	< .001
AQ	−.136 [−.360, .088]	−1.229	.229
Typ/Atyp vs. Ant/Cent	−.177 [−.377, .022]	−1.741	.082
Typ/Atyp vs. Ant/Post	−.320 [−.513, −-.126]	−3.241	.001
Typ/Atyp vs. *-ne/-yo*	−.425 [−.605, −-.244]	−4.616	< .001
Ant/Cent vs. *-ne/yo*	−.085 [−.285, .114]	−.838	.402
Ant/Post vs. *-ne/-yo*	−.298 [−.492, −-.105]	−3.023	.003
Typ/Atyp vs. AQ	.146 [.018, .274]	2.244	.025
Ant/Cent vs. AQ	.179 [.038, .321]	2.493	.013
Ant/Post vs. AQ	.253 [.116, .390]	3.620	< .001
-ne/-yo vs. AQ	.300 [.172, .427]	4.601	< .001
Typ/Atyp vs. Ant/Cent vs. *-ne/-yo*	.130 [−.152, .412]	.901	.368
Typ/Atyp vs. Ant/Post vs. *-ne/-yo*	.292 [.019, .566]	2.095	.036
Typ/Atyp vs. Ant/Cent vs. AQ	−.198 [−.397, .002]	−1.944	.052
Typ/Atyp vs. Ant/Post vs. AQ	−.330 [−.524, −-.137]	−3.347	.001
Typ/Atyp vs. *-ne/-yo* vs. AQ	−.319 [−.499, −-.138]	−3.465	.001
Ant/Cent vs. *-ne/-yo* vs. AQ	−.008 [−.207, .192]	−.075	.940
Ant/Post vs. *-ne/-yo* vs. AQ	−.175 [−.369, .018]	−1.775	.076
Typ/Atyp vs. Ant/Cent vs. *-ne/-yo* vs. AQ	−.028 [−.311, .254]	−.197	.844
Typ/Atyp vs. Ant/Post vs. *-ne/-yo* vs. AQ	.275 [.001, .548]	1.968	.049

Note. Values in brackets denote 95% confidence intervals. AQ: Autism-Spectrum Quotient.

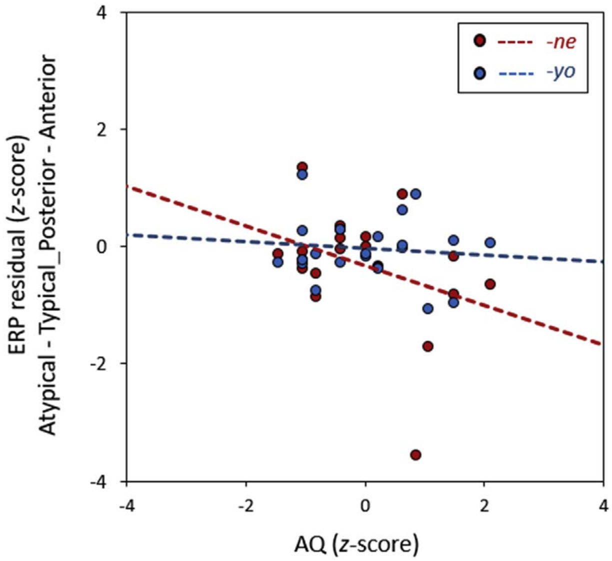

Fig. 5. Partial regression plot between the scaled Autism-Spectrum Quotient (AQ) score and the scaled residuals from ERP amplitude for atypical minus typical Japanese SFPs of the posterior minus anterior region within the 150–400 ms time window during the appropriate judgement task (n = 21).

3.1.3. Procedure

The procedure was identical to that in Experiment 1, except that participants underwent a "content comprehension task" to confirm that they had properly listened to the information that was exchanged during the stimulus dialogs. In Experiment 2, the participants were required to listen to the stimulus dialogs and then answer a simple comprehension question by pressing the true or false button when a description about the dialog content was presented. For example, when the statement "It seems the woman likes the spa" appeared on the computer screen, the participants were supposed to press the "false" button for the correct answer because the stimulus dialog indicated that it was the man, and not the woman, who went to the spa, and the female speaker in the second turn responded with "(You) really like the spa." As it was necessary that the content comprehension concerned factual things about which to make an explicit true-false judgment, the items for the addressee-oriented conditions (i.e., typical *-ne* and atypical *-yo*) asked about the male speaker (whose action was described in the first turn), and those for the addresser-oriented conditions (i.e., typical *-yo* and atypical *-ne*) asked about the female speaker (whose action was stated in the second turn). We prepared questions whose correct answer was "true" for half of the dialogs and "false" for the other half. In Experiment 2, no mention was made to the participants concerning SFPs until they were debriefed.

