Ohmann, K and Stahl, J and Mussweiler, T and Kedia, G (2016)

Immediate relativity: EEG reveals early engagement of comparison in social information processing.

Journal of Experimental Psychology: General. ISSN 0096-3445
Journal web site: http://www.apa.org/pubs/journals/xge/

Immediate Relativity: EEG Reveals Early Engagement of Comparison in Social Information Processing

Katharina Ohmann, *Social Cognition Center Cologne, University of Cologne, Germany*

Jutta Stahl, *Department of Psychology, University of Cologne, Germany*

Thomas Mussweiler, *Social Cognition Center Cologne, University of Cologne, Germany*

Gayannée Kedia, *Social Cognition Center Cologne, University of Cologne, Germany & Department of Psychology, University of Graz, Austria*

Authors' Notes

This research was funded by a Leibniz Award by the German Science Foundation (DFG) awarded to Thomas Mussweiler (MU 1500/5-1).

The authors would like to thank David Linden, Niklas Ihssen, Nathalie George and her group at ICM, as well as the members of the Social Cognition Center Cologne for their feedback at various stages of this project.

This work was previously presented as a poster at the annual conference of the Society for Personality and Social Psychology in Austin, Texas, on February 14, 2014, and in form of a conference talk at the 17th general meeting of the European Association of Social Psychology (EASP) in Amsterdam, Netherlands, on July 10, 2014. Moreover, the data were discussed at the EASP Small Group Meeting on Social Neuroscience in Graz, Austria, on September 11, 2015.

Correspondence concerning this article should be addressed to Katharina Ohmann, Department of Individual Differences and Psychological Assessment, Universität zu Köln, Pohligstr. 1, 50969 Köln, Germany; Phone: +49 (0) 221 470 5032; Fax: +49 (0) 221 470 5034. E-mail: katharina.ohmann@uni-koeln.de

Abstract

A wide array of social decisions relies on social comparisons. As such, these decisions require fast access to relative information. Therefore, we expect that signatures of the comparative process should be observable in electrophysiological components at an early stage of information processing. However, to date, little is known about the neural time course of social target comparisons. Therefore, we tested this hypothesis in two electroencephalography (EEG) studies using a social distance effect paradigm. The distance effect capitalizes on the fact that stimuli close on a certain dimension take longer to compare than stimuli clearly differing on this dimension. Here, we manipulated the distance of face characteristics regarding their levels of attractiveness (Study 1) and trustworthiness (Study 2), two essential social dimensions. In both studies, size comparisons served as a nonsocial control condition. In Study 1, distance related effects were apparent 170 milliseconds (VPP) and 200 milliseconds (N2) after stimulus onset for attractiveness comparisons. In Study 2, trustworthiness comparisons took effect already after 100 milliseconds (N1) and likewise carried over to an event-related N2. Remarkably, we observed a similar temporal pattern for social (attractiveness, trustworthiness) and nonsocial (size) dimensions. These results speak in favor of an early encoding of comparative information and emphasize the primary role of comparison in social information processing.

Keywords: comparison; social information processing; event-related potentials; attractiveness; trustworthiness

“One can state, without exaggeration, that the observation of and the search for similarities and differences are the basis of all human knowledge.” – Alfred Nobel

Introduction

We live in a world that is full of alternatives. Every single day, we are confronted with and have to choose between an enormous range of people, objects and opportunities. In light of a sheer endless stream of options, it seems fascinating that we often arrive at purposeful and sensible judgments and decisions. What enables us to do so? According to a large body of research, comparison plays a fundamental role in this process (e.g., Festinger, 1954; Goldstone & Medin, 1994; Kahnemann & Miller, 1986; Mussweiler, 2003; Tversky, 1977). In the social domain it has been shown that whenever individuals evaluate a person’s characteristics or abilities, they make comparisons with pertinent norms and standards (Kahneman & Miller, 1986; Mussweiler & Rüter, 2003). Moreover, research has documented the extensive impact of comparative thinking on our daily lives by showing that comparison influences a variety of domains ranging from person perception (e.g. Corcoran, 2013; Mussweiler & Damisch, 2008; Shepperd & Taylor, 1999) and stereotyping (Collins, Crandall, & Biernat, 2006; Corcoran, Hundhammer, & Mussweiler, 2009) to affective experiences (Epstude & Mussweiler, 2009), as well as judgment and decision making (e.g., Levine, Halberstadt, & Goldstone, 1996; Medin, Goldstone, & Markman, 1995). Furthermore, behavioral studies have provided evidence that individuals engage in comparison efficiently, effortlessly and with remarkable facility (e.g., Gilbert, Giesler, & Morris, 1995; Mussweiler & Epstude, 2009). Thus, a wide range of experimental and theoretical support highlights that comparison constitutes one of the essential building blocks of cognition.

Research suggests that particularly comparisons of social targets constitute an important aspect of social information processing as judgments of others are not made in a vacuum (Corcoran & Mussweiler, 2009; Mussweiler & Damisch, 2008; Ruys, Spears, Gordijn, & Vries, 2006; Shepperd & Taylor, 1999; Trope, 1986). Already in a child’s early development (between the ages of six to eleven), representations of other people build largely upon comparisons (Barenboim, 1981) and research suggests that this link holds throughout adulthood (e.g., Kahnemann & Miller, 1986; Manis, Biernat, & Nelson, 1991; Newman & Uleman, 1990). However, despite manifold evidence corroborating the substantial influence of comparative processes on person perception, it remains unclear at which stages of social information processing they come into play.

The Neural Time Course of Comparison

The present research aims at shedding light onto this question by investigating the neural time course of comparison in social information processing. To do so, we took advantage of the excellent temporal resolution of electroencephalography (EEG) and event-related potentials (ERPs). As Coles (1989) and Posner (2005) have argued, studying mental chronometry using psychophysiological tools provides us with considerable insight into the nature of thought and how the mind works. ERPs, for instance, allow to determine whether early processes associated with attention and perception are affected by an experimental manipulation or later stages that are associated with elaborate cognitive processing (for further discussion on the utility of ERPs for social neuroscience, see e.g., Amodio, Bartholow, & Ito, 2014; Woodman, 2010).

EEG has already been used to study the time course of outcome evaluations *following* self-other comparisons. These studies have found that the feedback-related negativity, an ERP component that peaks around 300 milliseconds after feedback onset, is sensitive to relative gains and losses in social comparison situations (Boksem, Kostermans & De Cremer, 2011; Qiu et al., 2010; Wu, Zhang, Elieson & Zhu, 2012). Yet, to our knowledge, the time course of the social comparative process *itself* has not been studied to date. Accordingly, it remains an open question when neural markers of comparative processing in social contexts are observable.

To bridge this gap, we use ERPs in combination with a social distance effect paradigm that allows to determine the instant at which comparison takes effect on the neural level (see below for a detailed description of the paradigm). Here, we focus on perceptions of facial attractiveness and trustworthiness, two essential social dimensions (e.g., Olson & Marshuetz, 2006; Todorov, Said, Engell, & Oosterhof, 2008). Previous studies have indicated that judgments of these two dimensions are not absolute in nature but prone to comparative processes (e.g., DeBruine, Jones, Little, & Perrett, 2008; DeBruine, 2002, 2005; Cogan, Parker & Zellner, 2013; Geiselman, Haight & Kimata, 1984; Kernis & Wheeler, 1981; Rodway, Schepman & Lambert, 2013; Todorov, Loehr, &Oosterhof, 2010, Study 1; Wedell, Parducci & Geiselman, 1987). For instance, Kenrick and Gutierres (1980) demonstrated that perceiving an attractive woman in the media will render subsequent attractiveness judgments of another woman less favorable. In a similar vein, Bateson and Healy (2005) have argued that the attractiveness of a given mate will depend on the others with whom he or she is being compared, rather than being an absolute function of his or her underlying qualities. Research thus seems to suggest that attractiveness and trustworthiness comparisons occur spontaneously and effortlessly.

But when can we expect such naturally occurring comparisons to unfold? When exactly do they manifest on the neural level? Hypotheses regarding this important question can be generated in at least two distinct ways: First, by looking at the time course of other similarly fundamental cognitive mechanisms. Second, by taking a closer look at the temporal dynamics of comparison-related phenomena. Concerning the time course of other cognitive mechanisms that seem similarly fundamental as comparison, previous ERP studies have demonstrated that mechanisms such as object and face categorization, take effect as early as 100 to 200 milliseconds after individuals encounter a respective stimulus (e.g. Jacques & Rossion, 2006; Rossion & Caharel, 2011; Tanaka, Luu, Weisbrod, & Kiefer, 1999). Similarly, basic mechanisms of social cognition, such as attributing a mind to others during joint attention (Wykowska, Wiese, Prosser & Müller, 2014), are carried out within the same time range. Moreover, ERP research examining the temporal dynamics of comparison in the non-social domain has demonstrated that numerical comparisons are observable already 200 milliseconds after stimulus onset (e.g., Dehaene, 1996; Pinel, Dehaene, Riviere, & LeBihan, 2001; Szũcs & Csépe, 2005; Szũcs, Soltész, Jármi & Csépe, 2007). Taken together, this research suggests that, as is true for these other basic cognitive mechanisms, comparison may also take place between 100 and 200 ms after stimulus onset on the neural level.

This possibility is further strengthened by looking at the time course of comparison-related phenomena. In fact, studies investigating comparison-related phenomena have shown that, for instance, face matching in a visual imagery task influences neural activity within the first 200 milliseconds after stimulus onset (Farah, Péronnet, Gonon, & Giard, 1988; Ganis & Schendan, 2008; Wu, Duan, Tian, Wang, & Zhang, 2012). A face matching task involves some comparative components as comparison enables the determination of matching (i.e., similar) and nonmatching (i.e., dissimilar) features. Likewise, the detection of perceptual novelty was found to affect neural processing within the first 200 milliseconds after stimulus onset (e.g., Folstein & Van Petten, 2008; Schomaker & Meeter, 2014; Tarbi, Sun, Holcomb, & Daffner, 2010). Novelty detection requires a comparison of the incoming information with information already stored in the system (Tulving, 2009).

In sum, the abovementioned findings suggest that other essential mechanisms of information processing and comparison-related phenomena such as matching and the detection of perceptual novelty take effect within the first 200 milliseconds after stimulus onset. Based on these findings and in light of the importance of comparison for person perception, we hypothesize that—as is true for other essential mechanisms of information processing—comparisons are engaged within the first 200 milliseconds after stimulus exposure.

ERP Components of Interest

Based on this hypothesis, the question arises which ERP components are sensitive to this early temporal dynamic. To answer this question, we resorted to two separate ERP literatures: one that focuses on face processing and one that focuses on comparison-related phenomena. With regard to face processing, it has been found that the ERPs P1, N170 and the Vertex Positive Potential (VPP) reflect face sensitive neural processing within the first 200 milliseconds after stimulus onset (e.g., Clark et al., 1995; Dering, Martin, Moro, Pegna, & Thierry, 2011; Di Russo et al., 2002; Joyce & Rossion, 2005). Importantly for the current research, the P1, N170, and VPP were found, inter alia, to be involved in face discrimination (Campanella et al., 2000)—a process that involves some comparative components—and to be modulated by variations in attractiveness and trustworthiness of *individually* presented faces (e.g., Dzhelyova, Perrett, & Jentzsch, 2012; Marzi, Righi, Ottonello, Cincotta, & Viggiano, 2014; Marzi & Viggiano, 2010; Pizzagalli, Lehmann, Hendrick, Regard, Pascual-Marqui, & Davidson, 2002; Trujillo, Jankowitsch, & Langlois, 2014). With regard to comparison related phenomena that affect ERPs within the first 200 milliseconds after stimulus onset, it has been found that the N1 and N2 are, inter alia, involved in race categorization made from faces (N1; Ito & Urland, 2003; 2005) and the processing of face matches and mismatches (N2; Wu et al., 2012). These processes are related to some aspects of the comparative process such as the identification of matching (similar) and non-matching (dissimilar) features (see Duncan & Humphreys, 1989; Goldstone, 1994; Hahn & Chater, 1998; Medin & Schaffer, 1978; Pomplun, Sichelschmidt, Wagner, Clermont, Rickheit, & Ritter, 2001; Tversky, 1977; Sloutsky, 2003).

Based on these two literatures, we focus our analysis on the face sensitive P1, N170 and VPP as well as on the N1 and N2 that were found to be modulated by comparison-related processes. In addition, we take into account that previous research has pointed towards functional differences of the anterior and posterior N2 (for a review, see Folstein & Van

Petten, 2008): The anterior N2 is associated with the detection of perceptual novelty and mismatch (Folstein & Van Petten, 2008), while the posterior N2 is related to the degree of attention required for stimulus processing, as demonstrated by studies using visual search paradigms in which several objects are presented simultaneously (Conci, Gramann, Müller, & Elliott, 2006; Hopf et al., 2000; Woodman & Luck, 1999). Moreover, previous findings in the ERP- and fMRI-literature indicate that the distance effect paradigm which we use in the current studies (see below for a detailed description) modulates different neural networks, specifically, a fronto-parietal (person comparison; Chiao et al, 2009; Kedia et al., 2014), a parieto-central (numerical comparison; Hsu & Szũcs, 2012), and an occipito-parietal network (numerical comparison; Dehaene, 1996; Dehaene, Piazza, Pinel, & Cohen, 2003). Because of these reasons, we decided to analyze the anterior and the posterior N2 separately.

The Distance Effect Paradigm

To test the hypothesis that social comparative information takes effect within the first 200 milliseconds after stimulus onset, we conducted two ERP studies investigating comparisons of facial attractiveness (Study 1) and trustworthiness (Study 2). To identify the instant at which social target comparison first appears in neural correlates of information processing, we employed a distance effect (DE) paradigm. The DE builds on Weber’s law and captures the fact that stimuli close to one another on a certain dimension (low distance) take longer to compare than stimuli clearly differing on that dimension (high distance; Moyer & Landauer, 1967). In the numerical domain, for example, it takes participants longer to decide that 4 is larger than 3 than to decide that 7 is larger than 3 (e.g., Reynvoet & Brysbaert, 1999). Importantly, this temporal difference in response to low and high distance pairs necessarily requires that the respective stimuli are being compared. ERP studies dedicated to the investigation of the neural time course of numerical comparisons have revealed that the DE is typically reflected in larger amplitudes for low as compared to high distance trials (e.g., Dehaene, 1996; Pinel, Dehaene, Rivière, & LeBihan, 2001). Thus, in the present research we used the occurrence of a DE in ERP components as a neural signature of comparative processing.

