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The presence of a culturally similar or dissimilar social partner affects neural responses to emotional stimuli

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Background: Emotional responding is sensitive to social context; however, little emphasis has been placed on the mechanisms by which social context effects changes in emotional responding.

Objective: We aimed to investigate the effects of social context on neural responses to emotional stimuli to inform on the mechanisms underpinning context-linked changes in emotional responding.

Design: We measured event-related potential (ERP) components known to index specific emotion processes and self-reports of explicit emotion regulation strategies and emotional arousal. Female Chinese university students observed positive, negative, and neutral photographs, whilst alone or accompanied by a culturally similar (Chinese) or dissimilar researcher (British).

Results: There was a reduction in the positive versus neutral differential N1 amplitude (indexing attentional capture by positive stimuli) in the dissimilar relative to alone context. In this context, there was also a corresponding increase in amplitude of a frontal late positive potential (LPP) component (indexing engagement of cognitive control resources). In the similar relative to alone context, these effects on differential N1 and frontal LPP amplitudes were less pronounced, but there was an additional decrease in the amplitude of a parietal LPP component (indexing motivational relevance) in response to positive stimuli. In response to negative stimuli, the differential N1 component was increased in the similar relative to dissimilar and alone (trend) context.

Conclusion: These data suggest that neural processes engaged in response to emotional stimuli are modulated by social context. Possible mechanisms for the social-context-linked changes in attentional capture by emotional stimuli include a context-directed modulation of the focus of attention, or an altered interpretation of the emotional stimuli based on additional information proportioned by the context.

Keywords: *event-related potential*; *emotion*; *emotion regulation*; *interpersonal context*; *social context*

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The sociality of human emotions plays an important role in many contemporary theories of emotion. Some accounts view emotions as arising fundamentally from the way in which an individual interacts with their environment (Campos, Walle, Dahl, & Main, 2011; Gross & Barrett, 2011). Others emphasise environmental context as a factor implicit to the emotion generation process (Barrett, Mesquita, Ochsner, & Gross, 2007). Even theories that view emotions as unique mental states arising from dedicated mechanisms still recognise an important role for the dynamic interaction between an individual and their environment in the development and subsistence of complex emotional states (Izard, 2009).

Empirical investigations of the effects of social context on emotional experience and expression

Much of the extant experimental work that has manipulated social context to investigate its influence on people's emotional responding has focused on the interplay between subjective emotional experience and (mostly facial) emotional expressive behaviour (for a relevant review, see Parkinson, 2005). Contrasting theoretical positions have been advocated (Ekman, Sorenson, & Friesen, 1969; Fridlund, 1991) in terms of the relative contributions of emotional experience and sociality to facial expressions. However, it is clear from the data that social context can affect both emotional experience and expression.

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More specifically, the presence of a friend consistently increases the expression and experience of happiness to positive stimuli (Bruder, Dosmukhambetova, Nerb, & Manstead, 2012; Fridlund, 1991; Fridlund, Kenworthy, & Jaffey, 1992; Gehricke & Fridlund, 2002; Gehricke & Shapiro, 2000, 2001; Hess, Banse, & Kappas, 1995; Jakobs, Manstead, & Fischer, 1999; Yamamoto & Suzuki, 2006; though for negative findings in males, see Gehricke & Fridlund, 2002), which also increases as more potential for social exchange is systematically incorporated (e.g. friend engaged in different versus the same task; Fridlund, 1991; Hess et al., 1995; Jakobs et al., 1999). This social facilitation of happiness expression is linked to specific display rules (defining culturally appropriate emotional expression) and social motives (why certain display rules are adhered to) reported by participants (Jakobs et al., 1999; Jakobs, Manstead, & Fischer, 2001; Zaalberg, Manstead, & Fischer, 2004). However, although some studies have demonstrated corresponding social facilitation of sadness expression and experience (Fridlund et al., 1992; Gehricke & Fridlund, 2002; Gehricke & Shapiro, 2000, 2001; Yamamoto & Suzuki, 2006), the expression of sadness can also be decreased in the presence of a friend (Buck, Losow, Murphy, & Costanzo, 1992; Gehricke & Shapiro, 2000; Jakobs et al., 2001).

