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People matter: Perceived sender identity modulates cerebral processing of socio-emotional language feedback

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ABSTRACT

How do human brains integrate content with social context in communication? Recent research demonstrates that the perceived communicative embedding of perceptually identical language messages alters their cortical processing. When emotional trait-adjectives are perceived as human-generated personality feedback, event-related brain potentials are considerably larger than when the same adjectives are perceived as random computer-generated feedback. Here, we investigate the unique role of ascribed sender humanness for the underlying neural mechanisms. Participants were told that they were going to receive written positive, negative, or neutral feedback from an unknown stranger or from a socially intelligent computer system while high-density EEG was recorded. In the event-related potential (ERP), feedback from the 'human sender' elicited larger P2, Early Posterior Negativity (EPN), P3, and Late Positive Potential (LPP) components. The sources of this activity were localized in extended visual cortex, but also in the right superior frontal gyri, related to mentalizing about others, and the bilateral postcentral gyri implicated in embodied language processing. For emotional feedback, larger EPN, P3 and LPP amplitudes were also observed, resulting from enhanced activity in visual and temporal regions. Finally, for the EPN an interaction between sender and emotion was found, showing substantially increased visual processing of human-generated emotional feedback. These data confirm visual amplification effects induced by motivated attention but crucially also reveal distinct effects of perceiving a communication partner as human that activate 'social brain' structures. Obviously *who* is perceived as saying something can be as relevant as what is said and induce specific brain activity.

Introduction

We constantly communicate with others, exchanging facts, preferences, attitudes or gossip. Language enables us to do this. However, as Fauconnier (1994) noted, in contrast to naive assumptions, the meaning of words is not fixed. Rather we need to have knowledge about the context to decode meaning (Fauconnier, 1994; p. xviii). Some communication theories even state that meaning is directly adopted from interaction with others, emphasizing the importance of social context (Blumer, 1969). However, particularly in modern-day virtual communication, such as e-mail, text messaging or twitter, the presence of interactive partners is often not physically perceived, but inferred from contextual cues, begging the question of how such socio-contextual inferences affect the processing of language content.

Recently, communicative context manipulations have been shown to modulate the processing of emotional language as reflected in brain event-related potentials (ERPs; Fields and Kuperberg, 2012; Herbert et al., 2011; Rohr and Abdel Rahman, 2015; Schindler et al., 2014, 2015). For example, Rohr and Abdel Rahman (2015) demonstrated that emotion effects in word processing were larger and occurred earlier when speakers in video-clips directly looked at participants. To the best of our knowledge, however, only one previous study manipulated (inferred) context without physically changing stimulus attributes: In a social feedback situation, the notion of interacting with a human partner has been found to amplify visual processing when compared with random feedback (Schindler et al., 2014, 2015). Participants supposedly received written personality feedback either from an unknown stranger or from a randomly acting computer program (Schindler et al., 2014, 2015). Although visual input was identical, word messages from the putative 'human sender' elicited enhanced ERPs whose generators could be localized in extended visual cortex. On the scalp, effects could be observed already when participants were expecting feedback (Schindler et al., 2014).

During feedback processing, sender-dependent differences started with the P2 potential, sometimes characterized as an initial stage of lexical processing (e.g. Trauer et al., 2012) and extended across the entire processing sequence, including EPN, P3, and LPP. The sources of these activities were localized particularly in fusiform areas. Content effects were also found in that emotional feedback magnified LPP amplitudes, largely replicating previous research on elaborative processing

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of emotional language (Herbert et al., 2006, 2008; Hofmann et al., 2009; Kanske and Kotz, 2007; Kissler et al., 2009; Schacht and Sommer, 2009). Similar to the sender effects, the content effects were mainly generated in bilateral fusiform gyri. In general, such enhanced visual activity in response to significant stimuli can be related to the framework of motivated attention, attributing enhanced visual activation in response to emotional stimuli to their higher motivational relevance (Lang et al., 1998; Schupp et al., 2004). Therefore, recent results show that next to stimulus content, stimulus context also drives motivated attention. Although demonstrating inferred context effects in the absence of stimulus change, the Schindler et al. (2015) study leaves open the decisive question of whether the amplified processing of 'human-generated' decisions is due to specific effects of human presence or simply reflects the contrast of receiving supposedly meaningful versus random feedback.