The Present Research

In the present research, we designed a social variant of a DE paradigm: We presented participants with images of two faces simultaneously. Within one pair, faces were either close to one another on the critical dimension (low distance, i.e., targets differed only slightly in attractiveness or trustworthiness) or further apart (high distance, i.e., targets differed substantially in attractiveness or trustworthiness; for a similar paradigm in the context of an fMRI study, see Kedia, Mussweiler, Mullins, & Linden, 2014). In both studies, we used a nonsocial feature of the same faces for comparison by varying the size of the images in a high and low distance manner. On the behavioral level, we expected to observe a DE reflected in prolonged reaction times on low distance trials relative to high distance trials in both studies. In case that—as we hypothesize—social comparisons follow a similarly early time course as numerical magnitude comparisons, categorization, and matching processes (Dehaene, 1996; Farah et al., 1988; Ganis & Schendan, 2008; Jacques & Rossion, 2006; Szũcs et al., 2007; Tanaka et al., 1999; Wu et al., 2005), neural markers of the DE should be observable within the first 200 milliseconds after stimulus onset. As explained above, our analyses focused on the N1, N2, and the face-sensitive ERP components P1, N170, and VPP. Does comparison indeed constitute an early mechanism in social information processing? Investigating its neural time course will provide us with new insights into this question.

Experiment 1

In the first experiment, we examined the neural time course of attractiveness (social) and size (nonsocial) comparisons. As outlined above, we chose physical attractiveness as the subject of observation due to its major role in person perception (for a review, see Langlois, Kalakanis, Rubenstein, Larson, Hallam, & Smoot, 2000) and its susceptibility to comparison (Cogan et al., 2013; Geiselman et al., 1984; Kernis & Wheeler, 1981; Rodway et al., 2013;

Wedell et al., 1987). Moreover, judgments of physical attractiveness do not require any preceding information about the targets as such judgments are performed regularly in daily life. During EEG recording, participants compared the attractiveness of two simultaneously presented female faces and the size of the respective images in two blocks each. The presented images varied in distance concerning either attractiveness or size. As described above, we predicted a behavioral DE on response times as well as an effect of distance on ERP components occurring within the first 200 milliseconds after stimulus onset for both, attractiveness and size comparisons.

Method

Participants. We recruited 26[1] right-handed female participants via an internal participant database at the University of Cologne. Four participants were removed from all final analysis as described below, leading to a final sample of 22 women (average age: 25.09). We opted for an entirely female sample to avoid potential sex differences in judgments of attractiveness of female faces as such differences were found to affect neural activity in previous ERP research (van Hooff, Crawford, & van Vugt, 2011). None of the participants reported current or past neurological or psychiatric illness and they all had normal or corrected-to-normal vision. Participants gave informed written consent prior to participating in the experiment and received a compensation of €8 per hour. The study was approved by the ethics committee of the German Psychological Association (DGPS).

Stimuli. The initial stimulus set used in this study consisted of 320 color images downloaded from the professional online platform Fotolia© displaying female faces. These images were pretested for attractiveness in a separate female sample (N = 25; mean age: 23.20). Participants in the pretest judged the attractiveness of sequentially presented female faces using an analog scale ranging from zero (= *very unattractive*) to 100 (= *very attractive*). Based on participants' mean ratings, we split the set of images into three categories, i.e. faces

---

[1] In Study 1, we did not perform an a priori power analysis because prior work did not report effect sizes.

of high attractiveness (highest mean ratings), of moderate attractiveness (average mean ratings) and of low attractiveness (lowest mean ratings). Out of these groups, we selected the images with the smallest standard deviations (*SDs* < 22) for the ERP experiment. This procedure yielded a final stimulus set of 90 images: Thirty of them were judged to be of high attractiveness (*M* = 72.34, *SD* = 3.18), 30 of moderate attractiveness (*M* = 51.91, *SD* = 3.12) and another 30 of low attractiveness (*M* = 28.24, *SD* = 6.35).

Attractiveness condition. To create high distance pairs, we matched faces that were judged as being of high and low attractiveness. Low distance pairs consisted of moderately attractive faces, combined with faces that were either of high or low attractiveness. In sum, we created 204 pairs, half of them being of high and half of them being of low distance, whose mean attractiveness levels did not differ, *t*(202) = .061, *p* = .951, Cohen's *d* = .01. To avoid any confounding influence of facial expressions, we created pairs of female faces who either both smiled or both looked neutral and equated the distribution of smiling and non-smiling pairs across the low and the high distance condition. Moreover, to rule out that any differences between the conditions arise from differences in low level visual properties of the stimuli, we calculated mean scores concerning luminance, color and local frequency for each pair of images. Our analysis revealed no significant differences between the high and low distance attractiveness conditions in any of these properties, *t*s(202) < 1.45, *p*s > .148, *d*s < .20.

Size condition. In the high distance size condition, we combined stimuli subtending a vertical visual angle of 4.08º with stimuli subtending a vertical visual angle of 4.38º. In the low distance size condition, the vertical visual angle was of 4.15º and 4.3º for their respective counterparts. Accordingly, mean size was constant across the low and high distance condition. This condition was also composed of 204 pairs, with 102 of them being of high and 102 of them being of low distance. Again, to exclude potential differences in low level visual properties of the stimuli as a confound, we calculated mean scores concerning luminance, color and local frequency for each pair of images. Our analysis revealed no significant differences between the high and low distance size conditions in any of these properties, *t*s(202) < 0.16, *p*s > .876, *d*s < .08.

The final task consisted of 408 stimulus pairs. The center-to-center distance between two targets presented subtended a horizontal visual angle of 4.23º. We presented participants with the same set of images in both conditions to ensure that attractiveness levels and sizes did not differ between them. To illustrate: When two images were presented in the attractiveness condition, then the visual angle of both images was either 4.08 º, 4.38º, 4.15º or 4.3º (i.e., size was constant within trials but varied between trials). When two images were presented in the size condition, then faces presented were either both of high attractiveness, both of moderate attractiveness or both of low attractiveness. Each image occurred at most five times per condition whereupon the same combination of images was nonrecurring. Finally, we pseudo-randomized the order of high and low distance trials as well as the order of stimulus position (left vs. right) to prevent that identical faces would follow immediately after one another.

Experimental task. On a single trial, participants had to indicate as accurately and quickly as possible which of two simultaneously presented faces they regarded as more attractive (in the attractiveness condition) or which of the images as bigger (in the size condition). They did so by pressing a key corresponding to the side of the image they chose. The images were presented on a white background. Participants completed four blocks in total, consisting of 102 trials each. Two blocks were dedicated to attractiveness and two blocks to size comparisons. Participants were randomly assigned to commencing the task either with the size comparison or the attractiveness comparison condition. We implemented the task using E-Prime (Psychology Software Tools, Pittsburgh, PA) to present the stimuli as well as to record reaction times and responses.

Procedure. During EEG-recording, participants sat in front of a computer at 60 cm distance in a sound-attenuated room with their head stabilized on a chin rest. We instructed them to fixate the center of the screen and to avoid body movements. At the beginning of the first attractiveness comparison block (and at the beginning of the first size comparison block), participants performed ten practice trials to adapt to the task. Each trial started with a jittered fixation point lasting between 700 and 900 milliseconds followed by the simultaneous presentation of two faces for 1500 milliseconds. Subsequently, a jittered blank serving as the inter-trial interval lasted between 1500 and 2000 milliseconds (for a schematic depiction of the task, see Figure 1). If participants regarded the woman presented on the left as more attractive / the image as bigger, they pressed the “1” key on the numeric keypad of a keyboard (ACER©) with their right index finger. Conversely, if they regarded the woman presented on the right as more attractive / the picture as bigger, they pressed the “2” key with their right middle finger. In between the blocks, participants took short breaks and read through the instructions again before every new block started. An entire session (including mounting and taking off the EEG cap) took around 1 hour and 15 minutes.

Electrophysiological recording. We used the *BrainAmp Vision Recorder©* to record EEG data from 61 scalp electrode sites (Fp1, Fp2, F7, F3, Fz, F4, F8, FC5, FC1, FC2, FC6, T7, C3, Cz, C4, T8, CP5, CP1, CP2, CP6, P7, P3, Pz, P4, P8, FCz, O1, Oz, O2, AF7, AF3, AF4, AF8, F5, F1, F2, F6, C3, FT7, FC3, FC4, FT8, C4, C5, C1, C2, C6, TP7, CP3, CPz, CP4, TP8, P5, P1, P2, P6, PO7, PO3, POz, PO4, PO8) that were set up according to the international 10-20 system. We referenced the active Ag/AgCl electrodes (*actiCAP, Brain Products©*) against the left mastoid and recorded horizontal electrooculograms (hEOG) from electrode positions next to both eyes. Additionally, we derived a vertical electrooculogram (vEOG) from an electrode placed below the left eye. We held electrode impedances constantly below 5 **Ω** and digitized them at a sampling rate of 500 Hz using BrainAmp DC (*Brain Products©*). We employed an on-line bandpass filter (DC – 70 Hz) for all channels.

Subsequently, we analyzed EEG data offline with segments ranging from a baseline period of 200 milliseconds before to 800 milliseconds after stimulus onset. Additionally, we conducted a DC detrend correction and screened the data for technical artifacts (± 500 µV). Thereafter, we applied an ocular correction algorithm (Gratton, Coles, & Donchin, 1983) to subtract the influences of eye movements. Subsequently, we performed a second artifact rejection at a stricter threshold (± 100 µV), set a low cut-off filter at 0.1 Hz and a high cut-off filter at 30 Hz. Finally, we conducted a current source density (CSD) analysis of the ERPs for all 61 electrode sites. Specifically, we computed CSD signals for each electrode site by taking the second derivative of the distribution of the voltage over the scalp. The CSD analysis accounts for the curvature of the head using a spline algorithm (Perrin, Pernier, Bertrand & Echallier, 1989). This makes the signal independent of the location of the reference electrode as different reference locations can affect the ERP signal differentially, but not the CSD signals. Moreover, the CSD analysis serves as a spatial filter that decreases the blur distortion caused by skull resistance (Katznelson, 1981) and reduces the effect of adjacent currents on the local recordings by amplifying shallow neural generators (for further discussion, see Bode, Sewell, Lilburn, Forte, Smith, & Stahl, 2012). Thereby, a CSD transformation provides a reference-free, spatially enhanced representation of the direction, location, and intensity of current generators that underlie the recorded scalp potentials (cf. Kayser & Tenke, 2006b). Moreover, it provides topographies (CSD maps) with more sharply localized peaks than those of the scalp potential, while eliminating volume-conducted contributions from distant regions and sources (Tenke & Kayser, 2005; Kayser et al., 2006; for further discussion, see Kamarajan, Pandey, Chorlian, & Porjesz, 2014). Finally, we computed grand averages separately for all conditions, that is, attractiveness high distance, attractiveness low distance, size high distance and size low distance. We used mean amplitudes of the ERP components of interest and peak latencies for further statistical analyses. The determination of time windows and electrode sites was based on topographical analysis and previous literature as described below in further detail.

Electrode sites and time windows. Our selection of electrode sites to be included in the ERP analyses was based on previous literature and visual inspection of the topographical distribution of the ERP components reflected in CSD maps. These maps—as described above—reflect the magnitude of the radial (transcranial) current flow from the brain to the scalp (source) and to the brain from the scalp (sink) (Perrin et al., 1989; Kayser et al., 2012). Thus, to determine the respective electrode sites for analysis, the CSD maps provided us with an estimation of the origin of the ERP signal. Furthermore, we focused our statistical tests only on relevant clusters of electrodes (cf. Luck, 2005, who suggests to 'analyze an ERP component only at sites where the component is actually present; p. 254).

P1, N170, and the VPP. As described in the introduction, facial stimuli typically elicit a posterior lateral P1, followed by an N170 and its fronto-central equivalent, the vertex positive potential (VPP; Eimer, 2011; Joyce & Rossion, 2005). In line with these previous studies, a CSD-map at 100 milliseconds after stimulus onset indicated a positive posterior lateral activation (P1; cf. Figure 3). The respective map at 170 milliseconds after stimulus onset showed a negative posterior lateral (N170) as well as a positive fronto-central activation (VPP; cf. Figure 3). The P1 occurred in the time window between 80 and 120 milliseconds after stimulus onset. The N170 and the VPP were observable within the interval between 120 and 220 milliseconds after stimulus onset. Previous research has observed (e.g., Itier & Taylor, 2004; Joyce & Rossion, 2005; Righart & de Gelder, 2007) maximal P1 and N170 amplitudes at electrode sites P7/8, PO7/8, P5/6. Visual inspection of the components' scalp distribution likewise suggests maximal amplitudes at these electrode sites wherefore we chose them for analysis of the two components. The VPP was present at FCz which is also in line with previous literature (e.g., Wong, Fung, McAlonan, & Chua, 2009; Zhang, Liu, Wang, Chen, & Luo, 2014).

N1 and N2. The N1 occurred in the interval between 70 and 130 milliseconds and was maximal at occipito-parietal midline and adjacent electrode sites (for CSD maps, see Figure 3). Based on this, we averaged mean activities and latencies of the N1 at electrode sites Pz, P1/2, POz, PO3/4, Oz, O1/2. The anterior N2 was maximal at the frontal electrode site FCz and the posterior N2 at centro-parietal electrode sites (cluster: POz, CPz, Pz, Cz, P1, P2) within the interval between 180 and 300 milliseconds. As previous research has pointed towards functional differences of the anterior and posterior N2 (for a review, see Folstein & Van Petten, 2008), we performed separate analyses on the anterior and posterior N2.

Statistical analyses. We analyzed participants' behavioral data (response time and accuracy) by performing two-way repeated-measures analyses of variance (ANOVA) using distance (high and low) and comparison type (attractiveness and size) as within-subject factors. We followed up on significant interaction effects with paired samples *t*-tests using Bonferroni corrections for multiple comparisons. Furthermore, we calculated main effect contrasts to specify whether the observed effects are present in both, the social and the non-social condition, or solely driven by one of the two conditions.