3.1.4. Electrophysiological data acquisition and processing, and statistical analyses

Identical to Experiment 1, 2.7% of the RT data were changed due to the same trimming procedure in Experiment 1.

3.2. Results

3.2.1. Behavioral data

The participants overall showed a high accuracy rate in the content comprehension task including the filler stimuli (M = .945, SD = .018). Particularly for the target stimuli including *-ne* and *-yo*, the AR data was generally high for both typical (M = .975, SD = .026 for *-ne*; M = .943, SD = .033 for *-yo*) and atypical (M = .960, SD = .030 for *-ne*; M = .869, SD = .043 for *-yo*) usages. None of the independent variables of Typicality (β = .545, z = 1.822, p = .068), SFP (β = −.471, z = −.896, p = .370), or AQ (β = .241, z = 1.245, p = .213) reached significance. RTs for the correctly-answered items were faster for typical usage (M = 1460 ms, SD = 508 for *-ne*; M = 1410 ms, SD = 420 for *-yo*) than for atypical usage (M = 1541 ms, SD = 497 for *-ne*; M = 1460 ms, SD = 427 for *-yo*). The main effects of Typicality (β = −.096, t = −2.411, p = .016), SFP (β = −.166, t = −2.566, p = .011), and their interaction effect (β = .189, t = 3.031, p = .002) were significant, indicating that participants took a longer time to comprehend dialogs with atypical SFP usages than typical ones, and this effect was greater for *-ne* than for *-yo*. The effect of AQ (β = −.044, t = −1.252, p = .211) was not significant. As in Experiment 1, we should be cautious with strongly interpreting RT findings due to the large interval (3000 ms) before the decision was made.

3.2.2. Electrophysiological data

Based on a preliminary visual inspection of ERP waveforms during *-ne* on the average of all the participants (Fig. 6), we set the same time window (during 150–400 ms) to conduct an LME analysis comparable to that in Experiment 1 (following Faja et al., 2016), even though the two conditions (i.e., typical vs. atypical) for *-yo* showed almost the same pattern (Fig. 7). The results of this LME modeling (Table 4) revealed a tendency similar to that in Experiment 1. While atypical SFP usage generally elicited a greater negativity than typical usage in the central (β = .239, t = 2.204, p = .028) and posterior regions (β = .481, t = 4.577, p < .001) than in the anterior region, this negativity was much greater for atypical *-ne* usage than the *-yo* counterpart both in the central (β = −.383, t = −2.500, p = .012) and posterior (β = -.720, t = −4.848, p < .001) regions. Again, participants with a higher AQ score (i.e., low-ability mentalizers) expressed a greater negativity in the posterior region in comparison with the anterior region for atypical usage of *-ne* than that of *-yo,* both of which were also greater than for their typical usage. The inter-individual differences in terms of AQ on the ERP effect while understanding the SFPs *-ne* and *-yo* are shown in Fig. 8.

3.3. Discussion

As the participants showed high accuracy overall in the content comprehension task for both the target and filler stimuli, we confirmed that they paid proper attention to the auditorily presented dialogs with SFPs. Interestingly, this task elicited a uniqueness of *-ne* understanding in comparison with that of *-yo*, such that participants took longer to comprehend dialog content with atypical usages of *-ne* than with either atypical usages of *-yo* or the typical usages of both *-ne* and *-yo*. What might have interfered with their smooth comprehension of turns with an atypical *-ne* could perhaps be associated with their involuntary consideration of the diverse possibilities of *-ne* usage, as discussed in Experiment 1. Native speakers may try to connect a variety of imaginable situations with the dialogs ending with *-ne*, even when these are not yet in the picture.

The uniqueness of understanding atypical *-ne* usages was also found in ERP data in Experiment 2, where the dialog contents were comprehended without explicit instruction about SFPs themselves, unlike in Experiment 1. Native Japanese speakers with a lower mentalizing ability expressed a greater EPN in response to the atypical usage of *-ne* than the typical usage, although they did not exhibit this for *-yo* understanding. This suggests that those with lower mentalizing abilities may be hypersensitive to the atypical *-ne* as a linguistic marker of interpersonal distance, even when they are not required to judge the appropriateness of the marker itself.

