‘I know something you don’t know’: Discourse and Social Context Effects on the N400 in Adolescents.

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Abstract

Adolescence is a time of great cognitive and social development. Despite this, relatively few studies to date have investigated how perspective taking affects on-line language comprehension in adolescents. In the current study we address this gap in the literature, making use of a Joint Comprehension Task, in which two individuals with differing background knowledge jointly attend to linguistic stimuli. Using event-related potentials (ERPs) we investigated adolescents' electrophysiological responses to (1) semantically anomalous sentence stimuli in discourse context, and (2) semantically plausible sentence stimuli that the participant believes another individual finds semantically implausible. Our results demonstrate that a robust N400-Effect is elicited by semantically anomalous sentences; this N400-Effect is subsequently attenuated by discourse context. Lastly, a Social N400-Effect is elicited by sentences that are semantically plausible for the participant, if he/she believes that another individual finds the sentence implausible. The results suggest that adolescents integrate the perspective of others during on-line language comprehension via simulation; that is, adolescents use their own language processing system to interpret language input from the perspective of other jointly attending individuals.

Introduction

Adolescence is a time of great cognitive and social development, yet there remains a paucity of research on the cognitive mechanisms that support specific social cognitive functions during this developmental period. In the current study, we investigate how the social environment interacts with language comprehension in adolescent participants. Specifically, we investigate whether adolescent participants' comprehension of language stimuli is affected by joint comprehension, i.e., the process of attending to language stimuli while in the presence of other co-attending individuals.

In adult participants, background information about interlocutors (i.e., individuals engaged in conversation) affects language comprehension. For example, social inferences drawn from cues encoded in speech signals provide information about a speaker's identity, age, sex, class and regional origins. This information has a profound influence on how spoken words and sentences are interpreted. For example the utterance "I have a large tattoo on my back" elicits electrophysiological markers of semantic incongruity if the utterance is made with an upper class accent (Van Berkum, van den Brink, Tesink, Kos, & Hagoort, 2008), despite the fact that the linguistic utterance alone is not semantically anomalous. Similarly, information about what a speaker can or cannot know, based on his/her background knowledge affects listeners' interpretation of ambiguous utterances (Brown-Schmidt, 2009; Hanna, Tanenhaus, & Trueswell, 2003/7; Keysar, Barr, Balin, & Brauner, 2000). There is general consensus in the adult literature that information about others affects language comprehension, although considerable debate persists about when and how social information influences language comprehension (Barr & Keysar, 2006; Brennan, Galati, & Kuhlen, 2010; Brown-Schmidt & Hanna, 2011). The limited research done with adolescents in similar scenarios suggests that while adolescents are sensitive to the perspective of others during language comprehension, their ability to integrate this information on-line continues to improve throughout late adolescence (Dumontheil, Apperly, & Blakemore, 2010).

Most research on the role of social cognition in language processing has focussed on how interactions between speaker and listener are modulated by various types of information. Recently, we demonstrated that background information about other co-listeners, or other co-recipients of language input, also affects language processing (Rueschemeyer, Gardner, & Stoner, 2015). During joint comprehension, two individuals simultaneously process language input in the presence of one another. Real world examples include, for example, two friends jointly listening to a third friend at a dinner party, or two individuals simultaneously reading a tweet or an email. Such joint comprehension scenarios are interesting, because although listeners are privy to the same input, they may interpret that input differently. For example, ambiguous words may be processed differently by two listeners, or differing background knowledge may lead one listener to parse a sentence differently than another listener. Making predictions about the interpretation of other listeners has potential benefits for communication—if a listener can understand why other listeners are confused, appropriate additional information can be provided to make sure a consistent message has been communicated to everyone. Therefore, listeners who are sensitive to potential discrepancies provide an interesting testing ground, as they simultaneously parse the intended meaning of the speaker, and understand how the same linguistic input has been parsed by other listeners.