Concerning the ERP data, we averaged mean activities measured at the respective electrode sites within each cluster and calculated either two-way repeated-measures ANOVAs using distance (high and low) and comparison type (attractiveness and size) as within-subject factors or, in case of bilateral activation, three-way ANOVAs using hemisphere as an additional within-subject factor. We followed up on significant interaction effects with paired-samples *t*-tests using Bonferroni corrections for multiple comparisons and report Greenhouse-Geisser corrections where sphericity was violated. As in the analysis of our behavioral data, we also calculated main effect contrasts to explore whether the effects are existent in both, the social and non-social condition, or only in one of the two.

Results

Behavioral data. Figure 2 presents reaction times and accuracy data for both types of comparison, that is, attractiveness and size. Overall, we had to exclude 3 % of the trials from the analysis because participants did not respond within the given interval of 1500 milliseconds.

Response times. First of all, our analysis revealed a significant main effect of distance, $F(1, 21) = 57.36$, $p < .001$; $\eta_p^2 = .73$, reflecting that it took participants longer to respond in the low ($M = 775$ ms, $SE = 33$) than in the high distance condition ($M = 700$ ms, $SE = 26$). In addition, we observed a main effect of comparison type, $F(1, 21) = 74.06$, $p < .001$; $\eta_p^2 = .80$, as participants took longer to respond in the attractiveness comparison ($M = 834$ ms, $SE = 35$) than in the size comparison condition ($M = 641$ ms, $SE = 24$). Finally, our analysis yielded a significant Distance x Comparison Type interaction, $F(1, 21) = 23.79$, $p < .001$; $\eta_p^2 = .53$. However, individual contrasts revealed that the distance effect was significant for both types of comparison, ts(21) > 4.53, ps < .001, ds > 1.98. (For an additional speed-accuracy tradeoff analysis, see Supplementary Material.)

Consistency with previous evaluation. We determined the accuracy of participants' responses on the basis of our pretest ratings. Accordingly, here we do not refer to accuracy in an absolute sense but to the consensus between judgments made by the current sample and the attractiveness judgments made in the pretest. A Two-Way repeated measures ANOVA revealed a main effect of distance, $F(1, 21) = 182.39$, $p < .001$; $\eta_p^2 = .90$, and a main effect of comparison type, $F(1, 21) = 16.98$, $p < .001$; $\eta_p^2 = .45$. This reflects that, overall, participants responded less accurate on low ($M = 83$ %) compared to high distance trials ($M = 95$ %) and that response accuracy was significantly lower in the attractiveness ($M = 85$ %) than in the size condition ($M = 93$ %). Individual contrasts revealed that the distance effect was present in both the social and the non-social condition, ts(21) > 4.53, ps < .001, ds > 1.98. Our analysis yielded no significant interaction effect ($p > .10$).

ERP data. Approximately 12 % of trials had to be excluded, either because of ocular artifacts or because participants did not respond within the given interval of 1500 milliseconds. As described above, we had to exclude four participants from the analysis due to a larger number movement artifacts (e.g., eye blinks) and technical artifacts (e.g., defect electrodes) in EEG recording. These data did not meet our cut-off criterion of 20 trials per condition to be included in the analyses (for further details, see Supplementary Material).

P1, N170 and the Vertex Positive Potential. Concerning the analysis of the P1 and N170, we calculated three-way repeated-measures ANOVAs using comparison type, distance and hemisphere as within-subject factors. We analyzed the VPP at electrode site FCz by calculating a two-way repeated-measures ANOVA using the within-subject factors comparison type and distance.

P1. Our analysis of mean amplitudes and peak latencies of the P1 did not reveal any significant main or interaction effects and we did not observe differences in peak latencies (*p*s > .10).

N170. With regard to the N170, our analysis yielded a marginally significant main effect of hemisphere, $F(1, 21) = 4.26$, $p = .052$, $\eta_p^2 = .17$, as amplitudes tended to be larger above the right ($M = 0.227$ µV/cm^2, $SE = 0.025$) relative to the left hemisphere ($M = 0.176$ µV/cm^2, $SE = 0.022$). Our analysis of the N170 did not reveal any additional main or interaction effects and no differences in latencies (*p*s > .10).

VPP. Concerning the VPP, we found a significant main effect of *distance*, $F(1, 21) = 4.88$, $p = .038$, $\eta_p^2 = .19$, reflecting that, overall, low distance trials elicited larger amplitudes ($M = 0.083$ µV/cm^2, $SE = 0.013$) than high distance trials ($M = 0.066$ µV/cm^2, $SE = 0.008$). Furthermore, our analysis yielded a significant Distance x Comparison Type interaction, $F(1, 21) = 6.52$, $p = .019$, $\eta_p^2 = .24$. Post-hoc pairwise comparisons within the social and the non-social condition revealed that the distance effect was significant for attractiveness, $t(21) = 3.09$, $p = .006$, $d = 1.35$, but not for size comparisons, $t(21) = 0.80$, $p = .434$, $d = 0.35$. We observed no significant differences in latencies with regard to the VPP (*p*s > .10). Figure 4 presents average-locked CSD-ERP waveforms at FCz.

N1 and N2. Concerning the analysis of the N1, anterior N2, and posterior N2, we calculated two-way repeated measures ANOVA including the within-subject factors comparison type and distance.

N1. Our analysis of N1 mean amplitudes yielded a marginally significant main effect of comparison type, $F(1, 21) = 3.45$, $p = .077$, $\eta_p^2 = .14$, as attractiveness comparisons tended to elicit larger N1 mean amplitudes ($M = 0.120$ µV/cm^2, $SE = 0.010$) than size comparisons ($M = 0.111$ µV/cm^2, $SE = 0.010$). We observed no additional main or interaction effects and found no differences in latencies at this early stage (*p*s > .10).

Anterior N2. Concerning the N2 at electrode site FCz, we found a significant main effect of distance, $F(1, 21) = 8.19$, $p = .009$, $\eta_p^2 = .28$, with larger amplitudes elicited by low ($M = 0.121$ µV/cm^2, $SE = 0.013$) compared to high distance trials ($M = 0.109$ µV/cm^2, $SE = 0.012$). Moreover, our analysis yielded that attractiveness comparisons tended to elicit larger amplitudes ($M = 0.124$ µV/cm^2, $SE = 0.014$) than size comparisons ($M = 0.106$ µV/cm^2, $SE = 0.013$), $F(1, 21) = 3.01$, $p = .097$, $\eta_p^2 = .13$. Individual contrasts within the social and the non-social condition revealed that the distance effect at FCz was significant for attractiveness, $t(21) = 2.41$, $p = .026$, $d = 1.05$, but not for size comparisons, $t(21) = 0.54$, $p = .599$, $d = 0.23$. We observed no additional interaction effect and no differences in latencies (*p*s > .10).

Posterior N2. At posterior electrode sites, our analysis revealed a significant main effect of comparison type, $F(1, 21) = 11.26$, $p = .003$, $\eta_p^2 = .35$, reflecting that attractiveness comparisons yielded larger amplitudes ($M = 0.170$ µV/cm^2, $SE = 0.016$) than size comparisons ($M = 0.141$ µV/cm^2, $SE = 0.016$). Furthermore, low distance trials tended to elicit larger amplitudes ($M = 0.157$ µV/cm^2, $SE = 0.014$) than high distance trials ($M = 0.154$ µV/cm^2, $SE = 0.014$), $F(1, 21) = 3.78$, $p = .065$, $\eta_p^2 = .15$. However, none of the post-hoc pairwise comparisons for each individual comparison type reached significance, *t*s (21) <

0.81, *p*s > .426, *d*s < 0.35). We observed no differences in latencies and no other main or interaction effects at this point (*p*s > .10). (For a correlation analysis between participants' reaction times and mean ERP waveforms, see Supplementary Material.)

Conclusion

The first experiment suggests that a comparative assessment of attractiveness takes place as early as 170 milliseconds (VPP) after stimulus onset as indicated by a significant impact of distance on attractiveness comparisons at electrode site FCz that carried over to an anterior N2. In line with our hypothesis, this suggests that attractiveness comparisons take effect within the first 200 milliseconds after stimulus onset in social information processing. Interestingly, our data revealed that comparisons of social (attractiveness) and nonsocial (size) characteristics follow the same time course on the neural level, although, on the behavioral level, comparative size judgments were made faster than attractiveness judgments. Concurrently, our data suggest that the evaluation of attractiveness is performed at higher neural costs than size evaluations as indicated by higher N2 amplitudes at posterior electrode sites. Taken together, these results provide initial evidence that the first comparative assessment of attractiveness is performed at an early stage of information processing. However, it is conceivable that our findings are specific to attractiveness comparisons and do not hold for other social judgments. Accordingly, to investigate whether other types of social judgments are also shaped by comparative information within the first 200 milliseconds after stimulus exposure on the neural level, we conducted a second ERP experiment examining trustworthiness comparisons.

Experiment 2

The second experiment was designed to explore the neural time course of trustworthiness comparisons. As outlined above, trustworthiness has been shown to be one of the crucial person characteristics by which people differentiate each other (Fiske, Cuddy & Glick, 2006) and deciding whether an unfamiliar person is trustworthy is one of the most important decisions in social environments (Engell, Haxby & Todorov, 2007) with far-ranging effects on social perception (Posten & Mussweiler, 2013) and cognition (Mayer & Mussweiler, 2011). As in Study 1, we used a distance effect paradigm consisting of low and high distance pairs of faces, this time varying either in trustworthiness or size. Participants were randomly assigned to commencing the task either with trustworthiness or size comparisons. On the basis of the first experiment, we predicted a behavioral distance effect for trustworthiness and size comparisons to be reflected in amplitudes of the ERPs of interest.

Method

Design and Participants. We determined the sample size based on the critical effect sizes obtained in Study 1. Effect sizes regarding the distance effect observed for the VPP and the anterior N2 were $\eta_p^2 = .19$ and $\eta_p^2 = .28$, respectively. Based on an a priori power analysis using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) including the effect size of $\eta_p^2 = .19$ and requiring 95% power and Type-I-error probability of 5%, we aimed for a minimum sample size of 18. As EEG data are sometimes strongly affected by different artifacts (see below) and some data sets have to be excluded, we recruited 30 right-handed participants distinct from the sample of the first study (mean age: 25.09, age range: 20 – 34 years, 18 female) through our participant data base at the University of Cologne. Six participants were removed from all final analyses as described below. None of them reported current or past neurological or psychiatric illness. As in Study 1, all participants were compensated with €8 per hour for their participation and had normal or corrected-to-normal vision. The study was approved by the ethics committee of the German Psychological Association (DGPS) and was carried out with informed written consent of the participants. Participants were randomly assigned to commencing the task either with the trustworthiness or the size condition.

Stimuli. Images used in the second experiment originated from the face database of the Social Perception Lab at Princeton University. This database provides, amongst others, 25 Caucasian male faces varying in trustworthiness that were created by Oosterhof and Todorov

(2008) using the Facegen Modeller program (FaceGen 3.1; http://facegen.com). Each of these faces is provided in seven different increments of trustworthiness that range from “0” (“very untrustworthy”) to “6” (“very trustworthy”). The dimensional model of face evaluation underlying the creation of these faces is based on behavioral studies and on computer modeling of how faces differ on social dimensions (Oosterhof & Todorov, 2008). Consistent with Experiment 1, we created pairs of varying distance with regard to either trustworthiness or size.

Trustworthiness Condition. In the high distance trustworthiness condition, we combined highly untrustworthy faces (“0”) with highly trustworthy faces (“6”). For low distance trials, we combined rather untrustworthy faces (“2”) with rather trustworthy faces (“4”). Thus, mean trustworthiness levels were constant for high and low distance trials. In total, we created 100 pairs, 50 of them being of high and 50 of them being of low distance. As in Study 1, we calculated mean scores concerning luminance, color and local frequency for each pair of images. Our analysis revealed no significant differences between the high and low distance trustworthiness condition in any of these low level visual properties, *t*s(98) < 0.38, *p*s > .708, *d*s < .08.

Size Condition. We resized the trustworthiness faces according to the following scheme: Faces whose vertical visual angles were of 5.92° and of 6.15° respectively composed the low distance condition. Faces whose vertical visual angles were of 5.81° and of 6.26° composed the high distance condition. Thus, the mean size of the images was identical in both conditions. In sum, we created 100 pairs of varying size, half of them being of high and half of them being of low distance. With regard to low level visual properties as potential confounds, we calculated mean scores concerning luminance, color and local frequency for each pair of images. Our analysis revealed no significant differences between the high and low distance size condition in any of these properties, *t*s(98) < 0.52, *p*s > .604, *d*s < .11.

The final task consisted of 200 stimulus pairs with 50 pairs presented in each experimental block. The center-to-center distance between two targets presented subtended a horizontal visual angle of 4.52°. As in Study 1, we presented participants with all four levels of trustworthiness within the size condition and with all four sizes within the trustworthiness condition. By way of reminder: When two images were presented in the trustworthiness condition, then the visual angle of both images was either of 5.92 $^{\circ}$, 6.15°, 5.81° or 6.26°. When two images were presented in the size condition, then faces presented were either both of high, moderate or low trustworthiness. Each image occurred three times per condition whereupon the same combination of images was nonrecurring. We pseudo-randomized the order of high and low distance trials as well as the order of stimulus position (left vs. right) to prevent identical faces from following immediately after one another.

Experimental Task. On a single trial, participants had to indicate as accurately and quickly as possible which of two simultaneously presented faces they regarded as more trustworthy (in the trustworthiness comparison condition) or which of the images as bigger (in the size comparison condition). They did so by pressing a key corresponding to the side of the image they chose. Participants were randomly assigned to commencing the task either with the size or the trustworthiness comparison condition and completed two blocks of trustworthiness and two of size comparisons, each consisting of 50 trials. We pseudo-randomized the occurrence of high and low distance trials as well as the respective stimulus position (left vs. right) to ensure that identical faces would not follow immediately after one another within one block. All stimuli were presented on a black background. We implemented the task using E-Prime (Psychology Software Tools, Pittsburgh, PA) for stimulus presentation and recording of participants’ reaction times and responses.

Procedure. We matched the procedures of the first and the second experiment one-to-one (for a schematic depiction of the trustworthiness comparison task, see Figure 5). If participants regarded the face on the left as more trustworthy / the image as bigger, they pressed the “1”-key with their left index finger on the number-line of the keypad (ACER©). Participants pressed the “9”-key with their right index finger on the number-line of the keypad, if they regarded the face on the right as more trustworthy / the image as bigger. Electrophysiological recording and statistical analysis of the data were identical to the first experiment.