4. General discussion

The present study shed light on inter-individual differences in mentalizing ability when understanding Japanese linguistic indicators of interpersonal distance. In this study, we employed two listening modes within the ERP experiments. One mode required an appropriateness judgment of the SFPs, while the other contained no explicit instruction regarding the SFPs. The results consistently revealed that the earlier ERP component (i.e., the EPN) was larger when native Japanese speakers heard an atypical usage of the SFP *-ne*, as compared to its more typical usage, while both usages were grammatical. Additionally, the EPN effect was found to be significantly greater in participants with a lower mentalizing ability.

Concerning the neurophysiological underpinnings of this phenomenon, previous ERP findings (e.g., Hirotani & Schumacher, 2011; Liu et al., 2009; Nieuwland et al., 2010) have led us to speculate whether a "pragmatic N400 effect" might arise during the understanding of Japanese SFPs as their appropriateness cannot be judged without social context. Instead, we expected an EPN effect, which has been shown to reflect emotional processing (Faja et al., 2016), as the Japanese SFP *-ne* often conveys empathy between the

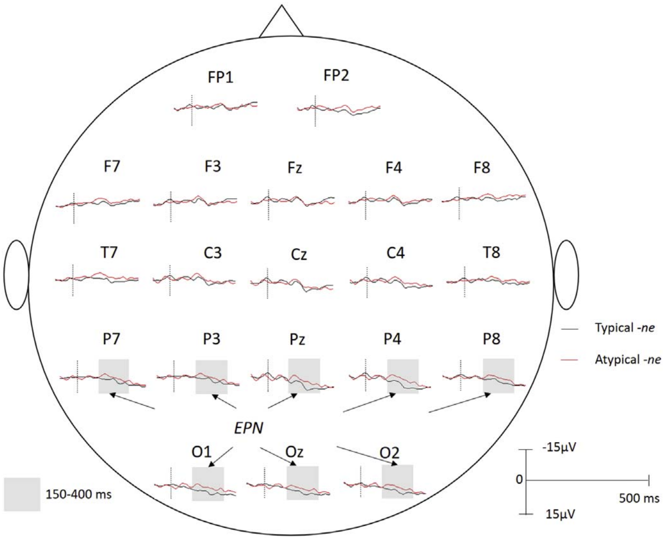

Fig. 6. Grand averaged ERPs time-locked to the onset of Japanese SFP ***-ne*** during the content comprehension task without explicit instruction on SFPs. EPN: early posterior negativity.

addresser and the addressee (e.g., Cook, 1990, 1992; Maynard, 1997). Our two experiments found a consistent earlier negativity between 150 and 400 ms in the posterior region (i.e., EPN) especially after the presentation of atypical *-ne* as opposed to typical *-ne*. The short duration of the marker (i.e., each SFP consists of only a single moraic symbol) might have resulted in an earlier negative deflection. This finding is in line with Kissler and Herbert (2013), who found EPN in response to emotional words in a reading paradigm, interpreting it as a reflection of spontaneous attentional highlighting of motivationally relevant emotional stimuli. Although the effect of quicker access to emotional stimuli has previously been reported only in reading designs, the present study now contributes evidence of the effect in the auditory realm of word processing.

Mittermeier et al. (2011) also found the EPN component within the auditory modality by utilizing an emotional choice reaction paradigm where the participants judged whether the auditorily presented emotional syllables/words had positively emotional, negatively emotional, or neutral intonation. They observed a greater EPN for the emotional stimuli with both positive and negative intonation, compared with neutral intonation. We, contrarily, did not obtain a similar outcome as revealed by an intonation analysis of our auditory stimuli, but manipulated the typicality of the usage of Japanese SFPs. As a result, we found a greater EPN effect especially during the understanding of atypical *-ne* as opposed to typical *-ne*. This effect, however, was not found in typical/atypical usages of *-yo*. This finding supports the view that the SFP *-ne* itself arouses emotion, even without noticeable intonation.