We have suggested previously that simulating language comprehension from another listener's perspective is a key mechanism in joint comprehension (Rueschemeyer et al., 2015). Specifically, we used event-related potentials (ERPs) to measure participants' on-line parsing of sentence stimuli that they judged to be semantically plausible, if they were seated next to an individual they believed would judge the same sentence semantically implausible. The results showed that an electrophysiological marker of semantic integration difficulty, an N400-Effect, was elicited in these situations, but only in the presence of the naïve other listener. When the other listener was removed from the experimental set-up, no N400-Effect was elicited by identical sentence stimuli. The Social N400-Effect elicited by perceiving another's misunderstanding did not differ significantly in latency or topography to that observed when participants were presented with sentences they judged to be semantically anomalous. These results suggest that tracking another individual's failure to understand a sentence engages the same cognitive mechanisms deployed when one fails to understand a sentence oneself.

Adolescence is an interesting developmental stage at which to investigate joint comprehension, because (1) lexical-semantic processing elicits robust effects that are in many ways similar to those seen in adults (Cummings, Ceponiene, Dick, Saygin, & Townsend, 2008; Hahne, Eckstein, & Friederici, 2004; Holcomb, Coffey, & Neville, 1992; Juottonen, Revonsuo, & Lang, 1996), however (2) social cognitive processes elicit different behavioural and neurocognitive results in adults and in adolescents (Burnett, Bird, Moll, Frith, & Blakemore, 2009; Dumontheil et al., 2010; Pfeifer & Blakemore, 2012). We can therefore assume that adolescents will be sensitive to manipulations of lexical-semantic information in the Joint Comprehension Task, but it is unclear whether adolescents will make inferences about others' lexical-semantic processing. Further, while data from our lab suggests that simulation may support perspective taking during language comprehension in adults (Rueschemeyer et al., 2015), it is unclear whether a similar mechanism supports on-line perspective taking in adolescents.

To investigate these issues, we tested a group of adolescent participants on a modified and age-appropriate version of the Joint Comprehension Task. On-line processing was investigated using event-related potentials (ERPs). Adolescent participants were tasked with reading short story stimuli in the presence of a confederate. The beginning of each story was presented to the adolescent alone (the confederate was present in the room, but not attending to the story), thereby providing information about adolescent lexical-semantic and discourse processing without taking the perspective of another individual into account. The final sentence of each story was presented to the adolescent and the confederate together, thereby providing additional information about how on-line language lexical-semantic and discourse processing is affected by the introduction of another perspective.

Based on previous literature, we hypothesized that adolescents would respond to semantic anomalies embedded in discourse at the beginning of stories in a manner much like that seen in adults: semantically anomalous statements should elicit a robust N400-Effect (Holcomb et al., 1992), unless the semantically anomalous statement was rendered plausible by discourse context (Filik & Leuthold, 2008; Nieuwland & Van Berkum, 2006). We therefore expected to see an interaction between lexical-semantic congruity and the amount of discourse context available in sentences that adolescents read alone. Based on research showing that adolescents take the perspective of *speakers* into account when interpreting their utterances (Dumontheil et al., 2010), we hypothesized that adolescents in our study would show sensitivity to the perspective of the jointly *attending* confederate during language comprehension as well. Thus, we hypothesized that anomalous sentences rendered plausible by discourse context for the adolescent (i.e., which should show an attenuated N400-Effect is isolation), but which were still anomalous for the naïve confederate should elicit a Social N400-Effect, despite the fact that the participant him/herself experienced no semantic anomaly. We therefore hypothesized a second interaction between semantic congruity and the cognitive presence of the confederate across the final sentences of discourse stimuli.

Methods

Participants

Twenty-three adolescents aged between 10 and 15 years (M = 149 months, SD = 19 months, 10 males) were recruited through the University of York and local schools. All participants were native speakers of English, with no prior history of neurological impairments, language disorders or difficulties, and normal, or corrected-to-normal, vision and hearing. Participants and their parents gave written informed consent before participating in the experiment. The study was approved by the Ethics Committee of the Department of Psychology at the University of York. Seven participants were removed from the final analysis: one due to a technical error during recording, and six due to too few trial contributions following excessive noise in the EEG signal (< 10 trials remaining), or poor comprehension of the task (< 75% correct). Therefore, the data from 16 participants entered the final analysis.