Results and Discussion

Behavioral Data. Figure 6 shows reaction times and accuracy data for both types of comparisons. Altogether, 4 % of the trials were excluded from the analysis because participants did not respond within the given interval of 1500 milliseconds.

Reaction Times. A Two-Way repeated-measures ANOVA with regard to participant’s reaction times revealed a main effect of distance, F (1, 23) = 92.57, p = .001; η_p^2 = .80, and a main effect of comparison type, F (1, 23) = 129.26, p = .001; η_p^2 = .85. The main effect of distance reflects that, overall, it took participants longer to respond on low (M = 810 ms, SE = 22) compared to high distance trials (M = 742 ms, SE = 19). The main effect of comparison type indicates that participants required more time to perform trustworthiness (M = 926 ms, SE = 29) than size comparisons (M = 627 ms, SE = 18). Individual contrasts concerning the trustworthiness and size condition revealed that the distance effect was significant for both types of comparison, ts(23) > 5.26, ps < .001, ds > 2.19.We did not observe a significant interaction effect (p > .10). (For an additional speed-accuracy tradeoff analysis, see Supplementary Material.)

Consistency with previous evaluation. Analysis of the percentage of correct responses—determined on the basis of trustworthiness evaluations in an independent sample (Oosterhof & Todorov, 2008)—revealed a significant main effect of distance, F(1, 23) = 95.42, p < . 001; η_p^2 = .81, such that, overall, participants responded less accurately on low (M = 78 %, SE = .02) relative to high distance trials (M = 91 %, SE = .02). In addition, our analysis yielded a main effect of comparison type, F(1, 23) = 61.16, p < .001; η_p^2 = .73, as response accuracy was lower in the trustworthiness (*M* = 75 %, *SE* = .03) than in the size comparison condition (*M* = 93 %, *SE* = .01). Besides, we observed a Distance x Comparison Type interaction, $F(1, 23) = 15.32$, $p < .001$; $\eta_p^2 = .40$. However, post-hoc pairwise comparisons revealed that the DE was significant for both types of comparison, *t*s(23) < 7.69, *p*s < .001, *d*s = 3.21.

ERP Data. Approximately 14% of all EEG segments had to be removed from the analysis, either because of artifacts or because participants did not respond within the given interval of 1500 milliseconds. As mentioned above, six participants had to be excluded due to a larger number movement artifacts (e.g., eye blinks) and technical artifacts (e.g., defect electrodes) in EEG recording, and consequently not meeting our cut-off criterion of 20 trials per condition to be included in the analysis (for further details, see Supplementary Material). This led to a final sample of 24 participants (average age: 25.25; 13 female).

P1, N170 and the Vertex Positive Potential. As in Experiment 1, we began our analysis by examining the face-sensitive components P1, N170, and the VPP. We used the same time windows and electrode sites for analysis as in Study 1, which was corroborated by visual inspection of the data and the respective CSD maps (see Figure 7). With regard to the P1 and N170, we calculated three-way repeated measures ANOVA including the within-subject factors comparison type, distance, and hemisphere. With regard to the VPP, we calculated a two-way repeated measures ANOVA including the within-subject factors comparison type and distance.

P1. Concerning the P1, we found a significant main effect of distance, $F(1, 23) = 4.76$, $p = .040$; $\eta_p^2 = .17$, reflecting that, overall, low distance trials led to larger amplitudes ($M = 0.077$ µV/cm^2, $SE = 0.007$) than high distance trials ($M = 0.069$ µV/cm^2, $SE = 0.007$). Individual contrasts revealed that the distance effect was significant for size comparisons above the right hemisphere (cluster: P8, PO8, P6), $t(23) = 2.76$, $p = .011$, $d = 1.15$, but did not reach significance for trustworthiness comparisons, neither above the right (cluster: P8, PO8, P6) nor above the left hemisphere (cluster: P7, PO7, P5), *t*s(23) < 1.41, *p*s > .171, *d*s < 0.59.

N170 and VPP. Our analysis of the N170 and the VPP yielded no significant main or interaction effects with regard to main amplitudes and peak latencies (*p*s > .10).

N1 and N2. We performed our analysis of the N1 and N2 as described in Study 1, as the CSD maps and visual inspection of the data suggested that these two ERPs occurred in the same time windows and were present at the same electrode sites. Again, we calculated two-way repeated measures ANOVA including the within-subject factors comparison type and distance. Figure 8 exemplarily presents average-locked CSD-ERP waveforms at POz.

N1. Our analysis of N1 mean amplitudes yielded a significant main effect of comparison type, $F(1, 23) = 4.55$, $p = .044$; $\eta_p^2 = .17$, reflecting that amplitudes were significantly larger in response to trustworthiness ($M = 0.068$ µV/cm^2, $SE = 0.008$) than to size comparisons ($M = 0.060$ µV/cm^2, $SE = 0.005$). Furthermore, low distance trials elicited larger amplitudes ($M = 0.067$ µV/cm^2, $SE = 0.006$) than high distance trials ($M = 0.061$ µV/cm^2, $SE = 0.006$), $F(1, 23) = 7.30$, $p = .013$; $\eta_p^2 = .24$. Individual comparisons within the social and non-social condition respectively revealed that the distance effect was significant for trustworthiness, $t(23) = 2.31$, $p = .030$, $d = 0.96$, and tended to be significant for size comparisons, $t(23) = 2.00$, $p = .058$, $d = 0.83$. We observed no differences in latencies at this stage and our analysis yielded no interaction effect (*p*s > .10).

Anterior N2. Our analysis of the anterior N2 yielded no significant main or interaction effects, neither with regard to mean amplitudes nor latencies (*p*s > .10).

Posterior N2. Our analysis of the posterior N2 revealed a significant main effect of comparison type, $F(1, 23) = 4.70$, $p = .041$; $\eta_p^2 = .17$, reflecting that mean amplitudes were larger in the trustworthiness condition ($M = 0.010$ µV/cm^2, $SE = 0.011$) compared to the size condition ($M = 0.084$ µV/cm^2, $SE = 0.007$). Moreover, we observed a significant main effect of distance, $F(1, 23) = 5.93$, $p = .023$; $\eta_p^2 = .21$, with larger amplitudes elicited by low ($M =$

0.095 μV/cm^2, *SE* = 0.009) relative to high distance trials (*M* = 0.088 μV/cm^2, *SE* = 0.008). Individual contrasts revealed that distance tended to modulate amplitudes in response to both trustworthiness, $t(23) = 1.94$, $p = .065$, $d = 0.81$, and size comparisons, $t(23) = 1.85$, $p = .077$, $d = 0.77$. We observed no interaction effects and no differences in latencies at this stage (*p*s > .10). (For a correlation analysis between participants' reaction times and mean ERP waveforms as well as for an additional exploratory analysis of the N2 at temporal electrode sites, see Supplementary Material.)

Conclusion

Study 2 reveals that comparative information about the trustworthiness of two faces already affects the N1 measured at parieto-central electrode sites. In addition, size comparisons modulated the P1 at occipito-parietal electrode sites. Moreover, distance tended to modulate a posterior N2 at centro-parietal electrode sites for both types of comparison. The data also suggest that social comparisons were performed more slowly and at higher neural costs than non-social comparisons as indicated by longer RTs and larger N1 and N2 amplitudes elicited by trustworthiness relative to size comparisons. However, we did not observe any differences in ERP latencies between trustworthiness and size comparisons at these stages of stimulus processing. Taken together, the results of Study 2 confirm our initial hypothesis that comparative information affects trustworthiness comparison processing within the first 200 milliseconds after stimulus exposure.

General Discussion

The current data indicate that in a paradigm which explicitly instructs participants to make comparative judgments, differences in attractiveness and trustworthiness of two simultaneously presented faces affect early neural processes (N1, N170, N2) within the first 200 milliseconds after stimulus onset. Previous research suggests that processing individually presented faces is typically accomplished within 200 milliseconds on the neural level (Rossion, 2014), including, for instance, the processing of a face's identity, emotional expression, or gaze direction (for reviews, see Eimer & Holmes, 2007; Watanabe, Miki, & Kakigi, 2005). Remarkably, the current studies indicate that the human brain is not only capable of processing social information derived from a single face but from two simultaneously presented faces already within this early time window. Moreover, the rapidity of comparative social information processing observed in the current studies is in support of previous research that has found prioritized and fast processing in humans of animate agents—particularly faces—relative to inanimate objects (New, Cosmides, & Tooby, 2007; Ro, Russel, & Lavie, 2001). While we found social comparative judgments to take effect already within the first 200 milliseconds after stimulus onset, instructing participants to engage in same-different judgments of simultaneously presented simple objects is reflected in neural activity from 190 to 280 milliseconds (Zhang et al., 2013). This is particularly remarkable given the complexity and multifaceted nature of social stimuli and thus the wealth of information that needs to be integrated (Cantor & Mischel, 1979; Dahlgren, 1985; Tversky, 1977). Moreover, the fact that comparisons take place at stages of information processing that are associated with early perception mechanisms may explain the pervasiveness of comparative processes.

In the following, we will discuss our findings in more detail. While, in fact, the ERPs of interest were affected by our experimental manipulation, we did not observe the same pattern in both studies. On that note, it is important to emphasize that a one-to-one comparison between the two studies is not possible as we did not use a full-factorial design. Instead, our main aim was to investigate on a general level whether two different types of social comparative judgments affect the stream of information processing within the post-stimulus time window of 200 milliseconds. Therefore, we will take a closer look at the individual findings and their potential significance within each study without interpreting any differences between them.

Theoretical Implications

In Study 1, we found that attractiveness comparisons modulate the VPP at FCz. The VPP and its correspondent component, the N170, reflect the same underlying face processing mechanism (Eimer, 2011; Itier &Taylor, 2002; Jemel et al., 2003; Joyce & Rossion, 2005) and are associated with holistic face processing, the coding of individual face representations, and the processing of facial expressions (Hinojosaa, Mercadoc, & Carretié, 2015; Itier & Parkington, 2015; Rossion & Jacques, 2011). Moreover, the VPP was of particular interest for the current research as previous studies have shown that variations in attractiveness of *individually* presented faces modulate this component and its occipito-temporal correspondence, the N170 (e.g., Marzi & Viggiano, 2010; Pizzagalli, Lehmann, Hendrick, Regard, Pascual-Marqui, & Davidson, 2002; Trujillo, Jankowitsch, & Langlois, 2014). Our results of Study 1 extend these findings by demonstrating that the VPP is also modulated by comparative information about the attractiveness of two simultaneously presented faces.

Following the face-sensitive VPP, the distance effect for attractiveness comparisons carried over to an anterior N2. The anterior N2 is, inter alia, sensitive to the detection of mismatch (for a review, see Folstein & Van Petten, 2008), a process that requires the determination of matching (i.e., similar) and non-matching (i.e., dissimilar) features (e.g., Duncan & Humphreys, 1989; Pomplun et al., 2001). With specific regard to face perception, our finding is in accordance with previous work by Wu and colleagues (2012) who observed that the anterior N2 is modulated by mismatch in a face identification task. Beyond mismatch the anterior N2 is also associated with response conflict (Gehring, Gratton, Coles, & Donchin, 1992; Zhang, Wang, Li, & Wang, 2003) and cognitive control (Azizian, Freitas, Parvaz, & Squires, 2006). The stronger the response conflict and the more a task demands cognitive control, the higher the amplitude of the anterior N2. As attractiveness comparisons tended to elicit higher anterior N2 amplitudes than size comparisons, this may suggest that the former led to more response conflict and demanded more cognitive control than the latter.

In Study 2, we found trustworthiness comparisons to significantly modulate the N1. Research has shown that the N1 reflects early attention allocation towards a relevant stimulus as well as early discrimination processes (Hillyard, Vogel, & Luck, 1998; Luck, Heinze, Mangun, & Hillyard, 1990; Vogel & Luck, 2000). This suggests that general information about facial trustworthiness (main effect of condition) and also relative information about two faces' trustworthiness (main effect of distance) bias early attention allocation that prepares efficient stimulus classification. One could speculate that such an early assessment is caused by the fact that understanding other persons' intend as early as possible is highly adaptive from an evolutionary point of view as it enables the rapid identification of potential friends and foes (Willis & Todorov, 2006). Overall, our finding concerning the N1 extends previous research investigating the speed of facial trustworthiness processing. For example, a recent study by Freeman, Stoiler, Ingbretsen, and Hehman (2014) shows that the human brain responds to the trustworthiness of a face before the respective face is even consciously perceived. As we regularly encounter more than one person in our environment, our data indicate that the comparison of two or more individuals concerning their potentially harmful intentions is achieved remarkably early on the neural level.

In Study 2, trustworthiness comparisons also tended to modulate a posterior N2. The posterior N2 is associated with the degree of attention required for stimulus processing, as demonstrated by studies using visual search paradigms in which several objects are presented simultaneously (Conci, Gramann, Müller, & Elliott, 2006; Hopf et al., 2000; Woodman & Luck, 1999). Woodman and Luck (1999) suggested that the posterior N2 reflects rapid attentional shifts among objects during visual search. Indeed, it is conceivable that more difficult comparisons (low distance and trustworthiness) require more attention to various details, as these are harder to disentangle, than simpler comparisons (high distance and size). From this perspective, the experimental modulation of the posterior N2 may be the result of faster attentional shifts on low compared to high distance and trustworthiness compared to size comparison trials. However, as these findings were only marginally significant, we do not intend to overinterpret them.

Finally, within each study, we observed differences in reaction times on the behavioral level between the attractiveness and size as well as trustworthiness and size comparisons. This effect may be accounted for by two—potentially combined—factors: complexity and arousal. It has been shown that the more complex the task, the longer it takes participants to respond (Loring-Meier & Halpern, 1999; Snodgrass, 1972). Attractiveness and trustworthiness judgments are by essence more complex than size judgments as many more features are brought into the equation (like, for instance, the symmetry of the face and the size of the eyes, nose, and chin to evaluate a female facial attractiveness and the distance between the eyebrows and shape of the mouth to evaluate facial trustworthiness, see Baudouin & Tiberghien, 2004; Cunningham, 1986; Oosterhof & Todorov, 2008). Interestingly, increased complexity of a stimulus has been associated with an increase of exploratory behavior (Mark, 1998) and may have gone hand in hand with increased levels of arousal in the current studies (Berlyne, 1974; Tuch, Bargas-Avila, Opwis, & Wilhelm, 2009). Thus, a potential combination of complexity, arousal and an increase in exploratory behavior in the attractiveness and trustworthiness condition may have caused the observed differences in reaction times between the social and the nonsocial comparison conditions.