Further, we found an enhanced EPN effect for atypical SFP *-ne* than typical *-ne* particularly in participants with lower mentalizing ability as opposed to those with higher mentalizing ability. This finding might reflect a hypersensitivity associated with individual

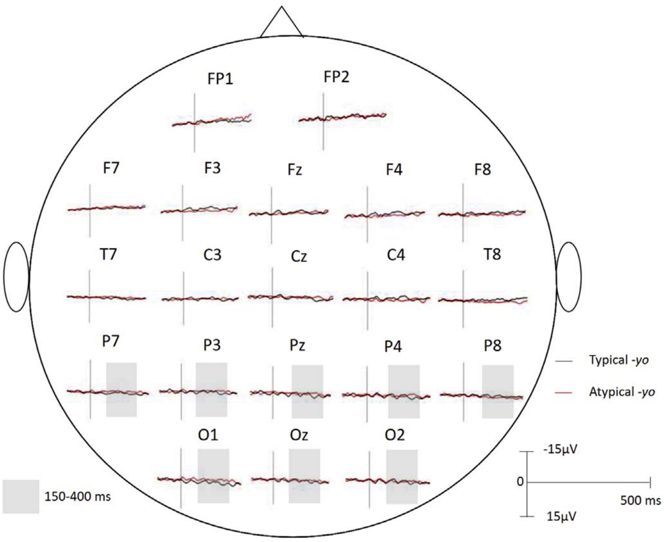

Fig. 7. Grand averaged ERPs time-locked to the onset of Japanese SFP ***-yo*** during the content comprehension task without explicit instruction on SFPs.

Table 4
Fixed effects of LME analysis on ERP amplitude in the 150–400 ms time window during the understanding of the Japanese SFP ***-ne*** within the content comprehension task without explicit instruction on SFPs.

Contrast	Estimate: β	*t*	*p*
(intercept)	-.118 [-.337, .102]	−1.084	.286
Typical vs. Atypical	-.203 [-.339, −-.067]	−2.933	.003
Anterior vs. Central	.109 [-.041, .259]	1.419	.156
Anterior vs. Posterior	.256 [.110, .401]	3.439	.001
-ne vs. *-yo*	-.138 [-.273, −-.002]	−1.985	.047
AQ	-.436 [-.655, −-.217]	−4.018	< .001
Typ/Atyp vs. Ant/Cent	.239 [.026, .451]	2.204	.028
Typ/Atyp vs. Ant/Post	.481 [.275, .687]	4.577	< .001
Typ/Atyp vs. *-ne/-yo*	.252 [.06, .444]	2.573	.010
Ant/Cent vs. *-ne/yo*	.299 [.087, .511]	2.761	.006
Ant/Post vs. *-ne/-yo*	.300 [.094, .506]	2.855	.004
Typ/Atyp vs. AQ	.343 [.207, .479]	4.954	< .001
Ant/Cent vs. AQ	.067 [-.084, .217]	.869	.385
Ant/Post vs. AQ	.134 [-.012, .279]	1.799	.072
-ne/-yo vs. AQ	.199 [.063, .334]	2.866	.004
Typ/Atyp vs. Ant/Cent vs. *-ne/-yo*	-.383 [-.683, −-.083]	−2.500	.012
Typ/Atyp vs. Ant/Post vs. *-ne/-yo*	-.720 [-1.012, −-.429]	−4.848	< .001
Typ/Atyp vs. Ant/Cent vs. AQ	-.126 [-.338, .087]	−1.162	.245
Typ/Atyp vs. Ant/Post vs. AQ	-.340 [-.546, −-.134]	−3.240	.001
Typ/Atyp vs. *-ne/-yo* vs. AQ	-.300 [-.492, −-.108]	−3.064	.002
Ant/Cent vs. *-ne/-yo* vs. AQ	-.048 [-.261, .164]	-.445	.657
Ant/Post vs. *-ne/-yo* vs. AQ	.060 [-.146, .266]	.573	.567
Typ/Atyp vs. Ant/Cent vs. *-ne/-yo* vs. AQ	.209 [-.091, .510]	1.365	.172
Typ/Atyp vs. Ant/Post vs. *-ne/-yo* vs. AQ	.330 [.039, .621]	2.220	.027

Note. Values in brackets denote 95% confidence intervals. AQ: Autism-Spectrum Quotient.