Stimuli

Experimental trials consisted of short written stories, i.e., small units of discourse, which were made up of five sentences of 5-9 words (M = 5.84, SD = 1.12). 104 stories were created for the experiment. Each story belonged to one of two conditions (see Figure 1). Plausible (PLAUS) stories were semantically plausible and were made up of 5 sentences which were semantically coherent even when presented alone. Implausible (IMPLAUS) stories presented a coherent narrative across the five sentences, but sentence 1 (S1), sentence 4 (S4) and sentence 5 (S5) were semantically incongruent when read in isolation. Importantly, incongruent sentences were rendered anomalous only on the presentation of the final word in the sentence (underlined in Figure 1). Each story therefore contained three target words: the sentence-final words in S1, S4 and S5. This resulted in six experimental conditions: the three target words in the PLAUS condition, and three in the IMPLAUS condition. Target words were identical in all six conditions, and were therefore matched for all psycholinguistic variables.

Procedure

Participants were seated on a padded immobile chair approximately 27 inches from a computer monitor and an EEG cap was fitted. A confederate (one of the experimental team wearing an EEG cap) was seated in an adjacent chair. The participant was led to believe the confederate was another participant. All participants and parents of participants were introduced to this set-up prior to testing.

The participant was provided with task instructions and several self-paced example stimuli were presented in order to familiarize participants with the task set-up. Participants received verbal feedback on their responses during the practice session, and were invited to ask the experimenter any clarification questions. Once the participant understood the task and had completed the examples, the experiment began.

Three blocks of trials (2x36, 1x32 trials) were presented to participants with a two minute break between blocks. Stimuli were pseudorandomized so that conditions were distributed evenly across the experiment, with no condition repeated more than four times in a row.

Each trial began with instructions to the confederate to cover his/her eyes. Once the confederate's eyes were closed, S1-S4 were presented to the participant on the computer screen (i.e., the confederate could not see these stimuli with closed eyes). Each sentence was presented a few words at a time across three screens: the first two screens contained 2-4 words each and were visible for 1000 ms; the final word of each sentence was presented in isolation for 1000 ms. Following the presentation of S1-S4, the participant was prompted to tell the confederate to open his/her eyes. When the participant was satisfied that the confederate's eyes were open, he/she pressed a button, and S5 was then presented on the computer monitor for both participant and confederate to read together.

Following S5, participants answered two questions: Q1 *'Do you think the last sentence was plausible for your partner?'* and Q2 *'Was the last sentence plausible for you?'*. Responses were recorded via button press. After the final response, a black screen was displayed for 2000 ms before the beginning of the next trial. Only correctly answered trials were used in the EEG analysis.

*****************Place Figure 1 approximately here******************************

Processing of EEG Data

Continuous EEG was recorded using ASALab in a quiet room from 32 shielded active electrodes placed in a 10-20 montage (recording reference = M1, ground = forehead, VEOG and HEOG included, electrode impedances < 10 kΩ, bandpass filter 0.5-100Hz, notch filter = 50Hz, sampling rate = 500 Hz). Data analysis and pre-processing was conducted using

EEGLab and ERPLab. Data were re-referenced off-line to the average of the mastoids, filtered using a 0.1 – 20 Hz bandpass filter, and resampled to 200Hz. Continuous EEG signal was visually inspected for major artefacts, and individual channels with excessive noise were interpolated as an average between two nearest neighbours (Planner interpolation). The signal elicited by correctly answered trials was segmented (-200 to 1000 ms relative to the onset of the target word in each sentence) and a semi-automatic artefact rejection using a 100 ms Moving Window, amplitude spikes > 100 µv as well as visual inspection were applied to reject segments with excessive noise. The average number of trials included in the analysis was S1 PLAUS = 29, S1 IMPLAUS = 27, S4 PLAUS = 30, S4 IMPLAUS = 29, S5 PLAUS = 26, S5 IMPLAUS = 24. Baseline correction was applied to the time window -200ms to 0 ms relative to the onset of the target word. Pre-processed segments were then averaged per condition within participant.