Limitations and Future Research

Altogether, the results of the two studies confirm our hypothesis that comparison has an early impact on social information processing. However, as emphasized above, a one-to-one comparison of the two studies was not our primary goal and is also not permitted by the studies’ design. Therefore, the current studies naturally come along with limitations and ideas for future research. First of all, future studies may elucidate which parameters led to the observed differences between the two studies. For instance, why did attractiveness comparisons elicit a VPP while trustworthiness comparisons did not? Differences in the materials used (artificial vs. natural faces) and differences with regard to facial expressions in the two studies (varying expressions in Study 1 vs. neutral expression in Study 2) may account for the observed variations. Moreover, the current studies leave room for the investigation of potential moderators, such as participants' empathy or anxiety, as such factors have been shown to have an impact on affective judgments of faces (e.g., Fox, Russo, & Georgiou, 2005; Li, Zinbarg, Boehm, & Paller, 2008; Willis, Lawson, Ridley, Koval, & Rendell, 2015). Especially with regard to trustworthiness judgments, participants' anxiousness or empathy may have an accelerating or slowing effect on the neural processing of comparative information.

Another limitation of the current studies follows from the nature of our stimuli. Albeit facial attractiveness and trustworthiness are of crucial importance for social interactions (e.g., Kampe, Frith, Dolan, & Frith, 2001; Reis et al., 1982; van t'Wout & Sanfey, 2008), they are not exhaustive when it comes to judgments made from faces. While the evaluation of these two dimensions relies heavily on physical features and their configuration (e.g., Baudouin & Tiberghien, 2004; Cunningham, 1986; Oosterhof & Todorov, 2008), it would be highly interesting to investigate the neural time course of other social attributions, such as intelligence, extraversion, openness, and competence, to name only a few. Such mental state based evaluations are equally made from faces and have an important impact on social encounters. Thus, even though research suggests that these social dimensions are processed as readily as trustworthiness and attractiveness (Sutherland et al., 2015; Todorov, Olivola, Dotsch & Mende-Siedlecki, 2015), future studies will have to reveal whether the rapidity of social comparative processing also applies in these cases. Moreover, in this context, we know from the fMRI literature that different types of comparison engage different neural networks. For instance, intelligence comparisons have been found to activate medial frontal, orbitofrontal and limbic areas as well as the temporoparietal junction (Lindner, Hundhammer, Ciaramidaro, Linden, & Mussweiler, 2008) while attractiveness and social status comparisons were shown to engage a fronto-parietal network (Chiao et al., 2009; Kedia et al., 2014). Investigating whether different types of comparisons that rely on different neural networks nevertheless share the same neural time course would be an interesting avenue for future research.

In addition, the current data do not allow inferences about the automaticity of attractiveness and trustworthiness comparisons as we explicitly instructed our participants to engage in comparison. Therefore, it remains an open question whether individuals *automatically* compare the attractiveness and trustworthiness of others, even when attentional resources are sparse. Interestingly, previous literature suggests a disparate picture. On the one hand, EEG research from social neuroscience shows that judgments of attractiveness concerning individually presented faces are rapid but not mandatory and that at least some attentional resources are required to effectively assess a face's attractiveness (Jung, Ruthruff, Tybur, Gaspelin & Miller, 2012; Schacht, Werheid & Sommer, 2008). Trustworthiness, by contrast, appears to be automatically processed regardless of the attentional load (Ochsner, 2004; Engell et al., 2007). Thus, future studies may investigate the automaticity of comparative attractiveness or trustworthiness judgments, for instance by introducing a second task that takes up attentional resources and measuring participants' judgment accuracy.

Finally, our ERP data leave open the question whether early information accumulation about the size, attractiveness or trustworthiness of two faces is realized in a comparative manner, or whether sufficient information is accumulated already on the neural level before comparative processing takes place. Pursuing this thought further would imply, for instance, that the impact of distance on the anterior N2 in Study 1 may either reflect the comparative process itself or the brain response to a comparison, i.e. the response to high and low conflict trials (Folstein & Van Petten, 2008). Future research may shed additional light on this question.

Conclusions

The current studies provide first insights into the rapidity of comparison in social information processing. They suggest that the human brain is able to compare two social targets with regard to their attractiveness and trustworthiness as fast—or even faster—as it is able to compare numerical magnitudes. In two studies, we observed neural signatures of comparison within the first 200 milliseconds after stimulus onset. While social target comparisons were performed at higher neural costs than nonsocial comparisons—as indicated by higher amplitudes on social comparison trials—they nevertheless affected early stages of information processing that set the stage for the processing stream that follows. Thus, even though higher complexity of social stimuli seems to be given (Cantor & Mischel, 1979; Dahlgren, 1985; Tversky, 1977), the current data indicate that this complexity does not impede fast comparative processing. In the light of Alfred Nobel's statement, the human brain may be able to quickly engage in comparative processing for good reasons as the search and observation of similarities and differences constitutes a crucial cornerstone in the acquisition of human knowledge. Altogether, the current research underlines that, as would be expected of a cognitive mechanism as basic as comparison, it is carried out early on in information processing.

References

Amodio, D. M., Bartholow, B. D., & Ito, T. A. (2013). Tracking the dynamics of the social brain: ERP approaches for. *Social Cognitive and Affective Neuroscience*, nst177. http://doi.org/10.1093/scan/nst177

Azizian, A., Freitas, A. L., Parvaz, M. A., & Squires, N. K. (2006). Beware misleading cues: perceptual similarity modulates the N2/P3 complex. *Psychophysiology*, *43*(3), 253–260. http://doi.org/10.1111/j.1469-8986.2006.00409.x

Barenboim, C. (1981). The development of person perception in childhood and adolescence: From behavioral comparisons to psychological constructs to psychological comparisons. *Child Development*, *52*(1), 129–144. http://doi.org/10.2307/1129222

Bateson, M., & Healy, S. D. (2005). Comparative evaluation and its implications for mate choice. *Trends in Ecology & Evolution*, *20*(12), 659–664. http://doi.org/10.1016/j.tree.2005.08.013

Baudouin, J.-Y., & Tiberghien, G. (2004). Symmetry, averageness, and feature size in the facial attractiveness of women. *Acta Psychologica*, *117*(3), 313–332. http://doi.org/10.1016/j.actpsy.2004.07.002

Boksem, M. A. S., Kostermans, E., & De Cremer, D. (2011). Failing where others have succeeded: Medial Frontal Negativity tracks failure in a social context. *Psychophysiology*, *48*(7), 973–979. http://doi.org/10.1111/j.1469-8986.2010.01163.x

Campanella, S., Hanoteau, C., Dépy, D., Rossion, B., Bruyer, R., Crommelinck, M., & Guérit, J. M. (2000). Right N170 modulation in a face discrimination task: An account for categorical perception of familiar faces. *Psychophysiology*, *37*(6), 796–806. http://doi.org/10.1111/1469-8986.3760796

Cantor, N., & Mischel, W. (1979). Prototypicality and personality: Effects on free recall and personality impressions. *Journal of Research in Personality*, *13*(2), 187–205. http://doi.org/10.1016/0092-6566(79)90030-8

Chiao, J. Y., Harada, T., Oby, E. R., Li, Z., Parrish, T., & Bridge, D. J. (2009). Neural representations of social status hierarchy in human inferior parietal cortex. *Neuropsychologia*, *47*(2), 354–363. http://doi.org/10.1016/j.neuropsychologia.2008.09.023

Clark, V. P., & Hillyard, S. A. (1996). Spatial selective attention affects early extrastriate but not striate components of the visual evoked potential. *Journal of Cognitive Neuroscience*, *8*(5), 387–402. http://doi.org/10.1162/jocn.1996.8.5.387

Cogan, E., Parker, S., & Zellner, D. A. (2013). Beauty beyond compare: Effects of context extremity and categorization on hedonic contrast. *Journal of Experimental Psychology: Human Perception and Performance*, *39*(1), 16–22. http://doi.org/10.1037/a0031020

Coles, M. G. H. (1989). Modern mind-brain reading: psychophysiology, physiology, and cognition. *Psychophysiology*, *26*(3), 251–269. http://doi.org/10.1111/j.1469-8986.1989.tb01916.x

Collins, E. C., Crandall, C. S., & Biernat, M. (2006). Stereotypes and implicit social comparison: Shifts in comparison-group focus. *Journal of Experimental Social Psychology*, *42*(4), 452–459. http://doi.org/10.1016/j.jesp.2005.06.006

Conci, M., Gramann, K., Müller, H. J., & Elliott, M. A. (2006). Electrophysiological correlates of similarity-based interference during detection of visual forms. *Journal of Cognitive Neuroscience*, *18*(6), 880–888. http://doi.org/10.1162/jocn.2006.18.6.880

Corcoran, K. (2013). The efficiency of similarity-focused comparisons in person perception. *The Journal of Social Psychology*, *153*(2), 127–130. http://doi.org/10.1080/00224545.2012.725111

Corcoran, K., Hundhammer, T., & Mussweiler, T. (2009). A tool for thought! When comparative thinking reduces stereotyping effects. *Journal of Experimental Social Psychology, 45*(4), 1008–1011. http://dx.doi.org/10.1016/j.jesp.2009.04.015

Corcoran, K., & Mussweiler, T. (2009). Comparative Thinking Styles in Group and Person Perception: One Mechanism – Many Effects. *Social and Personality Psychology Compass*, *3*(3), 244–259. http://doi.org/10.1111/j.1751-9004.2009.00173.x

Cunningham, M. R. (1986). Measuring the physical in physical attractiveness: Quasi-experiments on the sociobiology of female facial beauty. *Journal of Personality and Social Psychology, 50*(5), 925–935. http://doi.org/10.1037/0022-3514.50.5.925

Dahlgren, K. (1985). The cognitive structure of social categories. *Cognitive Science*, *9*(3), 379–398. http://doi.org/10.1207/s15516709cog0903_4

DeBruine, L. M. (2002). Facial resemblance enhances trust. *Proceedings of the Royal Society B: Biological Sciences*, *269*(1498), 1307–1312. http://doi.org/10.1098/rspb.2002.2034

DeBruine, L. M. (2005). Trustworthy but not lust-worthy: context-specific effects of facial resemblance. *Proceedings of the Royal Society B: Biological Sciences*, *272*(1566), 919–922. http://doi.org/10.1098/rspb.2004.3003

DeBruine, L. M., Jones, B. C., Little, A. C., & Perrett, D. I. (2007). Social perception of facial resemblance in humans. *Archives of Sexual Behavior, 37*(1), 64–77. http://doi.org/10.1007/s10508-007-9266-0

Dehaene, S. (1996). The organization of brain activations in number comparison: event-related potentials and the additive-factors method. *Journal of Cognitive Neuroscience*, *8*(1), 47–68. http://doi.org/10.1162/jocn.1996.8.1.47

Dehaene, S., Piazza, M., Pinel, P., & Cohen, L. (2003). Three parietal circuits for number processing. *Cognitive Neuropsychology*, *20*(3), 487–506. http://doi.org/10.1080/02643290244000239

Dering, B., Martin, C. D., Moro, S., Pegna, A. J., & Thierry, G. (2011). Face-sensitive processes one hundred milliseconds after picture onset. *Frontiers in Human Neuroscience, 5*, 93. http://doi.org/10.3389/fnhum.2011.00093

Douglas T. Kenrick, R. C. K. (1992). Age preferences in mates reflect sex differences in mating strategies. *Behavioral and Brain Sciences*, *15*(1), 75–133. http://doi.org/10.1017/S0140525X00067595

Duncan, J., & Humphreys, G. W. (1989). Visual search and stimulus similarity. *Psychological Review, 96*(3), 433–458. http://doi.org/10.1037/0033-295X.96.3.433

Dzhelyova, M., Perrett, D. I., & Jentzsch, I. (2012). Temporal dynamics of trustworthiness perception. *Brain Research*, *1435*, 81–90. http://doi.org/10.1016/j.brainres.2011.11.043

Eimer, M. (2011). The face-sensitivity of the N170 component. *Frontiers in Human Neuroscience, 5*. http://doi.org/10.3389/fnhum.2011.00119

Eimer, M., & Holmes, A. (2007). Event-related brain potential correlates of emotional face processing. *Neuropsychologia*, *45*(1), 15–31. http://doi.org/10.1016/j.neuropsychologia.2006.04.022

Engell, A. D., Haxby, J. V., & Todorov, A. (2007). Implicit trustworthiness decisions: automatic coding of face properties in the human amygdala. *Journal of Cognitive Neuroscience, 19*(9), 1508–1519. http://doi.org/10.1162/jocn.2007.19.9.1508

Epstude, K., & Mussweiler, T. (2009). What you feel is how you compare: how comparisons influence the social induction of affect. *Emotion (Washington, D.C.), 9*(1), 1–14. http://doi.org/10.1037/a0014148

Farah, M. J., Péronnet, F., Gonon, M. A., & Giard, M. H. (1988). Electrophysiological evidence for a shared representational medium for visual images and visual percepts. *Journal of Experimental Psychology. General*, *117*(3), 248–257.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. http://doi.org/10.3758/BF03193146

Festinger, L. (1954). A theory of social comparison processes. *Human Relations*, *7*(2), 117–140. http://doi.org/10.1177/001872675400700202

Folstein, J. R., & Van Petten, C. (2008). Influence of cognitive control and mismatch on the N2 component of the ERP: a review. *Psychophysiology*, *45*(1), 152–170. http://doi.org/10.1111/j.1469-8986.2007.00602.x

Fox, E., Russo, R., & Georgiou, G. A. (2005). Anxiety modulates the degree of attentive resources required to process emotional faces. *Cognitive, Affective, & Behavioral Neuroscience*, *5*(4), 396–404. http://doi.org/10.3758/CABN.5.4.396

Freeman, J. B., Stolier, R. M., Ingbretsen, Z. A., & Hehman, E. A. (2014). Amygdala responsivity to high-level social information from unseen faces. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, *34*(32), 10573–10581. http://doi.org/10.1523/JNEUROSCI.5063-13.2014

Ganis, G., & Schendan, H. E. (2008). Visual mental imagery and perception produce opposite adaptation effects on early brain potentials. *NeuroImage*, *42*(4), 1714–1727. http://doi.org/10.1016/j.neuroimage.2008.07.004

Gehring, W. J., Gratton, G., Coles, M. G., & Donchin, E. (1992). Probability effects on stimulus evaluation and response processes. *Journal of Experimental Psychology. Human Perception and Performance*, *18*(1), 198–216.