Whilst there have been some reports of corresponding social facilitation of happiness expression by strangers (Bruder et al., 2012; Chapman & Wright, 1976; Yamamoto & Suzuki, 2006), this effect is smaller than that by friends (Bruder et al., 2012; Yamamoto & Suzuki, 2006). Other studies have demonstrated reduced emotional expression, in the presence of a stranger (Buck et al., 1992; Jakobs et al., 2001; Lee & Wagner, 2002; Matsumoto & Kupperbusch, 2001). The presence of strangers has also been linked to the expression of emotions conflicting with those experienced (Lee & Wagner, 2002; Matsumoto & Kupperbusch, 2001).

Thus, there is clear evidence for differences in emotional responding that are dependent on social context and for an important role for the closeness of affiliation to an interaction partner. Display rules and social motives are widely assumed to play a role in these differences (e.g. see Gehricke & Fridlund, 2002), and in line with this, display rules condone increased expression of emotions in more closely affiliated interpersonal contexts (Diefendorff, Morehart, & Gabriel, 2010; Matsumoto et al., 2008). However, social motives have been more strongly associated with the social facilitation of happiness expression than social inhibitory effects (Jakobs et al., 1999, 2001). Although associations between these motivational constructs and emotional responding may inform on why emotional responding is influenced by social context, they cannot inform on *how* contextual differences in emotional responding are accomplished. In the present study we aimed to investigate the mechanisms by which individuals' emotional responding changes across social context. Although it has been suggested that one factor contributing to the impact of closeness of affiliation to a social partner on emotional responding is the perceived level of the partner's responsibility in one's own welfare (Clark & Finkel, 2005), there has been little empirical investigation of such factors. A second aim of the present study was to empirically investigate one such factor.

ERPs as an index for processes involved in emotional responding

Event-related potentials (ERPs) have been widely used to study neural activity in response to emotionally arousing photographic stimuli. These data, of relatively high temporal precision, have allowed the isolation of specific processes, which have the potential to inform on the mechanisms involved in changes in emotional responding across social contexts. Presenting participants with photographic stimuli has demonstrated that ERP components as early as 100 ms post stimulus onset and peaking before 300 ms can show increased amplitude to emotional relative to neutral stimuli. The difference in ERP amplitude to emotional versus neutral stimuli is assumed to reflect initial attentional capture by emotional stimuli (Foti, Hajcak, & Dien, 2009; Kovalenko, Pavlenko, & Chernyi, 2010). Nicely demonstrating the critical importance of attentional processes for determining this ERP amplitude difference, it has been demonstrated that whilst under conditions of instructed local attentional focus, appetitive stimuli are associated with an increased N1 amplitude compared to neutral stimuli, instructing participants to broaden their attentional focus reduces this N1 amplitude difference (Gable & Harmon-Jones, 2011).

Although it has been suggested that the amplitude of early ERP components may be determined more by the physical characteristics of stimuli than their emotional content (Bradley, Hamby, Low, & Lang, 2007), it has been demonstrated that both the physical characteristics and emotional content of stimuli make separable contributions to the allocation of attentional resources, that can be distinguished at a neural level (Brosch, Pourtois, Sander, & Vuilleumier, 2011). In line with this, N1 amplitude is sensitive to contextual factors that alter the subjective experience of emotion in response to a stimulus, in the absence of any change to its physical properties (Foti & Hajcak, 2008). In this experiment, participants were presented with auditory contextual information about negatively arousing photographs before their onset, which could either be neutral or negative. Participants' subjective experience of emotion (rating of negative arousal) was greater when photographs were preceded by negative contextual information, and this also led to increased N1 amplitude.