Canonical N400-Effect

To determine the time window in which reliable differences between PLAUS and IMPLAUS stimuli were seen on S1 (i.e., a canonical N400-Effect), the ERP signal from these conditions were submitted to a repeated measures, two-tailed cluster mass permutation test using a family-wise alpha level of 0.05 (Bullmore et al., 1999; Groppe, Urbach, & Kutas, 2011) using the Mass Univariate ERP Toolbox. All time points between 100 and 900 ms post presentation of the critical word in each condition on S1 at all 30 scalp electrode sites were included in the test, and any electrodes within approximately 5.44 cm of each other were considered potential components of a contiguous spatial cluster. Repeated measures t-tests were performed for each comparison using the original data and 10,000 random within-participant permutations of the data. For each permutation, all t-scores corresponding to uncorrected p-values of 0.01 were formed into clusters. The sum of the t-scores in in each cluster defines the mass of the cluster, and the most extreme cluster mass in each of the 10,001 sets of tests was recorded and used to estimate the time window and distribution of the null hypothesis.

Differences in the N400-Effect across Sentence Conditions

In order to compare the N400 across sentence conditions, the mean amplitude of the ERP signal from three central electrodes that showed the most consistent difference across the N400 time window (i.e., from onset to offset) in the cluster permutation analysis (C3, Cz, C4) was extracted from each participant for each of the six experimental conditions (PLAUS, IMPLAUS at each of the 3 sentence positions). In order to assesses whether significant differences between the conditions could be seen across sentence positions, mean amplitude changes were first entered into a 2x3 repeated measures ANOVA with the factors Condition (PLAUS, IMPLAUS) and Sentence (S1, S4, S5). Following this, planned paired samples t-tests (directional for S1 and S5, bi-directional for S4, Bonferroni corrected significance threshold was set at $\alpha = 0.0166$ to account for multiple comparisons) were run to test for differences between conditions in each sentence position.

Latency of N400-Effect

In addition, the peak latency of the N400-Effect elicited on S1 and S5 was extracted and entered into a paired samples t-test in order to test for differences in the latency of the effect across sentence positions.

Results

Behavioural Analysis

Responses to the two questions posed after each trial were analysed in a 2 x 2 repeated measures ANOVA with and Question (Q1=confederate's perspective, Q2=own perspective) and Condition (PLAUS, IMPLAUS) as main factors. Accuracy rates were generally high (Q1-PLAUS: M=86.90%, SD = 9.08%, Q1-IMPLAUS: M=87.38%, SD = 9.60%, Q2-PLAUS: M=96.39%, SD=4.49%, Q2-IMPLAUS: M = 90.50 %, SD = 11.93%), indicating that participants remained engaged in the task. A main effect of Question was observed: more errors were made when participants were asked about the confederate's perspective (Q1) vs.

their own perspective (Q2), $F(1, 15) = 14.16$, $p < .005$, $\eta p^2 = .49$. No main effect of Condition was observed, $F(1, 15) = 1.39$, p >0.1, indicating that neither Condition was significantly more difficult for participants than the other. In addition, a significant interaction between Question x Condition was observed, $F(1, 15) = 10.15$, $p <.01$, $\eta p^2 = .40$. Post-hoc paired samples t-tests were run to resolve the interaction; the Bonferroni corrected significance threshold was set at $\alpha = 0.0125$ to account for multiple post-hoc comparisons. This analysis revealed a trend in participants' performance rates when judging IMPLAUS sentences vs. PLAUS sentences when asked about their own perspective (Q2), t(15) = 2.76, p = 0.015, but no similar difference between the two sentence conditions when asked about the confederate's understanding (Q1), t(15) = 0.17, p>0.1. The larger number of errors made for one's own interpretation of IMPLAUS stimuli suggests that not all implausible scenarios were successfully mitigated by discourse context; where discourse context is irrelevant (i.e., in answering Q1), no difference in the number of errors is seen between conditions.

EEG Analysis

Canonical N400-Effect

The cluster mass permutation analysis revealed just one significant cluster (p < 0.001) broadly distributed across centro-parietal electrodes over both hemispheres in the time window from 365-630 ms (p < 0.001). In this time window, IMPLAUS target words elicited a significantly stronger negative signal than PLAUS target words. The time window and topography of this effect is consistent with those generally seen for the N400-Effect (see Figure 2). The average response from the three electrodes showing the most robust response within in the cluster (C3, Cz, C4) was used for all further analyses across sentence conditions.