Geiselman, R. E., Haight, N. A., & Kimata, L. G. (1984). Context effects on the perceived physical attractiveness of faces. *Journal of Experimental Social Psychology*, *20*(5), 409–424. http://doi.org/10.1016/0022-1031(84)90035-0

Giacometti, P., Perdue, K. L., & Diamond, S. G. (2014). Algorithm to find high density EEG scalp coordinates and analysis of their correspondence to structural and functional regions of the brain. *Journal of Neuroscience Methods*, *229*, 84–96. http://doi.org/10.1016/j.jneumeth.2014.04.020

Gilbert, D. T., Giesler, R. B., & Morris, K. A. (1995). When comparisons arise. *Journal of Personality and Social Psychology*, *69*(2), 227–236. http://dx.doi.org/10.1037/0022-3514.69.2.227

Goldstone, R. L. (1994). The role of similarity in categorization: providing a groundwork. *Cognition*, *52*(2), 125–157. http://doi.org/10.1016/0010-0277(94)90065-5

Goldstone, R. L., & Medin, D. L. (1994). Time course of comparison. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*(1), 29–50. http://doi.org/10.1037/0278-7393.20.1.29

Grandjean, D., & Peters, C. (2011). Novelty Processing and Emotion: Conceptual Developments, Empirical Findings and Virtual Environments. In R. Cowie, C. Pelachaud, & P. Petta (Eds.), *Emotion-Oriented Systems* (pp. 441–458). Berlin: Springer.

Gratton, G., Coles, M. G., & Donchin, E. (1983). A new method for off-line removal of ocular artifact. *Electroencephalography and Clinical Neurophysiology*, *55*(4), 468–484. http://doi.org/10.1016/0013-4694(83)90135-9

Hahn, U., & Chater, N. (1998). Similarity and rules: distinct? exhaustive? empirically distinguishable? *Cognition*, *65*(2–3), 197–230. http://doi.org/10.1016/S0010-0277(97)00044-9

Hillyard, S. A., Vogel, E. K., & Luck, S. J. (1998). Sensory gain control (amplification) as a mechanism of selective attention: electrophysiological and neuroimaging evidence. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *353*(1373), 1257–1270.

Hinojosa, J. A., Mercado, F., & Carretié, L. (2015). N170 sensitivity to facial expression: A meta-analysis. *Neuroscience & Biobehavioral Reviews*, *55*, 498–509. http://doi.org/10.1016/j.neubiorev.2015.06.002

Hopf, J. M., Luck, S. J., Girelli, M., Hagner, T., Mangun, G. R., Scheich, H., & Heinze, H. J. (2000). Neural sources of focused attention in visual search. *Cerebral Cortex*, *10*(12), 1233–1241.

Hsu, Y.-F., & Szűcs, D. (2012). The time course of symbolic number adaptation: Oscillatory EEG activity and event-related potential analysis. *NeuroImage*, *59*(4), 3103–3109. http://doi.org/10.1016/j.neuroimage.2011.11.017

Itier, R. J., & Taylor, M. J. (2002). Inversion and contrast polarity reversal affect both encoding and recognition processes of unfamiliar faces: A repetition study using ERPs. *Neuroimage*, *15*. http://doi.org/10.1006/nimg.2001.0982

Itier, R. J., & Taylor, M. J. (2004). N170 or N1? Spatiotemporal Differences between Object and Face Processing Using ERPs. *Cerebral Cortex*, *14*(2), 132–142. http://doi.org/10.1093/cercor/bhg111

Itier, R., & Parkington, K. (2015). From eye to face: support for neural inhibition in holistic processing. *Journal of Vision*, *15*(12), 679. http://doi.org/10.1167/15.12.679

Ito, T. A., & Urland, G. R. (2003). Race and gender on the brain: electrocortical measures of attention to the race and gender of multiply categorizable individuals. *Journal of Personality and Social Psychology*, *85*(4), 616–626. http://doi.org/10.1037/0022-3514.85.4.616

Ito, T. A., & Urland, G. R. (2005). The influence of processing objectives on the perception of faces: an ERP study of race and gender perception. *Cognitive, Affective & Behavioral Neuroscience*, *5*(1), 21–36. http://doi.org/10.3758/CABN.5.1.21

Jacques, C., & Rossion, B. (2006). The speed of individual face categorization. *Psychological Science*, *17*(6), 485–492. http://doi.org/10.1111/j.1467-9280.2006.01733.x

Jemel, B., Schuller, A.-M., Cheref-Khan, Y., Goffaux, V., Crommelinck, M., & Bruyer, R. (2003). Stepwise emergence of the face-sensitive N170 event-related potential component. *Neuroreport*, *14*(16), 2035–2039. http://doi.org/10.1097/01.wnr.0000092465.31470.2f

Joyce, C., & Rossion, B. (2005). The face-sensitive N170 and VPP components manifest the same brain processes: The effect of reference electrode site. *Clinical Neurophysiology*, *116*(11), 2613–2631. http://doi.org/10.1016/j.clinph.2005.07.005

Jung, K., Ruthruff, E., Tybur, J. M., Gaspelin, N., & Miller, G. (2012). Perception of facial attractiveness requires some attentional resources: implications for the "automaticity" of psychological adaptations. *Evolution and Human Behavior*, *33*(3), 241–250. http://doi.org/10.1016/j.evolhumbehav.2011.10.001

Kahneman, D., & Miller, D. T. (1986). Norm theory: Comparing reality to its alternatives. *Psychological Review*, *93*(2), 136–153. http://doi.org/10.1037/0033-295X.93.2.136

Kamarajan, C., Pandey, A. K., Chorlian, D. B., & Porjesz, B. (2015). The use of current source density as electrophysiological correlates in neuropsychiatric disorders: A review of human studies. *International Journal of Psychophysiology*, *97*(3), 310–322. http://doi.org/10.1016/j.ijpsycho.2014.10.013

Kampe, K. K. W., Frith, C. D., Dolan, R. J., & Frith, U. (2001). Psychology: Reward value of attractiveness and gaze. *Nature*, *413*(6856), 589–589. http://doi.org/10.1038/35098149

Katznelson, R. (1981). EEG recording, electrode placement, and aspects of generator localization. In *Electric fields of the brain*. Oxford: Nunez, PL.

Kayser, J., & Tenke, C. E. (2006). Principal components analysis of Laplacian waveforms as a generic method for identifying ERP generator patterns: I. Evaluation with auditory oddball tasks. *Clinical Neurophysiology: Official Journal of the International Federation of Clinical Neurophysiology*, *117*(2), 348–368. http://doi.org/10.1016/j.clinph.2005.08.034

Kayser, J., Tenke, C. E., Gates, N. A., Kroppmann, C. J., Gil, R. B., & Bruder, G. E. (2006). ERP/CSD indices of impaired verbal working memory subprocesses in schizophrenia. *Psychophysiology*, *43*(3), 237–252. http://doi.org/10.1111/j.1469-8986.2006.00398.x

Kedia, G., Mussweiler, T., Mullins, P., & Linden, D. E. J. (2014). The neural correlates of beauty comparison. *Social Cognitive and Affective Neuroscience*, *9*(5), 681–688. http://doi.org/10.1093/scan/nst026

Kenrick, D. T., & Gutierres, S. E. (1980). Contrast effects and judgments of physical attractiveness: When beauty becomes a social problem. *Journal of Personality and Social Psychology*, *38*(1), 131–140. http://doi.org/10.1037/0022-3514.38.1.131

Kenrick, D. T., & Keefe, R. C. (1992). Age preferences in mates reflect sex differences in human reproductive strategies. *Behavioral and Brain Sciences*, *15*(1), 75–91. http://doi.org/10.1017/S0140525X00067595

Kernis, M. H., & Wheeler, L. (1981). Beautiful friends and ugly strangers: radiation and contrast effects in perceptions of same-sex pairs. *Personality and Social Psychology Bulletin*, *7*(4), 617–620. http://doi.org/10.1177/014616728174017

Langlois, J. H., Kalakanis, L., Rubenstein, A. J., Larson, A., Hallam, M., & Smoot, M. (2000). Maxims or myths of beauty? A meta-analytic and theoretical review. *Psychological Bulletin*, *126*(3), 390–423.

Levine, G. M., Halberstadt, J. B., & Goldstone, R. L. (1996). Reasoning and the weighting of attributes in attitude judgments. *Journal of Personality and Social Psychology, 70*(2), 230–240. http://doi.org/10.1037/0022-3514.70.2.230

Li, W., Zinbarg, R. E., Boehm, S. G., & Paller, K. A. (2007). Neural and behavioral evidence for affective priming from unconsciously perceived emotional facial expressions and the influence of trait anxiety. *Journal of Cognitive Neuroscience*, *20*(1), 95–107. http://doi.org/10.1162/jocn.2008.20006

Lindner, M., Hundhammer, T., Ciaramidaro, A., Linden, D. E. J., & Mussweiler, T. (2008). The neural substrates of person comparison—An fMRI study. *NeuroImage*, *40*(2), 963–971. http://doi.org/10.1016/j.neuroimage.2007.12.022

Loring-Meier, S., & Halpern, D. F. (1999). Sex differences in visuospatial working memory: components of cognitive processing. *Psychonomic Bulletin & Review*, *6*(3), 464–471. http://doi.org/10.3758/BF03210836

Luck, S. J. (2005). *An Introduction to the Event-related Potential Technique*. MIT Press.

Luck, S. J., Heinze, H. J., Mangun, G. R., & Hillyard, S. A. (1990). Visual event-related potentials index focused attention within bilateral stimulus arrays. II. Functional dissociation of P1 and N1 components. *Electroencephalography and Clinical Neurophysiology*, *75*(6), 528–542. http://doi.org/10.1016/0013-4694(90)90138-A

Manis, M., Biernat, M., & Nelson, T. F. (1991). Comparison and expectancy processes in human judgment. *Journal of Personality and Social Psychology*, *61*(2), 203–211.

Mark, L. S. (1998). The exploration of complexity and the complexity of exploration. Hoffman, R. R., Sherrick, M. F. & Warm, J. S. (Eds.), *Viewing psychology as a whole: The integrative science of William N. Dember* (pp. 191–204). Washington, DC: American Psychological Association.

Marzi, T., Righi, S., Ottonello, S., Cincotta, M., & Viggiano, M. P. (2014). Trust at first sight: evidence from ERPs. *Social Cognitive and Affective Neuroscience*, *9*(1), 63–72. http://doi.org/10.1093/scan/nss102

Marzi, T., & Viggiano, M. P. (2010). When memory meets beauty: Insights from event-related potentials. *Biological Psychology*, *84*(2), 192–205. http://doi.org/10.1016/j.biopsycho.2010.01.013

Mayer, J., & Mussweiler, T. (2011). Suspicious spirits, flexible minds: When distrust enhances creativity. *Journal of Personality and Social Psychology*, *101*(6), 1262–1277. http://doi.org/10.1037/a0024407

Medin, D. L., Goldstone, R. L., & Markman, A. B. (1995). Comparison and choice: Relations between similarity processes and decision processes. *Psychonomic Bulletin & Review*, *2*(1), 1–19. http://doi.org/10.3758/BF03214410

Medin, D., & Schaffer, M. (1978). Context theory of classification learning. *Psychological Review*, *85*(3), 207–238. http://dx.doi.org/10.1037/0033-295X.85.3.207

Moyer, R. S., & Landauer, T. K. (1967). Time required for judgements of numerical inenequality. *Nature*, *215*(5109), 1519–1520. http://doi.org/10.1038/2151519a0

Mussweiler, T. (2003). Comparison processes in social judgment: Mechanisms and consequences. *Psychological Review*, 472–489.

Mussweiler, T., & Damisch, L. (2008). Going back to Donald: how comparisons shape judgmental priming effects. *Journal of Personality and Social Psychology*, *95*(6), 1295–1315. http://doi.org/10.1037/a0013261

Mussweiler, T., & Epstude, K. (2009). Relatively fast! Efficiency advantages of comparative thinking. *Journal of Experimental Psychology: General*, *138*(1), 1–21. http://doi.org/10.1037/a0014374

Mussweiler, T., & Rüter, K. (2003). What friends are for! The use of routine standards in social comparison. *Journal of Personality and Social Psychology*, *85*(3), 467–481. http://doi.org/10.1037/0022-3514.85.3.467

New, J., Cosmides, L., & Tooby, J. (2007). Category-specific attention for animals reflects ancestral priorities, not expertise. *Proceedings of the National Academy of Sciences*, *104*(42), 16598–16603. http://doi.org/10.1073/pnas.0703913104

Newman, L. S., & Uleman, J. S. (1990). Assimilation and contrast effects in spontaneous trait inference. *Personality and Social Psychology Bulletin*, *16*(2), 224–240. http://doi.org/10.1177/0146167290162004

Ochsner, K. N. (2004). Current directions in social cognitive neuroscience. *Current Opinion in Neurobiology*, *14*(2), 254–258. http://doi.org/10.1016/j.conb.2004.03.011

Olson, I. R., & Marshuetz, C. (2005). Facial attractiveness is appraised in a glance. *Emotion*, *5*(4), 498–502. http://doi.org/10.1037/1528-3542.5.4.498

Oosterhof, N. N., & Todorov, A. (2008). The functional basis of face evaluation. *Proceedings of the National Academy of Sciences*, *105*(32), 11087–11092. http://doi.org/10.1073/pnas.0805664105

Perrin, F., Pernier, J., Bertrand, O., & Echallier, J. F. (1989). Spherical splines for scalp potential and current density mapping. *Electroencephalography and Clinical Neurophysiology*, *72*(2), 184–187. http://doi.org/10.1016/0013-4694(89)90180-6

Pinel, P., Dehaene, S., Rivière, D., & LeBihan, D. (2001). Modulation of parietal activation by semantic distance in a number comparison task. *NeuroImage*, *14*(5), 1013–1026. http://doi.org/10.1006/nimg.2001.0913

Pizzagalli, D. A., Lehmann, D., Hendrick, A. M., Regard, M., Pascual-Marqui, R. D., & Davidson, R. J. (2002). Affective judgments of faces modulate early activity (∼160 ms) within the fusiform gyri. *NeuroImage*, *16*(3, Part A), 663–677. http://doi.org/10.1006/nimg.2002.1126