Intuitively, there seems to be something special, qualitatively distinct, about the social context of receiving feedback from another human rather than a machine, although computer algorithms actually can perform equally well or even better than humans in assessing human personality (Youyou et al., 2015). Still, people often respond in a distinct manner when interacting with another human rather than a machine. For instance, when interacting with a computer partner, participants exhibit less interpersonal display (Aharoni and Fridlund, 2007). Also, when talking, humans adapt to another human's age, but not to a robot's suggested age or cognitive status (Fischer et al., 2011a, 2011b). Similarly, on the cerebral level fMRI studies indicate less activity in empathy (Rosenthal-von der Pütten et al., 2014) and mentalizing (Chaminade et al., 2012; Kircher et al., 2009) networks for human–machine compared to human–human interactions. Further, when monetary reward depends on the behavior of interaction partners, strong brain responses can be found for unfair behavior of 'humans' but not of computer agents (Harlé et al., 2012; Phan et al., 2010). When participants see faces putatively representing intentionally acting players in the ultimatum game, enhanced bilateral fusiform activity can be observed next to increased activity in the left amygdala, bilateral insula, superior temporal sulcus, and reward-related areas. The same is not observed when the players whose faces are shown are said to have no influence on the game, the decisions being computer-generated (Singer et al., 2004).

On the basis of these findings, it seems reasonable to expect a unique influence of attributed humanness in social communicative situations. Still, despite language being intrinsically communicative, there is almost no data on the effects of implied social contexts and specifically implied human presence on language processing. Moreover, most previous studies investigating unique effects of humanness in interactive set-ups focused on hemodynamic responses, neglecting temporal dynamics.

In our previous EEG study, we showed that processing of single words was substantially amplified from early processing stages when supposedly generated by another human rather than by a randomly acting machine (Schindler et al., 2015). However, an open question is to what extent these effects were due to differences in attributed meaningfulness or due to the notion of a human partner's presence. This is the focus of the present study. In other words, will context-driven differences persist when perceived competence is suggested to be equal? Will quantitative effects remain, because human feedback is always more relevant, resulting in unspecific visual processing enhancement, in line with the model of motivated attention (Lang et al., 1998; Schupp et al., 2004)? Importantly, will there be also qualitative differences indicative of the recruitment of distinct social brain networks? The high temporal resolution of EEG recordings can reveal the time-course of visual and social brain activation and integration, while source estimations can provide us with information on specific effects of 'humanness'.

To address these questions, we used the very same set-up as in our previous study (Schindler et al., 2015): Participants received written emotional and neutral feedbacks. They were told that in one condition feedback came from an unknown stranger and, crucially, in the other condition from an equally competent socially intelligent computer program. Thereby, for the first time, resulting sender differences in processing can only be ascribed to the 'human presence'. We hypothesized that a putative 'human sender' would elicit larger EPN and LPP amplitudes' and that these differences would be reflected in enhanced visual processing in source space, possibly even in increased activations in mentalizing-related brain regions (Chaminade et al., 2012; Kircher et al., 2009). Finally, in accordance with the model of motivated attention, enhanced processing of emotional decisions on the scalp and in source space was predicted.

Method

Participants

Twenty-eight participants were recruited at the University of Bielefeld. They gave written informed consent according to the Declaration of Helsinki and received 10 Euros for participation. The study was approved by the local Ethics Committee. Due to large artifacts one participant had to be excluded, leaving twenty-seven participants for final analysis. The resulting participants (18 females) were 25.26 years on average ($SD = 2.92$), all of them right-handed and had normal or corrected-to normal vision. No participant reported a previous or current neurological or psychiatric disorder.

Stimuli

Presented adjectives were rated beforehand in terms of valence and arousal using the Self-Assessment Manikin. The 20 student raters who did not participate in the actual experiment were instructed to consider the adjectives' valence and arousal in an interpersonal evaluative context. The selected 150 adjectives (60 negative, 30 neutral, 60 positive) were matched in their linguistic properties, such as word length, frequency, familiarity and regularity (see Schindler et al., 2014, 2015). Importantly, negative and positive adjectives differed in valence only. Neutral adjectives were allowed to deviate from emotional adjectives on rated concreteness since truly neutral trait adjectives are rare in an interpersonal evaluative context.

Procedure

The experimental procedure mirrored the one described previously (Schindler et al., 2014, 2015). All subjects underwent both conditions, while the sequence of conditions was counterbalanced across participants.

Upon arrival, participants were instructed to briefly describe themselves in a structured interview in front of a camera. They were informed that the video of their self-description would be presented to a second participant next door as well as imported into a socially intelligent computer algorithm. This socially intelligent computer algorithm was the critical difference to the previous studies, that had introduced a randomly acting computer (Schindler et al., 2014, 2015). Subsequently, during EEG preparation, participants filled out demographic questionnaires. To ensure face validity, a research assistant left the testing room a couple of minutes ahead of the fictitious feedback, guiding an 'unknown person' to a laboratory room next to the testing room.

Stimuli were presented within a desktop environment of a fictitious program 'Interactional Behavioral Systems' supposedly allowing instant online communication. In order to ensure credibility of the situation, network cables and changes of the fictitious software desktop image that showed the 'Interactional Behavioral Systems' environment were made salient. The presented feedback was randomly generated in both conditions. Half of all adjectives were endorsed, leading to 30 affirmative negative, 30 neutral, and 30 affirmative positive decisions.

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