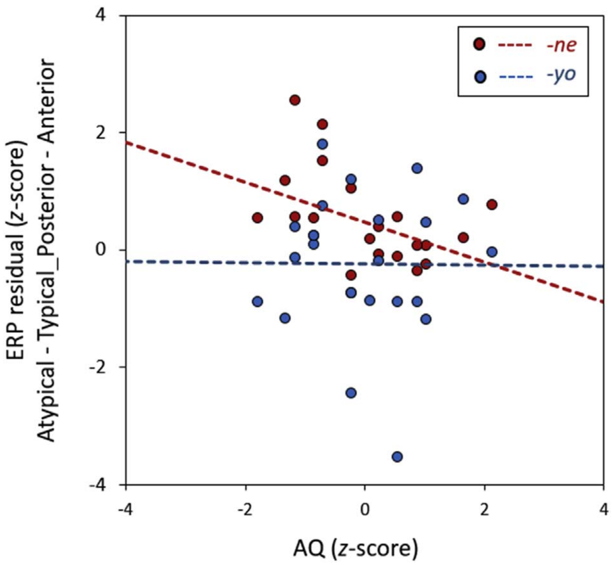

Fig. 8. Partial regression plot between the scaled Autism-Spectrum Quotient (AQ) score and the scaled residuals from ERP amplitude for atypical minus typical Japanese SFPs of the posterior minus anterior region within the 150–400 ms time window during the content comprehension task without explicit instruction on SFPs (n = 22).

mentalizing ability. As people with insufficient mentalizing ability are known to portray low mental flexibility in social interactions (e.g., van Eylen et al., 2011), it is not inconceivable that they are comparatively unable to grasp subtle indications of interpersonal relationships revealed by linguistic markers in actual encounters. This may result in a stereotypical interpretation of SFP *-ne* usage, which causes inappropriate detection of an atypical *-ne*. In a similar vein, high-ability mentalizers may be tolerant of atypical *-ne* because they are flexible enough and try to ascertain others' attitudes attached to potential usage(s) of *-ne*. Even with sufficient linguistic knowledge of grammar and vocabulary, some native speakers seem to have a certain degree of difficulty recognizing social distance in language communication, so they experience a sense of uneasiness toward interpersonal relationships. Lack of tolerance to atypical SFP usage might partially contribute to this.

We should note that the increased EPN effect for low-ability mentalizers has been shown especially for understanding atypical *-ne* than typical -*ne*, but the effect was not found in -*yo*. This result likely stems from the basic feature of -*ne* as an addressee-oriented particle in its typical usage. Unlike the addresser-oriented -*yo*, -*ne* inevitably claims the addressee's attention because it indicates that the stated proposition relates to the addressee(s), and not the addresser (Takiura, 2008). This feature of addressee orientation may underlie the diversity of -*ne* usages and the individual differences in native speakers' neural reactivity to it, as shown in our ERP results. This characteristic of -*ne* is shown to have an effect even on bystanders, as the current study had the participants as bystanders (not as addressees) of the stimulus dialogs. As suggested in Tamaoka et al. (2007), even a bystander must use their mentalizing ability to infer what the addressee interprets from the addresser's utterance. Our ERP experiments do suggest that the Japanese SFP -*ne* fulfills a diversified role that enables native Japanese speakers to readily understand a discourse (despite the lack of pronouns).

Naturally, the current study has some limitations. First, we did not manipulate prosody in our auditory stimulus dialogs with SFPs in order not to induce any confounding pragmatic implications. However, some prosodic manipulations of SFPs (i.e., to arouse emotions) could elicit larger neural reactivity, as Paulmann, Pell, and Kotz (2008) and Kissler and Herbert (2013) have demonstrated. The present study, as the first attempt at neurophysiological observation of Japanese SFPs, employed the simple dichotomy of addresser-/addressee-oriented content in the given sentences. Nevertheless, with respect to discourse comprehension, more elaborate mechanisms of involuntary attention to SFPs might be hidden in subtle prosodic changes, which could only be perceived by high-ability mentalizers. Second, even though our two experiments consistently support individual differences in linguistic pragmatic comprehension by native Japanese speakers, further replication studies are necessary to better understand the effect of mentalizing ability on the understanding of Japanese SFPs, as the number of participants in the present experiments might have been relatively small. Although we currently refer to the ERP effect obtained from our experiments as EPN, subsequent studies are necessary to confirm the ERP label (as the present study was the first to examine Japanese SFPs in auditorily presented dialogs).