Pomplun, M., Sichelschmidt, L., Wagner, K., Clermont, T., Rickheit, G., & Ritter, H. (2001). Comparative visual search: a difference that makes a difference. *Cognitive Science*, *25*(1), 3–36. http://doi.org/10.1207/s15516709cog2501_2

Posner, M. I. (2005). Timing the brain: Mental chronometry as a tool in neuroscience. *PLoS Biology*, *3*(2). http://doi.org/10.1371/journal.pbio.0030051

Posten, A.-C., & Mussweiler, T. (2013). When distrust frees your mind: The stereotype-reducing effects of distrust. *Journal of Personality and Social Psychology*, *105*(4), 567–584. http://doi.org/10.1037/a0033170

Qiu, J., Yu, C., Li, H., Jou, J., Tu, S., Wang, T., … Zhang, Q. (2010). The impact of social comparison on the neural substrates of reward processing: An event-related potential study. *NeuroImage*, *49*(1), 956–962. http://doi.org/10.1016/j.neuroimage.2009.08.025

Reis, H. T., Wheeler, L., Spiegel, N., Kernis, M. H., Nezlek, J., & Perri, M. (1982). Physical attractiveness in social interaction: II. Why does appearance affect social experience? *Journal of Personality and Social Psychology*, *43*(5), 979–996. http://doi.org/10.1037/0022-3514.43.5.979

Reynvoet, B., & Brysbaert, M. (1999). Single-digit and two-digit Arabic numerals address the same semantic number line. *Cognition*, *72*(2), 191–201. http://doi.org/10.1016/S0010-0277(99)00048-7

Righart, R., & de Gelder, B. (2007). Impaired face and body perception in developmental prosopagnosia. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(43), 17234–17238. http://doi.org/10.1073/pnas.0707753104

Ro, T., Russell, C., & Lavie, N. (2001). Changing faces: A detection advantage in the flicker paradigm. *Psychological Science*, *12*(1), 94–99. http://doi.org/10.1111/1467-9280.00317

Rodway, P., Schepman, A., & Lambert, J. (2013). The influence of position and context on facial attractiveness. *Acta Psychologica*, *144*(3), 522–529. http://doi.org/10.1016/j.actpsy.2013.09.004

Rossion, B. (2014). Understanding face perception by means of human electrophysiology. *Trends in Cognitive Sciences*, *18*(6), 310–318. http://doi.org/10.1016/j.tics.2014.02.013

Rossion, B., & Caharel, S. (2011). ERP evidence for the speed of face categorization in the human brain: Disentangling the contribution of low-level visual cues from face perception. *Vision Research*, *51*(12), 1297–1311. http://doi.org/10.1016/j.visres.2011.04.003

Ruys, K. I., Spears, R., Gordijn, E. H., & de Vries, N. K. (2006). Two faces of (dis)similarity in affective judgments of persons: Contrast or assimilation effects revealed by morphs. *Journal of Personality and Social Psychology*, *90*(3), 399–411. http://doi.org/10.1037/0022-3514.90.3.399

Schacht, A., Werheid, K., & Sommer, W. (2008). The appraisal of facial beauty is rapid but not mandatory. *Cognitive, Affective and Behavioral Neuroscience, 8*(2), 132. http://doi.org/10.3758/CABN.8.2.132

Schomaker, J., & Meeter, M. (2014). Novelty detection is enhanced when attention is otherwise engaged: an event-related potential study. *Experimental Brain Research*, *232*(3), 995–1011. http://doi.org/10.1007/s00221-013-3811-y

Schwarz, W., & Heinze, H. (1998). On the interaction of numerical and size information in digit comparison: a behavioral and event-related potential study. *Neuropsychologia*, *36*(11), 1167–1179. http://doi.org/10.1016/S0028-3932(98)00001-3

Shepperd, J. A., & Taylor, K. M. (1999). Ascribing advantages to social comparison targets. *Basic and Applied Social Psychology*, *21*(2), 103–117. http://doi.org/10.1207/S15324834BA210203

Sloutsky, V. M. (2003). The role of similarity in the development of categorization. *Trends in Cognitive Sciences*, *7*(6), 246–251. http://doi.org/10.1016/S1364-6613(03)00109-8

Snodgrass, J. G. (1972). Matching patterns vs matching digits: The effect of memory dependence and complexity on “same”-“different” reaction times. *Perception & Psychophysics, 11*(5), 341–349. http://doi.org/10.3758/BF03206264

Sutherland, C. A. M., Rowley, L. E., Amoaku, U. T., Daguzan, E., Kidd-Rossiter, K. A., Maceviciute, U., & Young, A. W. (2015). Personality judgments from everyday images of faces. *Frontiers in Psychology, 6*, 1616. http://doi.org/10.3389/fpsyg.2015.01616

Szũcs, D., & Csépe, V. (2005). The effect of numerical distance and stimulus probability on ERP components elicited by numerical incongruencies in mental addition. *Brain Research. Cognitive Brain Research*, *22*(2), 289–300. http://doi.org/10.1016/j.cogbrainres.2004.04.010

Szũcs, D., Soltész, F., Jármi, E., & Csépe, V. (2007). The speed of magnitude processing and executive functions in controlled and automatic number comparison in children: an electro-encephalography study. *Behavioral and Brain Functions: BBF*, *3*, 23. http://doi.org/10.1186/1744-9081-3-23

Tanaka, J., Luu, P., Weisbrod, M., & Kiefer, M. (1999). Tracking the time course of object categorization using event-related potentials. *Neuroreport*, *10*(4), 829–835.

Tarbi, E. C., Sun, X., Holcomb, P. J., & Daffner, K. R. (2011). Surprise? Early visual novelty processing is not modulated by attention. *Psychophysiology*, *48*(5), 624–632. http://doi.org/10.1111/j.1469-8986.2010.01129.x

Temple, E., & Posner, M. I. (1998). Brain mechanisms of quantity are similar in 5-year-old children and adults. *Proceedings of the National Academy of Sciences of the United States of America*, *95*(13), 7836–7841.

Tenke, C. E., & Kayser, J. (2005). Reference-free quantification of EEG spectra: combining current source density (CSD) and frequency principal components analysis (fPCA). *Clinical Neurophysiology: Official Journal of the International Federation of Clinical Neurophysiology*, *116*(12), 2826–2846. http://doi.org/10.1016/j.clinph.2005.08.007

Tenke, C. E., & Kayser, J. (2012). Generator localization by current source density (CSD): Implications of volume conduction and field closure at intracranial and scalp resolutions. *Clinical Neurophysiology*, *123*(12), 2328–2345. http://doi.org/10.1016/j.clinph.2012.06.005

Todorov, A., Loehr, V., & Oosterhof, N. N. (2010). The obligatory nature of holistic processing of faces in social judgments. *Perception*, *39*(4), 514–532. http://doi.org/10.1068/p6501

Todorov, A., Olivola, C. Y., Dotsch, R., & Mende-Siedlecki, P. (2015). Social attributions from faces: determinants, consequences, accuracy, and functional significance. *Annual Review of Psychology*, *66*, 519–545. http://doi.org/10.1146/annurev-psych-113011-143831

Todorov, A., Said, C. P., Engell, A. D., & Oosterhof, N. N. (2008). Understanding evaluation of faces on social dimensions. *Trends in Cognitive Sciences*, *12*(12), 455–460. http://doi.org/10.1016/j.tics.2008.10.001

Trope, Y. (1986). Identification and inferential processes in dispositional attribution. *Psychological Review*, *93*(3), 239–257. http://doi.org/10.1037/0033-295X.93.3.239

Trujillo, L. T., Jankowitsch, J. M., & Langlois, J. H. (2014). Beauty is in the ease of the beholding: a neurophysiological test of the averageness theory of facial attractiveness. *Cognitive, Affective & Behavioral Neuroscience*, *14*(3), 1061–1076. http://doi.org/10.3758/s13415-013-0230-2

Tuch, A. N., Bargas-Avila, J. A., Opwis, K., & Wilhelm, F. H. (2009). Visual complexity of websites: Effects on users' experience, physiology, performance, and memory. *International Journal of Human-Computer Studies*, *67*(9), 703–715. http://doi.org/10.1016/j.ijhcs.2009.04.002

Tversky, A. (1977). Features of similarity. *Psychological Review*, *84*(4), 327–352. http://doi.org/10.1037/0033-295X.84.4.327

van Hooff, J. C., Crawford, H., & van Vugt, M. (2011). The wandering mind of men: ERP evidence for gender differences in attention bias towards attractive opposite sex faces. *Social Cognitive and Affective Neuroscience*, *6*(4), 477–485. http://doi.org/10.1093/scan/nsq066

van 't Wout, M., & Sanfey, A. G. (2008). Friend or foe: The effect of implicit trustworthiness judgments in social decision-making. *Cognition*, *108*(3), 796–803. http://doi.org/10.1016/j.cognition.2008.07.002

Vogel, E. K., & Luck, S. J. (2000). The visual N1 component as an index of a discrimination process. *Psychophysiology*, *37*(2), 190–203.

Watanabe, S., Miki, K., & Kakigi, R. (2005). Mechanisms of face perception in humans: a magneto- and electro-encephalographic study. *Neuropathology: Official Journal of the Japanese Society of Neuropathology*, *25*(1), 8–20.

Wedell, D. H., Parducci, A., & Geiselman, R. E. (1987). A formal analysis of ratings of physical attractiveness: Successive contrast and simultaneous assimilation. *Journal of Experimental Social Psychology*, *23*(3), 230–249. http://doi.org/10.1016/0022-1031(87)90034-5

Willis, J., & Todorov, A. (2006). First impressions: making up your mind after a 100-ms exposure to a face. *Psychological Science*, *17*(7), 592–598. http://doi.org/10.1111/j.1467-9280.2006.01750.x

Willis, M. L., Lawson, D. L., Ridley, N. J., Koval, P., & Rendell, P. G. (2015). The contribution of emotional empathy to approachability judgments assigned to emotional faces is context specific. *Frontiers in Psychology*, *6*, 1209. http://doi.org/10.3389/fpsyg.2015.01209

Wong, T. K. W., Fung, P. C. W., McAlonan, G. M., & Chua, S. E. (2009). Spatiotemporal dipole source localization of face processing ERPs in adolescents: a preliminary study. *Behavioral and Brain Functions*, *5*(1), 1–12. http://doi.org/10.1186/1744-9081-5-16

Woodman, G. F. (2010). A brief introduction to the use of event-related potentials (ERPs) in studies of perception and attention. *Attention, perception & psychophysics*, *72*(8). http://doi.org/10.3758/APP.72.8.2031

Woodman, G. F., & Luck, S. J. (1999). Electrophysiological measurement of rapid shifts of attention during visual search. *Nature*, *400*(6747), 867–869. http://doi.org/10.1038/23698

Wu, J., Duan, H., Tian, X., Wang, P., & Zhang, K. (2012). The effects of visual imagery on face identification: an ERP study. *Frontiers in Human Neuroscience*, *6*, 305. http://doi.org/10.3389/fnhum.2012.00305

Wu, Y., Zhang, D., Elieson, B., & Zhou, X. (2012). Brain potentials in outcome evaluation: when social comparison takes effect. *International Journal of Psychophysiology: Official Journal of the International Organization of Psychophysiology*, *85*(2), 145–152. http://doi.org/10.1016/j.ijpsycho.2012.06.004

Wykowska, A., Wiese, E., Prosser, A., & Müller, H. J. (2014). Beliefs about the minds of others influence how we process sensory information. *PLoS ONE*, *9*(4), e94339. http://doi.org/10.1371/journal.pone.0094339

Zhang, D., Liu, Y., Wang, X., Chen, Y., & Luo, Y. (2014). The duration of disgusted and fearful faces is judged longer and shorter than that of neutral faces: the attention-related time distortions as revealed by behavioral and electrophysiological measurements. *Frontiers in Behavioral Neuroscience*, *8*, 293. http://doi.org/10.3389/fnbeh.2014.00293

Zhang, X., Wang, Y., Li, S., & Wang, L. (2003). Event-related potential N270, a negative component to identification of conflicting information following memory retrieval. *Clinical Neurophysiology: Official Journal of the International Federation of Clinical Neurophysiology*, *114*(12), 2461–2468. http://dx.doi.org/10.1016/S1388-2457(03)00251-7

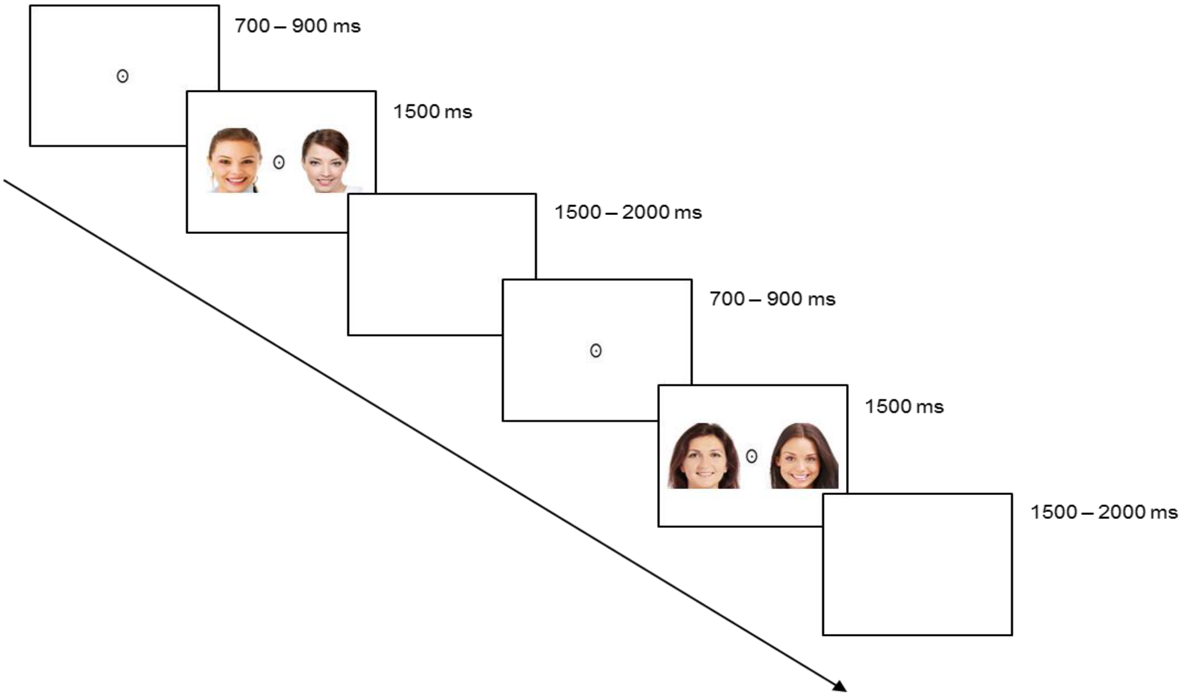

Figure 1. Schematic depiction of the attractiveness comparison task presenting a low (top) and high (bottom) distance trial.