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Further, indicating a link between early emotional versus neutral differential ERP amplitudes and individual experience with emotion and specific strategies for emotional change, participants who report greater every day difficulties in expressing their emotions (alexythymia) show reduced amplitude differences in early (particularly N2 & P2) ERP components to negative versus neutral photographs, under specific instructions not to express their emotions (Walker, O'Conner, & Schaefer, 2011). Alexythymia has been associated with increased hiding of emotional expressions at trait level (Swart, Kortekaas, & Aleman, 2009), so the authors suggest that the participants reporting greater alexythymia were more efficient at not expressing their emotions. These data therefore suggest that it is possible for conscious strategies that are commonly engaged in by individuals to change their emotional responding across contexts, to affect early ERP responses to emotional stimuli. This view has been supported by an additional study in which it was further suggested that the effect of conscious strategies for emotional change on early ERP components is linked to the degree of automaticity of such processes (Gallo, Keil, McCulloch, Rockstroh, & Gollwitzer, 2009). In this study, differential P2 amplitude in response to negatively arousing versus neutral stimuli was decreased when participants were provided with specific instructions about how to reduce their negative emotional experience (argued to be more automatic), rather than just being asked to adhere to a goal of reducing their emotional experience.

Thus, ERP components peaking before 300 ms post stimulus onset demonstrate increased amplitude in response to emotionally arousing compared to neutral photographs, reflecting attentional capture by emotional stimuli. It has been shown that this interaction between the emotionally arousing nature of stimuli and attentional processes can be influenced by contextual factors that alter the degree to which emotion is expressed or experienced. In addition, conscious emotion change strategies can impact on these amplitude differences, and greater effects may be linked to increased automaticity of such strategies.

A parietal ERP component beginning around 300 ms post stimulus onset, which can extend even after stimulus offset is known as the parietal late positive potential (parietal LPP). It has been consistently demonstrated that parietal LPP amplitude is increased in response to emotionally arousing versus neutral stimuli, an effect that is increased as emotional stimuli become more arousing (though not sensitive to valence), highly reliable even over repeated presentations of the same stimuli and does not appear to be affected by the physical characteristics of stimuli (e.g. Foti et al., 2009; Lang & Bradley, 2010). Thus, it has been argued that parietal LPP is a reliable index of the motivational significance of stimuli (Bradley, 2009).

Suggesting that parietal LPP amplitude can reflect the changing emotional relevance of stimuli across time and context, a large number of studies have demonstrated that when participants are explicitly instructed to increase or decrease their emotional experience by changing the way they think about a presented photograph, the parietal LPP amplitude in response to these photographs increases or decreases accordingly (Hajcak & Nieuwenhuis, 2006; Krompinger, Moser, & Simons, 2008; Langeslag & Van Strien, 2010; Moser, Hajcak, Bukay, & Simons, 2006; Moser, Krompinger, Dietz, & Simons, 2009). In addition, when contextual information about the photographs is presented before presentation, which implicitly increases or decreases participants' emotional experience, parietal LPP amplitude also increases or decreases accordingly (Foti & Hajcak, 2008; Macnamara, Foti, & Hajcak, 2009; Macnamara, Oschner, & Hajcak, 2011; Mocaiber et al., 2010).

Similarly, further suggesting that processes which alter the experience of emotionally arousing stimuli are reflected in parietal LPP amplitude, directing participants' attention towards more versus less emotionally arousing aspects of a stimulus has been shown to alter emotional experience and increase or decrease parietal LPP amplitude respectively (Dunning & Hajcak, 2009; Hajcak, Moser, & Simons, 2006). In line with the association between parietal LPP amplitude and emotional experience, changes in parietal LPP amplitude under instructions to alter emotional experience have been associated with corresponding changes in self-reported arousal (Hajcak & Nieuwenhuis, 2006). Interestingly, differentiating parietal LPP amplitude from cognitively effortful processes that may be engaged under instructions to alter one's emotional experience, increasing cognitive load does not affect the parietal LPP response to emotional stimuli (Hajcak, Dunning, & Foti, 2007).

Thus, a parietal LPP component beginning around 300 ms post stimulus onset and extending past offset, is associated specifically with the motivational relevance of stimuli. Explicit goals and contextual factors that alter emotional experience are associated with changes in this parietal LPP amplitude.