Additionally, as the present study only examined simple bound morphemes (i.e., the SFPs -*ne* and -*yo*), we should be cautious to generalize that the emotional EPN component reflects sensitivity to any linguistic markers that indicate interpersonal distance in other languages. Given the abundance of discourse functions of SFPs as bound morphemes at the right periphery (Yap, Yang, & Wong, 2014, pp. 179–220), it might be a typologically common motivation throughout particular East and South-East Asian pro-drop languages that SFPs might have evolved for efficient modulation of interpersonal distance in chaotic communication, reliant on individuals' sensitive awareness of others' mental states. Although we only examined Japanese, cross-linguistic insights into the neural mechanisms for the understanding of SFPs in relation to the pro-drop phenomenon will prove to be informative.

5. Conclusion

Our study presents the first electrophysiological evidence that a linguistic marker (i.e., the Japanese SFP -*ne*) serves as an indicator of interpersonal relationships that can prompt emotions in the addressee, and that the degree of an individual's mentalizing ability regulates their flexibility in recognizing others' attitudes via the various usages of the marker. Low-ability mentalizers seem to adopt a more stereotypical understanding of the SFP, which might underlie their difficulty with flexibly recognizing interpersonal distances in social encounters.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jneuroling.2018.01.005.

References

Abell, F., Happé, F., & Frith, U. (2000). Do triangles play tricks? Attribution of mental states to animated shapes in normal and abnormal development. *Cognitive Development, 15*, 1–16.
American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.
Baayen, R. H. (2008). *Analyzing linguistic data: A practical introduction to statistics using R.* Cambridge University Press.
Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language, 59*, 390–412.
Baltaxe, C. A. M. (1977). Pragmatic deficits in the language of autistic adolescents. *Journal of Pediatric Psychology, 2*, 178–180.
Baron-Cohen, S. (1988). Social and pragmatics deficits in autism: Cognitive or affective? *Journal of Autism and Developmental Disorders, 18*, 379–402.
Baron-Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind.* Boston: MIT Press/Bradford Books.
Baron-Cohen, S., Jolliffe, T., Mortimore, C., & Robertson, M. (1997). Another advanced test of theory of mind: Evidence from very high functioning adults with autism or asperger syndrome. *Journal of Child Psychology and Psychiatry, 38*, 813–822.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The Autism Spectrum Quotient (AQ): Evidence from Asperger syndrome/high functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders, 31*, 5–17.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2014b). *Fitting linear mixed-effects models using lme4.* arXiv preprint arXiv:1406.5823.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2014a). *lme4: Linear mixed-effects models using Eigen and S4. R package version 1.1-6.* Retrieved from: http://CRAN.R-project.org/package=lme4Kuznetsova Brockhoff, & Christensen, 2014 .

Boersma, P. (2002). Praat, a system for doing phonetics by computer. *Glot International, 5*, 341–345.

Constantino, J. N., & Todd, R.,D. (2003). Autistic traits in the general population: A twin study. *Archives of General Psychiatry, 60*, 524–530.

Cook, H. M. (1990). The sentence-final particle *ne* as a tool for cooperation in Japanese conversation. *Japanese/Korean Linguistics, 1*, 29–44.

Cook, H. M. (1992). Meanings of non-referential indexes: A case study of the Japanese sentence-final particle *ne*. *Text, 12*, 507–539.

Davidson, D. J., & Indefrey, P. (2007). An inverse relation between event-related and time-frequency violation responses in sentence processing. *Brain Research, 1158*, 81–92.

Davis, C. (2009). Decision, dynamics and the Japanese particle *yo*. *Journal of Semantics, 26*, 329–366.

van Eylen, L., Boets, B., Steyaert, J., Evers, K., Wagemans, J., & Noens, I. (2011). Cognitive flexibility in autism spectrum disorder: Explaining the inconsistencies? *Research in Autism Spectrum Disorders, 5*, 1390–1401.

Faja, S., Dawson, G., Aylward, E., Wijsman, E. M., & Webb, S. K. (2016). Early event-related potentials to emotional faces differ for adults with autism spectrum disorder and by serotonin transporter genotype. *Clinical Neurophysiology, 127*, 2436–2447.

Gratton, G., Coles, M. G. H., & Donchin, E. (1983). A new method for off-line removal of ocular artifact. *Electroencephalography and Clinical Neurophysiology, 55*, 468–484.

Hirotani, M., & Schumacher, P. B. (2011). Context and topic marking affect distinct processes during discourse comprehension in Japanese. *Journal of Neurolinguistics, 24*, 276–292.