Differences in the N400-Effect across Sentence Conditions

Mean amplitude of the ERPs elicited by the target words in all six conditions (S1, S4, S5 for both PLAUS and IMPLAUS trials) were calculated in the time window defined by the S1 N400-

Effect (365-630 ms) and entered into a 2x3 repeated measures ANOVA with the factors Condition (PLAUS, IMPLAUS) and Sentence (S1, S4, S5). Main effects of both Condition, $F(1,15)=10.75$, $p = .005$, $\eta p^2 = .42$, and Sentence, $F(2,30)=18.42$, $p < 0.001$, $\eta p^2 = .55$, were observed. In addition a significant Condition x Sentence interaction was observed, $F(2,30)=3.42$, $p <.05$, $\eta p^2 = .19$, indicating that plausibility affected the signal differently at the different sentence positions. Planned comparisons between the plausibility conditions (IMPLAUS < PLAUS) at each sentence position demonstrated a significant effect on S1, $t(15)=4.81$, $p<0.001$, M=3.63, SEM=0.75 and S5, $t(15)=2.32$, $p<0.016$, M=3.53, SEM=1.51, but not on S4, $t(15) < 1$, $p = 0.9$, M=0.085, SEM=1.06.

Latency of the N400-Effect

There was no difference between the peak latency of the N400-Effect elicited on S1 (Mean = 508 ms, SD = 95 ms) and S5 (Mean = 494 ms, SD = 92 ms), $t(15) = .42$, $p > 0.1$.

*******************Place Figure 2 approximately here.

Discussion

In the current study, we investigated the effect of joint comprehension (i.e., processing language stimuli in the presence of another individual) on language processing in adolescents. Our results suggest that adolescents, like adults, simulate the perspective of others during joint language comprehension: this is supported by the observation of a robust Social N400-Effect for sentence stimuli that are *implausible* for the confederate, but *plausible* for the participant him/herself (Sentence 5). In addition, we replicate two well-established findings from the adult literature in an adolescent population: (1) we show a robust N400-Effect for the processing of semantically anomalous compared to semantically plausible sentence stimuli (Sentence 1), and (2) we show that the N400-Effect elicited by implausibility is attenuated by discourse context: anomalous sentences that are coherent within discourse context elicit no significant N400-Effect (Sentence 4). The implications of these findings are discussed below.

Previous literature has shown that young children are sensitive to information about interlocutors during language comprehension. For example, children as young as 4-5 years of age are sensitive to referential precedents, or the ways that speakers choose to refer to items in a conversation (Graham, Sedivy, & Khu, 2014; Matthews, Lieven, & Tomasello, 2010). Specifically, they show confusion if referential pacts are broken by speakers, indicating that the ways specific interlocutors use language is important for language comprehension. Furthermore, it has been suggested that young children consider information about the speaker's perspective on-line during language processing (Nadig & Sedivy, 2002), but that the ability to adjust behaviours to accommodate a speaker's perspective (in particular if the speaker's perspective differs from one's own) continues to improve throughout adolescence (Dumontheil et al., 2010). The results of the current study are in line with these previous findings, in that they provide converging evidence that information gleaned from the social environment directly affects language processing on-line in adolescent participants.

The current data set extends previous literature in that it demonstrates the importance not only of attending to the mental states of *speakers* (or of interlocutor dyads) but also of other jointly *attending* individuals, i.e., others in the environment jointly attending to the same linguistic input. Thus, models of conversation need to take into account how knowledge about interlocutors is incorporated into language comprehension, as well as how information about other listeners in the environment is included. It is unclear whether children as young as those tested in previous developmental studies will also show this sensitivity to other *listeners*, however by early adolescence listeners in the environment have been integrated in the conversational model.

One of the central questions in the on-line perspective taking literature is: when does information about others affect language comprehension (Barr & Keysar, 2006; Brennan et al., 2010; Brown-Schmidt & Hanna, 2011) . Advocates of full constraint models argue that language comprehension can be affected from the very onset by assumptions about what other speakers know or see (Clark, 1996; Hanna et al., 2003), while partial constraint and no constraint models suggest that language comprehension is initially egocentric, and that initial interpretations are adjusted to take others' perspectives into account in later processing stages (Keysar et al., 2000; Kronmüller & Barr, 2007). In the current data, participants show sensitivity to a semantic anomaly experienced by the confederate (i.e., the Social N400-Effect on Sentence 5) within the same time window that sensitivity to egocentrically experienced semantic errors is seen (i.e., the canonical N400-Effect on Sentence 1). The peak latency of the Social N400-Effect does not differ from that of the canonical N400-Effect, suggesting that non-linguistic information about the other's perspective has an immediate effect on language comprehension. In addition, no significant difference in the size of the N400-Effect in earlier vs. later portions of the N400 time window was seen. Taken together, the current data are therefore more broadly in line with models that suggest information about others affects on-line language comprehension from the very earliest stages (Brown-Schmidt & Hanna, 2011; Hanna et al., 2003).