Although relatively less investigated, a frontal LPP component (similar time course to the parietal LPP, although sometimes peaking later; Macnamara et al., 2009) is being identified as relevant in emotional picture viewing paradigms with increasing frequency. Though this component appears not to be affected by the emotional content of stimuli (Macnamara et al., 2009), when participants are instructed to change the way they think about a photograph in order to alter their emotional experience (Bernat, Cadwallader, Seo, Vizueta, & Patrick, 2011; Langeslag & Van Strien, 2010) or when contextual information is provided about a photograph to implicitly alter the associated emotional experience

(Macnamara et al., 2009), frontal LPP amplitude is increased. Importantly, this increase occurs regardless of the direction in which emotional experience is altered. In addition, in European Americans, but not East Asians, frontal LPP amplitude has been shown to increase when participants are instructed not to express their emotions in response to negative photographs, something which is argued to be generally more practiced in East Asians (Murata, Moser, & Kitayama, in press).

Thus, a frontal LPP component has been identified as important when participants are engaged in processes that result in a change in emotional experience or expression but is not linked to the resulting emotional experience or expression. Frontal LPP amplitude is therefore thought to reflect effortful prefrontal control mechanisms that can be engaged when people's emotional experience and expressions are modulated.

Emotion regulation and changing emotional experience and expression across social context

The discussion in Section 1.2 describes how specific process relevant to changes in emotional expression and experience across social context can be indexed by ERP components, and this will be the main focus of the present study. However, any discussion that incorporates processes involved in changes in emotional expression or experience requires some introduction of the construct of emotion regulation. Defining emotion regulation as the processes by which emotional responding is changed to achieve the goals of an individual (Gross & John, 2003; Thompson, 2011; slightly different definitions that both include this aspect) has generated a large body of research. Notably, many of the ERP studies reviewed above were designed to investigate specific emotion regulation processes. Arguably the two most investigated emotional regulation strategies within this approach are cognitive reappraisal (referring to an individual changing the way they think about a stimulus in order to change their emotional experience) and expressive suppression (referring to individuals hiding their emotional expressions; Gross & John, 2003). These strategies both appear to be cognitively effortful, engaging prefrontal control brain regions, but are differentially associated with changes in subjective emotional experience, activity of emotion linked brain regions (e.g. amygdala) and facial expressions of emotion in line with their differing objectives (Eippert et al., 2007; Goldin, McRae, Ramel, & Gross, 2008; Moser et al., 2009; Ochsner, Bunge, Gross, & Gabrieli, 2002; Ochsner et al., 2004; Ray, McRae, Oschner, & Gross, 2010; Urry, 2009).

Supporting a role for emotion regulation strategies in the changes that are evidenced in emotional responding across social context, 98% of self-reported emotion regulation occurs in interpersonal contexts (Gross, Richards, & John, 2006; cited in Campos et al., 2011) and dramatic changes in broad social context (Srivastava, Tamir, McGonigal, John, & Gross, 2009) have been associated with changes in specific emotion regulation strategies. In addition, differences in display rules, which as discussed in Section 1.1 are important in social-context-linked changes in emotional responding, are associated with differences in the emotion regulation strategies that people report engaging in (McRae, Heller, John, & Gross, 2011). Further, the emotion regulation strategies that people report they would use in different social contexts vary as a function of closeness of affiliation to the social partner (Martini, 2011).

Thus, changes in emotional responding across social contexts correspond well with reported engagement in emotion regulation strategies, and thus it is possible that at least some of the difference in emotional responding evidenced across social contexts is linked to engagement in such strategies.

The current study: design and hypotheses

Measurements of participants' ERPs in response to emotionally arousing photographs and self-reports of subjective emotional experience and emotion regulation (cognitive reappraisal and expressive suppression) will be taken in different social contexts in order to investigate the processes by which emotional responding changes across social contexts. In an effort to extend the literature reviewed, and to begin to systematically manipulate variables that may contribute to the closeness of affiliation to a social partner dimension, we exposed participants to emotional or neutral stimuli whilst alone or in the presence of a culturally similar or culturally dissimilar researcher. By exposing participants to two strangers we were able to exclude a possibly confounding contribution of any previous social interaction history on social context effects. We were also able to match perceptions of certain personal characteristics across the two researchers, whist making salient cultural differences, perceptions of which could be measured. Given that the changes in emotional experience and expression across social context may occur in different ways for different emotions (see above), we examined participants' responses to both positive and negative photographs separately.