Hooker, C. I., Verosky, S. C., Germine, L. T., Knight, R. T., & D'Esposito, M. (2008). Mentalizing about emotion and its relationship to empathy. *Social Cognitive and Affective Neuroscience, 3*, 204–217.

Iwasaki, S. (1993). *Subjectivity in grammar and discourse.* Amsterdam: John Benjamins.

Jaspers-Fayer, F., Ertl, M., Leicht, G., Leupelt, A., & Mulert, C. (2012). Single-trial EEG-fMRI coupling of the emotional auditory early posterior negativity. *NeuroImage, 62*, 1807–1814.

John, O. P., & Gross, J. J. (2004). Healthy and unhealthy emotion regulation: Personality processes, individual differences, and life span development. *Journal of Personality, 72*, 1301–1334.

Junghöfer, M., Peyk, P., Kissler, J., Herbert, C., Flaisch, T., Stockburger, J., et al. (2004). Rapid serial visual presentation in studies on early motivated attention: An overview. *Psychophysiology, 41*, S17.

Kajikawa, S., Amano, S., & Kondo, T. (2004). Speech overlap in Japanese mother-child conversations. *Journal of Child Language, 31*, 215–230.

Kamio, A. (1994). The theory of territory of information: The case of Japanese. *Journal of Pragmatics, 21*, 67–100.

Katagiri, Y. (2007). Dialogue functions of Japanese sentence-final particles '*Yo*' and '*Ne*'. *Journal of Pragmatics, 39*, 1313–1323.

Kissler, J., & Herbert, C. (2013). Emotion, etmnooi, or emitoon? faster lexical access toemotional than to neutral words during reading. *Biological Psychology, 92*, 464–479.

Koo, H.-J., & Rhee, S. (2013). On an emerging paradigm of sentence-final particles of discontent: A grammaticalization perspective. *Language Sciences, 37*, 70–89.

Kousta, S. T., Vinson, D. P., & Vigliocco, G. (2009). Emotion words, regardless of polarity, have a processing advantage over neutral words. *Cognition, 112*, 473–481.

Kutas, M., & Federmeier, K. D. (2011). Thirty years and counting: Finding meaning in the N400 component of the event-related brain potential (ERP). *Annual Review of Psychology, 62*, 621–647.

Kutas, M., & Hillyard, S. A. (1980). Reading senseless sentences: Brain potentials reflect semantic incongruity. *Science, 207*, 203–205.

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2014). *lmerTest: Tests for random and fixed effects for linear mixed effect models (lmer objects of lme4 package). R package version 2.0-6.* Retrieved from: http://CRAN.R-project.org/package=lmerTest.

Li, C. N., & Thompson, S. A. (1989). *Mandarin Chinese: A functional reference grammar.* University of California Press.

Liu, B., Jin, Z., Li, W., Li, Y., & Wang, Z. (2009). The pragmatic meanings conveyed by function words in Chinese sentences: An ERP study. *Journal of Neurolinguistics, 22*, 548–562.

Locker, L., Hoffman, L., & Bovaird, J. A. (2007). On the use of multilevel modeling as an alternative to items analysis in psycholinguistic research. *Behavior Research Methods, 39*, 723–730.

Matthews, S., & Yip, V. (1994). *Cantonese: A comprehensive grammar.* London: Routledge.

Maynard, S. K. (1994). *An introduction to Japanese grammar and communication strategies.* Toyko: The Japan Times.

Maynard, S. K. (1997). *Japanese communication: Language and thought in context.* University of Hawaii Press.

Mittermeier, V., Leicht, F., Karch, S., Hegerl, U., Möller, H.-J., Pogarell, O., et al. (2011). Attention to emotion: Auditory-evoked potentials in an emotional choice reaction tasks and personality traits as assessed by the NEO FFI. *European Archives of Psychiatry and Clinical Neurosciences, 261*, 111–120.

Mizutani, O., & Mizutani, N. (1987). *How to be polite in Japanese.* Tokyo: The Japan Times.

Moratti, S., Clementz, B. A., Gao, Y., Oritz, & Keil, A. (2007). Neural mechanisms of evoked oscillations: Stability and interaction with transient events. *Human Brain Mapping, 28*, 1318–1833.

Neeleman, A., & Szendröi, K. (2007). Radical pro drop and the morphology of pronouns. *Linguistic Inquiry, 38*, 671–714.

Newman, A. J., Tremblay, A., Nichols, E. S., Neville, H. J., & Ullman, M. T. (2012). The influence of language proficiency on lexical semantic processing in native and late learners of English. *Journal of Cognitive Neuroscience, 24* 1025–1023.