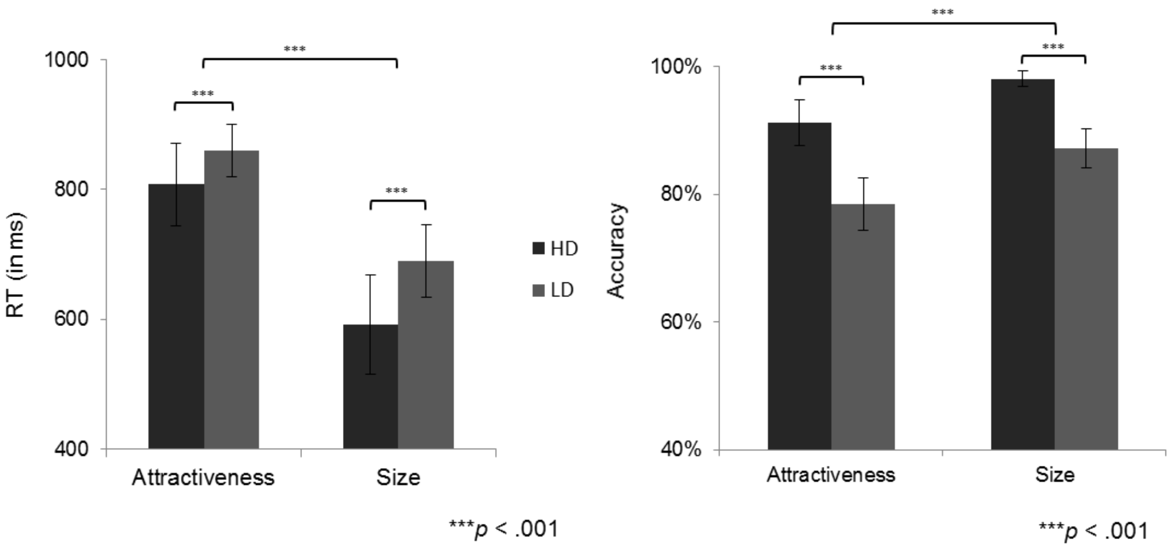

Figure 2. Reaction times and accuracy, i.e., consistency with previous evaluation in an independent sample, regarding low (LD) and high distance (HD) trials in the attractiveness comparison study. Error bars represent 95% confidence intervals of means.

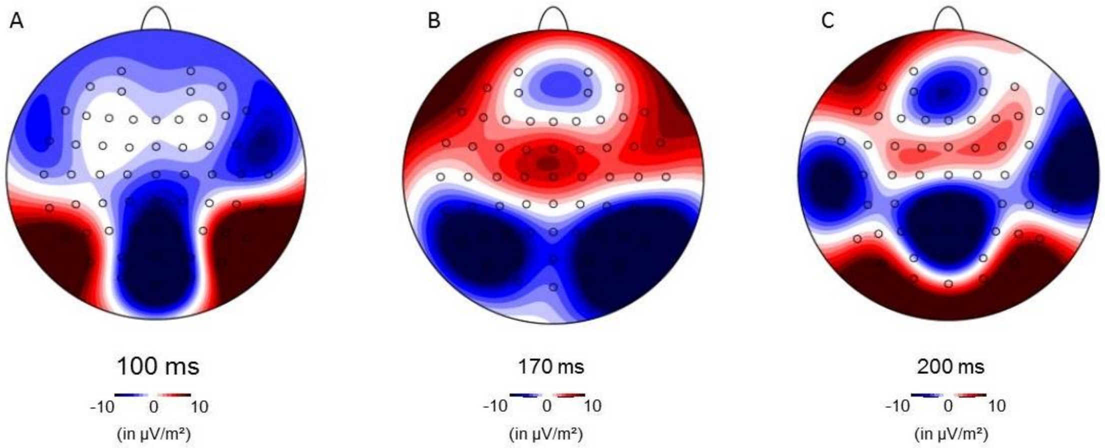

Figure 3. Topographic maps of mean CSD-transformed ERPs at (A) 100 milliseconds, (B) 170 milliseconds, and (C) 200 milliseconds after stimulus onset in the attractiveness comparison study.

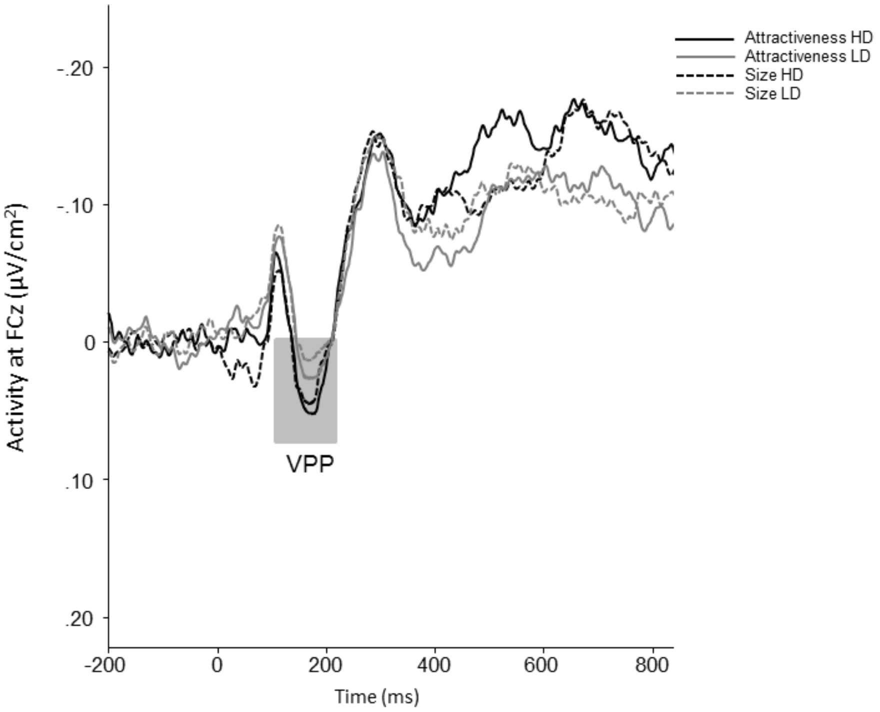

Figure 4. Grand-average CSD-ERP waveforms at electrode site FCz for high (HD) and low distance (LD) attractiveness and size comparisons. Negative values are plotted upwards and time point zero represents the onset of face presentation.

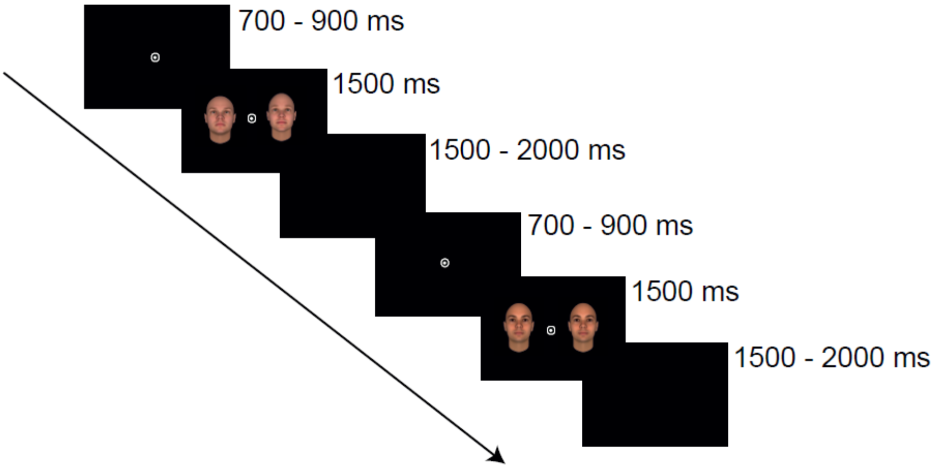

Figure 5. Schematic depiction of the trustworthiness comparison task showing a high (top) and low (bottom) distance trial.

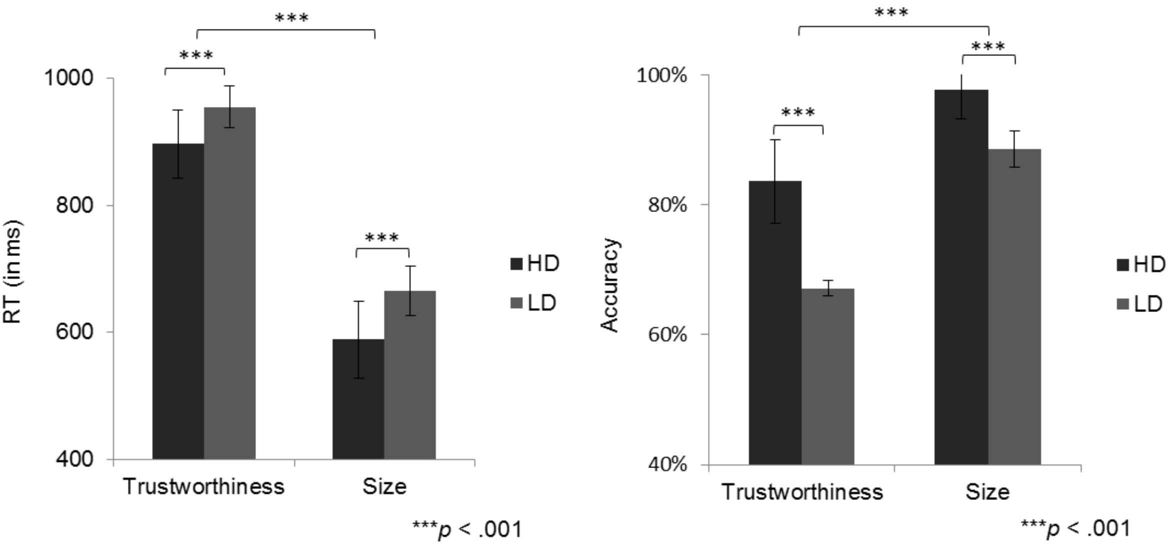

Figure 6. Reaction times and accuracy—determined on the basis of trustworthiness evaluations in an independent sample (Oosterhof & Todorov, 2008)—regarding low (LD) and high distance (HD) trials in the trustworthiness comparison study. Error bars represent 95% confidence intervals of means.

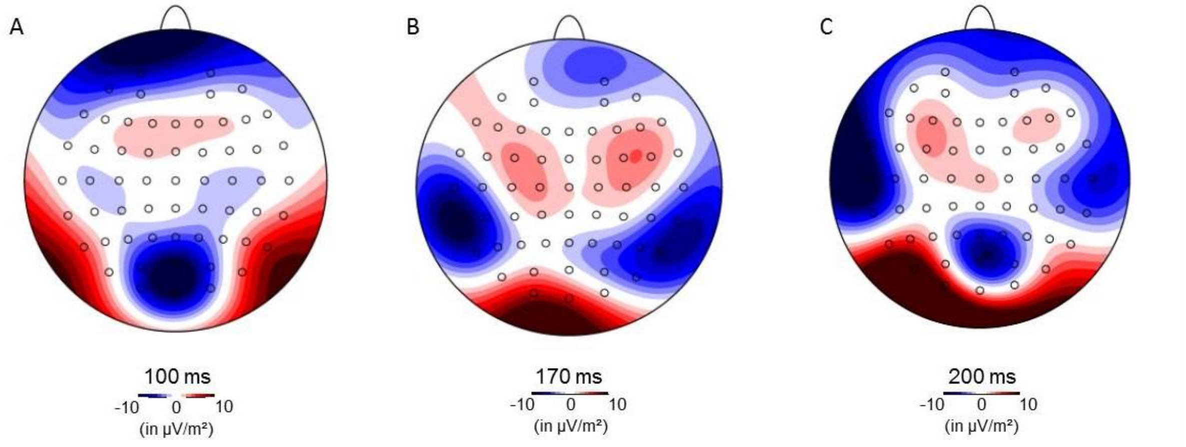

Figure 7. Topographic maps of mean CSD-transformed ERPs at (A) 100 milliseconds, (B) 170 milliseconds, and (C) 200 milliseconds after stimulus onset in the trustworthiness comparison study.

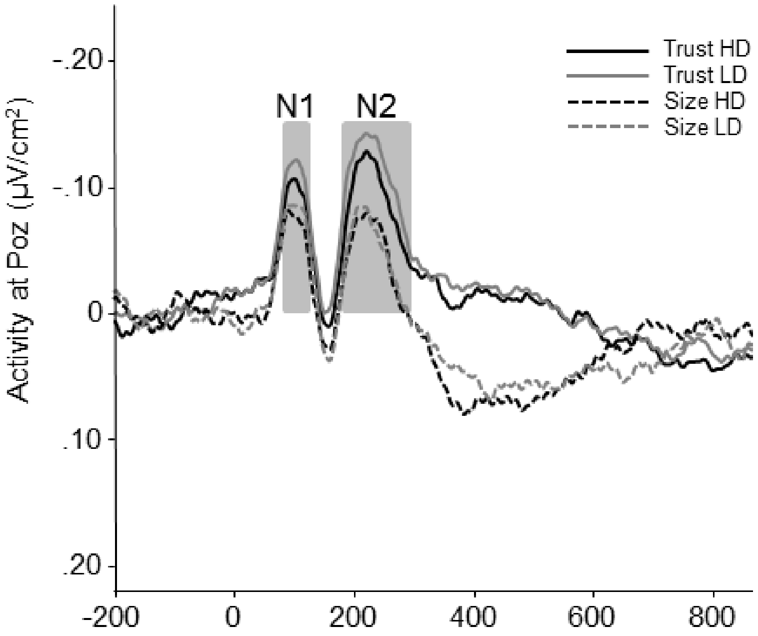

Figure 8. Grand-average CSD-ERP waveforms at electrode site POz for high (HD) and low distance (LD) trustworthiness and size comparisons. Negative values are plotted upwards and time point zero represents the onset of face presentation.