In line with the previously demonstrated reduced expression of emotions in the company of strangers, we hypothesised that emotional responding would be reduced in the presence of the culturally dissimilar researcher relative to whilst alone. Considering the importance of closeness of affiliation of a social partner on emotion responding, we hypothesised that the presence of the culturally similar researcher (we expected our manipulation would render this person to be perceived as more closely affiliated to participants) would result in different effects on emotional responding. In general, we expected that this context would be associated with increased emotional responding relative to the culturally dissimilar context, but given the social facilitation of emotion effects of closely affiliated social partners, we also considered the possibility that emotional responding would be increased in this context even relative to whilst alone. Given that previous ERP studies investigating contextual effects on emotional responding have used different paradigms and assess different contexts to those we report here (Ibanez et al., 2012), we did not hypothesise about which ERP-indexed processes would be most important. However, given the specific findings on the increased reported engagement in expressive suppression in less closely affiliated social contexts (Martini, 2011), we hypothesised that increased expressive suppression would be reported in the culturally dissimilar context.

Materials and methods

Participants

Twenty-one female Chinese university students with a mean age of 22.4 years (SD: 3.05; range: 19–32) participated in the study as paid volunteers; however, one participant was excluded due to excessive eye movement during ERP data acquisition, leaving a total sample of 20. All were right handed, spoke Chinese (first language) and had lived only in China. Informed written consent was obtained and experimental procedures were approved by the European Research Council's ethics committee and a local ethics committee at the Department of Psychology, Peking University. Only female participants were included because gender differences have been demonstrated in emotion expression, experience and regulation (McRae, Ochsner, Mauss, Gabrieli, & Gross, 2008; Schmeichel, Volokhov, & Demaree, 2008; Shiota & Levenson, 2009).

Stimulus materials

Positive, negative, and neutral photographs (80 each) from the International Affective Picture System (IPAS; Lang et al., 2005) comprised task stimuli (*mean normative ratings*: positive: V:7.1, A:5.3; negative: V:2.4, A:6.0; neutral: V:5.0, A:3.1). Positive stimuli depicted nature scenes, food or sporting scenes; negative stimuli depicted animal or human mutilation or threat, and neutral stimuli depicted household items. Asian or White racial content was avoided. Ten additional IPAS neutral pictures were used for practice stimuli. Four images displaying irrelevant, non-emotional content were selected from the World Wide Web as dummy cues (see Appendix A). Stimuli were 400×300 pixels; subtending a visual angle of $7.17^\circ \times 5.73^\circ$ at a viewing distance of 100 cm.

Experimental paradigm

Electroencephalography was used to record ERPs during six superblocks (counterbalanced in order); two in each of the three conditions (alone: participant alone; similar: participant accompanied by a Chinese researcher; dissimilar: participant accompanied by a British researcher). IAPS stimuli were presented in blocks of 30 photographs (20 emotional; 10 neutral). A total of eight blocks, four comprising positive and neutral, and four comprising negative and neutral stimuli, were presented within each condition. Thus, each of the 80 photographs was presented three times, once in each condition. Within each superblock (each comprising two positive and two negative blocks), positive and negative blocks were presented alternately, with the valence of the first block being counterbalanced across participants.

Positive and negative photographs were presented in separate blocks in order to maximise the possibility of detecting sustained effects of context on emotional responding, and to avoid potential effects of task switching (e.g. see Bernat et al., 2011). Neutral photographs were included in all blocks in order to ensure that the present procedure was comparable with previous related studies. Positive, negative, and neutral photographs presented across different blocks were matched for mean ratings of arousal and valence (see Appendix B) and the order of blocks administered in each condition was counterbalanced across participants. Within each block IAPS pictures were presented in random order.

Trials consisted of a central fixation cross (500 ms), followed by a central IPAS picture (2,000 ms duration), then a blank screen until response. Participants responded at picture offset with Q, W, space bar, O or P keys on a standard keyboard, using index and middle fingers from both hands and a thumb for the space bar, to indicate their current level of emotional arousal on a Likert scale from 1 to 5. ERPs were analysed within the time window between 200 ms before IAPS picture onset and IAPS picture offset (see below).