In addition, the current data suggest that simulation of others' experiences is a key cognitive mechanism supporting on-line perspective taking during joint comprehension. Identifying a semantic anomaly from someone else's perspective elicits an electrophysiological signal that is comparable to that elicited by one's own experience of a semantic anomaly. This suggests that in joint comprehension situations, the putative interpretation of others is achieved by parsing language from the perspective of others using the same cognitive mechanisms used to support egocentric language processing. This result is in line with the joint action literature, which suggests that individuals engaged in co-operative actions (e.g., lifting a table together) model the actions of others using their own action processing system (Knoblich, Butterfill, & Sebanz, 2011; Sebanz, Knoblich, & Prinz, 2003, 2005). The current data thus provide insight into the cognitive mechanisms supporting on-line perspective taking, and demonstrate that a common principle, i.e., simulation, may underlie perspective taking in multiple cognitive domains, e.g., language, action.

The results of the current study are broadly in line with what we observed previously in adults (Rueschemeyer et al., 2015). A direct comparison of the data acquired in the previous study and our current study is made difficult, because of fundamental differences between the experimental designs. Specifically, in the current study we introduced a modified version of the Joint Comprehension Task which allows us to investigate the effects of discourse processing (i.e., whether the participants accepts unusual semantic content over time) and perspective taking (i.e., whether the participant is sensitive to another's mismatching perspective) in a within-subjects design. This was achieved by presenting participants with longer pieces of discourse (5 sentences), and controlling how much of that discourse was made available to the confederate. The fact that discourse processing affects later sentence processing can be seen in the overall reduction in the amplitude of the N400-component elicited by target words in both sentence conditions in Sentence 5 compared to Sentence 1 (Nieuwland & Van Berkum, 2006). In the previous adult study, the presence of the confederate was manipulated in a between-subjects design, i.e., while one group of participants read stimuli in the presence of the confederate, another group of participants read the same stimuli in isolation. Experimental stimuli were much shorter (i.e., two sentences long), making it impossible to directly compare the size and latency of the N400-Effect elicited by target words in our previous study with those elicited in the current study. Although both studies suggest a centro-parietal distribution of the N400-Effect, as in previous studies, the peak electrodes identified across the two studies are not identical (see also Holcomb, Coffey & Neville 1992). The pattern of effects across the two studies, however, is common. That is, adolescent participants, like adults, show a robust N400-Effect when presented with semantically anomalous sentences; this effect is attenuated by context. Most importantly, the Social N400-Effect is elicited in participants in both age groups when sentence stimuli are assumed to be implausible for the confederate, even if the sentence is plausible for the participant him/herself. The current data thus suggest that by early adolescence, listeners are attuned to how language is interpreted by others in the environment, and that this process is supported by simulating the putative experience of the other.

Our data do not provide conclusive evidence on the question of why people consider the perspective of others in some situations, and not in others. In the current experiment, participants were motivated to attend to the perspective of the confederate by task demands. In real world conversational settings, it seems likely that our propensity to attend to others is modulated by factors such as the relationship between the adolescent and the confederate, the adolescent's motivation to understand the confederate's perspective, and intrinsic individual differences in the adolescent's propensity to engage with the perspective of others spontaneously. The results of this study therefore speak to the cognitive mechanisms that support perspective taking when it occurs, but not to the automaticity or spontaneity with which adolescents typically engage in perspective taking. These questions form the basis for exciting research in the future, but cannot be answered with the current data.

In addition the Joint Comprehension Paradigm introduces a method of investigating theory of mind and perspective taking using time sensitive measures. Identifying the precise onset of perspective taking has proven difficult in previous perspective taking paradigms. This experimental paradigm therefore has the potential to be informative in studying theory of mind abilities in further developmental as well as clinical populations.