Nieuwland, M. S., Ditman, T., & Kuperberg, G. R. (2010). On the incrementality of pragmatic processing: An ERP investigation of informativeness and pragmatic abilities. *Journal of Memory and Language, 63*, 324–346.

Orekhova, E. V., & Stroganova, T. A. (2014). Arousal and attention re-orienting in autism spectrum disorders: Evidence from auditory event-related potentials. *Frontiers in Human Neuroscience, 8*, 34.

Paulmann, S., Pell, M. D., & Kotz, S. A. (2008). How aging affects the recognition of emotional speech. *Brain and Language, 104*, 262–269.

Perry, A., Levy-Gigi, E., Richter-Levin, G., & Shamay-Tsoory, S. G. (2015). Interpersonal distance and social anxiety in autistic spectrum disorders: A behavioral and ERP study. *Social Neuroscience, 10*, 354–365.

Rosip, J. C., & Hall, J. A. (2004). Knowledge of nonverbal cues, gender, and nonverbal decoding accuracy. *Journal of Nonverbal Behavior, 28*, 267–286.

Sakamoto, T. (2002). Processing filler-gap constructions in Japanese: The case of empty subject sentences. In M. Nakayama (Ed.). *Sentence processing in East Asian languages* (pp. 189–221). Stanford, CA: Center for the Study of Language and Information.

Schacht, A., & Sommer, W. (2009). Time course and task dependence of emotion effects in word processing. *Cognitive, Affective, & Behavioral Neuroscience, 9*, 28–43.

Schupp, H. T., Flaisch, T., Stockburger, J., & Junghöfer, M. (2006). Emotion and attention: Event related brain potential studies. *Progress in Brain Research, 156*, 31–51.

Schupp, H. T., Junghöfer, M., Weike, A. I., & Hamm, A. O. (2003). Emotional facilitation of sensory processing in the visual cortex. *Psychological Science, 14*, 7–13.

Scott, G. G., O'Donnell, P. J., Leuthold, H., & Sereno, S. C. (2009). Early emotion word processing: Evidence from event-related potentials. *Biological Psychology, 80*, 95–104.

Shirai, J., Shirai, H., & Furuta, Y. (2000). Acquisition of sentence-final particles in Japanese. In M. Perkins, & S. Howard (Eds.). *New directions in language development and disorders* (pp. 243–250). New York: Kluwer Academic/Plenum.

Takiura, M. (2008). *Politeness nyuumon [An introduction to politeness].* Tokyo: Kenkyusha.

Tamaoka, K., Matsuoka, M., & Sakamoto, T. (2007). Identifying empty subjects by modality information: The case of Japanese sentence-final particles *-yo* and *-ne*. *Journal of East Asian Linguistics, 16*, 145–170.

Tanaka, H. (2000). The particle *ne* as a turn-management device in Japanese conversation. *Journal of Pragmatics, 32*, 1135–1176.

Wakabayashi, A., Baron-Cohen, S., Wheelwright, S., & Tojo, Y. (2006). The autism-spectrum quotient (AQ) in Japan: A cross-cultural comparison. *Journal of Autism*

Development Disorder, 36, 263–270.
Wang, L., Verdonschot, R. G., & Yang, Y. (2016). The processing difference between person names and common nouns in sentence contexts: An ERP study. *Psychological Research, 80*, 94–108.
Watamaki, T. (1997). Jiheisho-ji ni okeru kyookan kakutoku hyoogen josi *-ne* no siyoo no ketsujo: Jiree kenkyuu. [Lack of the particle *-ne* in conversation by a child with autism: A case study]. *Hattatsu Shoogai Kenkyuu [Japanese Journal on Developmental Disabilities], 19*, 146–157.
Yap, F. H., Yang, Y., & Wong, T.-S. (2014). On the development of sentence final particles (and utterance tags) in Chinese. In K. Beeching, & U. Detges (Eds.). *Discourse functions at the left and right periphery: Crosslinguistic investigations of language use and language change*. Leiden, The Netherlands: Brill.
Zhang, D., He, W., Wang, T., Luo, W., Zhu, X., Gu, R., et al. (2014). Three stages of emotional word processing: An ERP study with rapid serial visual presentation. *Social Cognitive and Affective Neuroscience, 12*, 1897–1903.