Measures

All written materials were translated from English to Chinese by a native Chinese speaker, translated back into English by a different native Chinese speaker, and finalised through discussion with native English and Chinese speakers.

Emotion regulation

A self-report measure of emotion regulation was adapted from the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003), which assesses tendencies towards cognitive reappraisal or expressive suppression (1–7 Likert rating). For the measurement of regulation of particular emotions during the experimental paradigm, we separated items referring to positive from those referring to negative emotions, and reworded some items to refer specifically to positive or negative emotions (see Appendix C). Thus, a total of nine ERQ items were administered following each block, which referred specifically how participants regulated their (positive or negative) emotions during that block. Outcome measures were mean scores across items referring to each type of regulation: 1) cognitive up-reappraisal, 2) cognitive down-reappraisal and 3) expressive suppression of a) positive emotion and b) negative emotion. We also included an implicit measurement of participants' values surrounding emotion regulation in specific culturally relevant contexts, using the (author compiled) scenarios ERQ. However, for the present study the only purpose of this questionnaire was to ensure that participants were able to self-report on emotion regulation.

Other ratings

A manipulation check questionnaire consisted of four questions measuring how far (9-point Likert scale) participants believed they were similar (in terms of cultural group, traditions and customs, cultural beliefs, and experiences) to the Chinese and British researchers (see Appendix D). An additional question asked participants how familiar each of the researchers was to them. A background questionnaire recorded demographic information (see Appendix E).

Procedure

Participants were greeted by both researchers (both female; described to participants as graduate researchers), neither of whom had met the participants before. To maximise the salience of cultural group differences, the researchers spoke exclusively in their native language. All instructions were given in written form to participants in order to minimise the need for verbal instructions. However, the verbal dialog required to ensure the participants were happy with the instructions was necessarily performed by the Chinese researcher in Chinese. Participants first completed the Scenarios ERQ (30–40 min; introducing the concept of emotion regulation). Participants were then seated in front of a 21-inch monitor in a shielded room and fitted with the electroencephalography (EEG) cap (see Section 2.6). The monitor was connected to a computer in a neighbouring control room running Matlab (version 7.11.584 R2010b).

Participants first completed a practice session comprising three blocks of the 10 practice stimuli. The six superblocks were then presented in counterbalanced order with between 5 and 10 min between each superblock. The background questionnaire was presented following the first superblock and the manipulation check questionnaire was presented following the final superblock. Following superblocks 2–4, questionnaires on cultural values were administered as part of a wider cross-cultural comparison study.

Participants were told that at different times during the procedure, one of the two researchers would sit next to them in the room in order to make notes for further analysis about how they responded to the stimuli. In order to ensure that demand characteristics relevant to the true manipulation were reduced as far as possible, an additional fixation cross (500 ms) followed by a dummy cue (200 ms) was presented at the beginning of each block (order counterbalanced across participants) and participants were led to believe in the written information provided about the experiment that the experimenter expected that the dummy cues may influence their emotional responding. At the end of each block, items from the adapted ERQ (only the positive or negative items matching the valence of the block) were presented one at a time on the computer screen. Participants were given as much time as required to respond to each item using the number keypad on a standard keyboard.

ERP data recording

A second computer in the control room allowed the EEG to be continuously recorded using Neuroscan Acquire Software. Recordings were taken from 62 scalp electrodes mounted on an elastic cap based on the 10–20 system, with two additional electrodes placed on the left and right mastoids (M1 and M2 respectively); electrodes were referenced to the average M1 and M2. The electrooculogram (EOG; monitoring blinks and eye movements) was recorded from four electrodes; two approximately 1 cm above and below the middle of the participant's left eye and two approximately 1.5 cm in a lateral direction from each eye. Electrical impedance was maintained at less than 5 kΩ. The EEG was amplified using 0.05–100 Hz band pass and 50 Hz notch filters, then digitised at a rate of 250 Hz. ERPs for the period between 200 ms before and 2,000 ms after IAPS picture onset were analysed offline, with the 200 ms preceding stimulus onset taken as the baseline. Trials in which the EOG recorded activity exceeding 50 μV were excluded and ERPs for each valence within each condition were then averaged separately [the mean number of trials retained in each condition were: dissimilar, positive (dpos): 67; d, negative (dneg): 72; d, neutral (dneu): 63; similar, pos (spos): 72; sneg: 73; sneu: 72; alone, pos (apos): 73; aneg: 72; aneu: 73].