Conclusion

The current study shows that adolescents take the perspective of other jointly attending individuals into account during language comprehension. Importantly, understanding language from the perspective of another individual is supported by simulation, i.e, participants use their own language processing faculty to parse language from the perspective of others.

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C closes eyes — P reads sentences alone. — C opens eyes — P & C read sentence.

	S1			S4	S5	Q1	Q2
PLAUS	The boy rode the bicycle.	The bicycle had a flat tyre.	The boy stopped the bicycle.	The boy got off the bicycle.	The boy pushed the bicycle.	YES	YES
IMPLAUS	The boy argued with the bicycle.	The boy made the bicycle angry.	The bicycle was scared of the boy.	The boy threatened the bicycle.	The boy hurt the bicycle.	NO	YES

Figure 1. Example Stimuli. Stories made up semantically plausible (PLAUS) and semantically implausible (IMPLAUS) sentences were presented one at time. The critical target word was the final word in Sentences 1, 4 and 5 (S1, S4, S5) (underlined above). S1-S4 were read by the participant (P) alone. S5 was read simultaneously by P and confederate (C). Following each story, P was asked whether S5 was plausible for C (Q1), and whether he/she found S5 plausible (Q2).

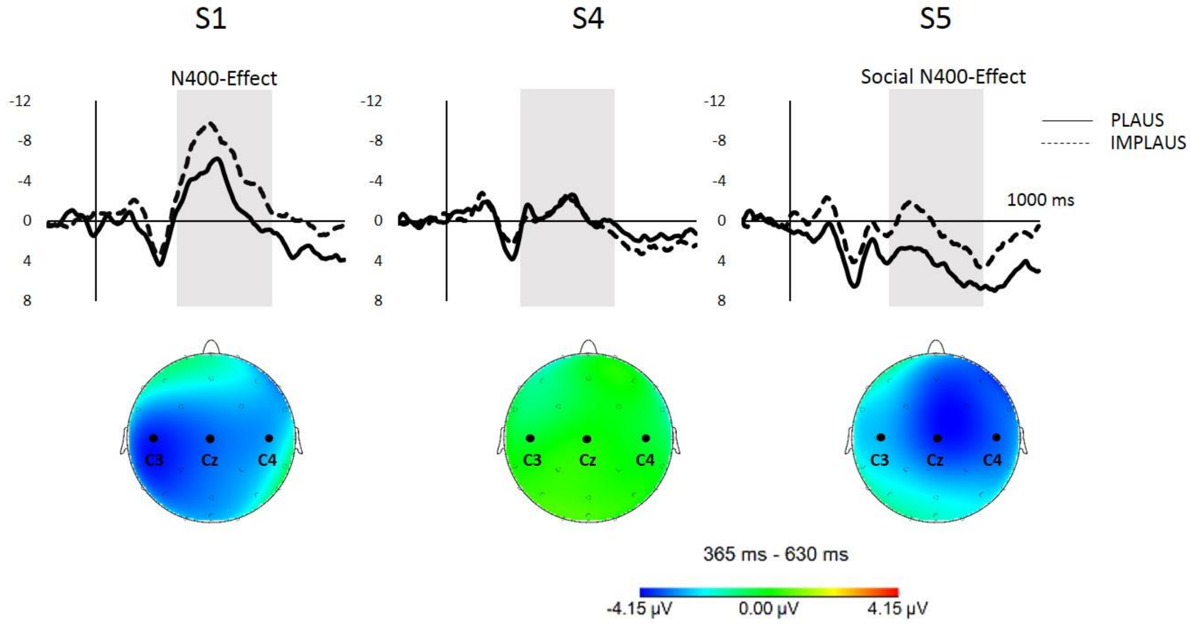

Figure 2. Event-related potentials (ERPs) and scalp topography. Time courses of the average ERPs from the three peak electrodes C3, Cz, C4 can be seen for target words in each sentence position (S1= Sentence 1, S4= Sentence 4, S5 = Sentence 5). ERPs that were elicited by target words in semantically plausible sentence stimuli are depicted by the solid line; ERPs elicited by target words in semantically implausible sentence stimuli are depicted by the dashed lines. In the bottom panel scalp distributions showing differences between the conditions across the N400 time window are seen for each sentence position.