To reduce the spatial dimensions of the dataset, eight clusters of five electrodes were created. In line with Dien and Santuzzi's (2005) suggestions [a method cited and employed in relevant paradigms in Foti and Hajcak (2008), Hajcak et al. (2007), and Hajcak and Olvet (2008)], two-level clusters: left versus right hemisphere, anterior versus posterior and inferior versus superior, were employed. The anterior-superior clusters for left/right

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hemispheres included AF3/4, F1/2, F3/4, FC1/2 and FC3/4; the corresponding anterior-inferior clusters included AF7/8, F5/6, F7/8, FC5/6 and FT7/8; the posterior-superior clusters included CP1/2, CP3/4, P1/2, P3/4 and PO3/4; and the posterior-inferior clusters included CP5/6, P5/6, P7/8, PO7/8 and TP7/8. Due to malfunction during recording, electrode FC2 was excluded from analysis. Thus, the right anterior-superior cluster comprised only the remaining four electrodes.

Early ERP components were defined as the average activity within the time windows and over the clusters at which they were maximal in the alone, neutral condition. N1 was defined between 110 and 160 ms post stimulus onset over anterior-superior and anterior inferior clusters; N2, between 230 and 290 ms post stimulus onset over the same clusters; and P2, between 210 and 274 ms post stimulus onset over posterior-inferior clusters. A parietal LPP was defined separately within two time windows at 340–500 ms and 524–1,000 ms post stimulus onset, over posterior-inferior and posterior-superior clusters. A frontal LPP was defined separately within two time windows at 524–1,000 ms and 1,000–2,000 ms post stimulus onset, over anterior-inferior and anterior-superior clusters. Time windows were selected by examining the ERP time course in the alone, neutral condition, aiming to best encompass the peak for relevant component.

Data analyses

Mean ERP amplitudes did not significantly differ from normality (Kolmogorov–Smirnov tests; $Z < 1.1$, $p > .21$). Studies reviewed in Section 1.3 dealing with the ERP components peaking before 300 ms post stimulus onset have generally conducted analyses at the level of the differential amplitude in response to emotional versus neutral stimuli (e.g. Gable & Harmon-Jones, 2011; Walker et al., 2011). Thus, N1, N2, and P2 components were first analysed using a series of two conditions by two valences, two-way repeated measures ANOVAs, in which mean amplitudes to positive versus neutral, and negative versus neutral stimuli were compared in the dissimilar relative to the alone conditions, the dissimilar relative to the similar conditions, and the similar relative to the alone conditions. Here, because the hypothesised processes linked to changes in emotional responding should be indexed by relevant condition wise differences in differential (emotional vs. neutral stimuli) ERP amplitudes, valence by condition interactions comprised the effects of interest. We systematically compared the relevant sets of two levels on valence and condition factors in this way in line with the previous research and our hypotheses, and in order to maximise the clarity of presentation of our results. Where appropriate, *t*-tests were used to further describe valence by condition interactions. The findings reviewed in Section 1.2 referring to the effects of processes linked to change in emotional responding on LPP components have generally reported LPP amplitude to emotional stimuli across conditions (e.g. comparing the LPP amplitude in response to negatively arousing stimuli when participants are first presented with a negative versus a neutral frame of reference: Macnamara et al., 2009). In addition, as discussed in Section 1.2, the frontal LPP component is not differentially sensitive to emotionally arousing content, and it has been shown that under conditions of instructed expressive suppression, even the parietal LPP may be reduced in response to both negatively arousing and neutral stimuli (Murata et al., in press). Thus, for parietal and frontal LPP components we did not expect effects of condition on differential emotion versus neutral LPP amplitude and it was the main effects of condition that comprised the primary effects of interest. We therefore conducted a series of two conditions by three valences, two-way repeated measures ANOVAs comparing dissimilar and alone, dissimilar and similar, and similar and alone conditions. All three possible levels were included on the valence factor in this way because, contrary to for the pre 300 ms ERP components, for LPP components our hypotheses did not specify a particular set of comparisons comprising two levels on the valence factor in which we would expect to see effects. Main effects of condition identified over the three valence levels were further described using corresponding two valences by two conditions, two way ANOVAs and *t*-tests.

Mean arousal and ERQ ratings did not significantly differ from normality (Kolmogorov–Smirnov tests; $Z < .83$, $p > .50$). Mean arousal ratings were analysed using an equivalent series of ANOVAs. Given the different emotion regulation strategies measured on the ERQ, mean ERQ ratings were analysed using an equivalent series of ANOVAs, with the additional inclusion of a strategy factor with three levels (up-reappraisal, down-reappraisal and expressive suppression). Further ANOVAs and paired *t*-tests were used to delineate significant effects. A Greenhouse–Geisser correction was applied to all ANOVA results.

Manipulation check

A manipulation check was conducted to assess Chinese females' perceived similarity in terms of cultural beliefs and values to the Chinese and British researchers, and to ensure that no potentially confounding differences existed in the perceived personal characteristics of the two researchers. An additional sample of 38 Chinese females (mean age 21 years; SD: 2.56; range: 18–26) rated photographs of the two researchers (in counterbalanced order; all rated both researchers as completely unfamiliar). The British and Chinese researchers did not significantly differ in perceived attractiveness, trustworthiness, friendliness, generosity, authority, how nervous they made raters feel or how relaxed they made raters feel [$t(37) = .11 \sim 1.28$, $p = .909 \sim .210$]. However, relative to the British researcher, the Chinese researcher was perceived as significantly more similar to raters, having more Chinese cultural values, relying on friends and family more, having less Western cultural values, being less independent and being more likely to understand the raters' problems [$t(37) = 3.14 \sim 8.34$, $p = .003 \sim < .001$], and tended to be perceived as less self-reliant [$t(37) = 1.75$, $p = .089$]. Thus, whilst Chinese and British researchers did not significantly differ on perceived personal characteristics, the Chinese researcher was perceived as being more similar to Chinese raters and more representative of Chinese and collectivist cultural characteristics, and the British researcher was perceived as being more representative of British and individualist cultural characteristics.

Results

Behavioural results

Mean scores and standard deviations for online arousal and ERQ are shown in Table 1.

Manipulation check questionnaire results

Wilcoxin Signed Rank tests (few items, limited sample size) were employed to analyse results from the manipulation check questions. Participants rated the Chinese researcher as significantly more similar to themselves than the British researcher (Z score $= 3.92$; $p < .001$), suggesting that the present manipulation succeeded in making participants perceive that they were being accompanied by two individuals who differed in how similar their cultural group was to participants' own cultural group. Participants also rated the Chinese researcher as significantly more familiar than the British researcher (Z score $= 2.97$; $p = .003$); however, this familiarity score was not associated with any ERP difference scores per condition or behavioural ratings relevant to our hypotheses.

Online arousal and ERQ ratings

Comparing dissimilar and alone [$F(2,38) = 88.83, p < .001, \eta_p^2 = .824$]; dissimilar and similar [$F(2,38) = 87.38, p < .001; \eta_p^2 = .821$]; and similar and alone [$F(2,38) = 88.34, p < .001; \eta_p^2 = .823$] conditions, the valence by condition ANOVAs of mean online arousal ratings demonstrated significant main effects of valence. Across all conditions, negative photographs were rated as more arousing than positive photographs [$t(19) = 6.55$, $p < .001$], which were more arousing than neutral photographs [$t(19) = 6.66$, $p < .001$]. However, the main effects of condition and condition by valence interactions were not significant ($p > .415$; $\eta_p^2 < .044$).

The strategy by valence by condition ANOVAs of mean ERQ ratings[1] comparing dissimilar and alone [$F(2,32) = 7.18, p = .010, \eta_p^2 = .307$]; dissimilar and similar [$F(2,32) = 11.21, p = .001, \eta_p^2 = .412$]; and similar and alone [$F(2,32) = 7.22, p = .008, \eta_p^2 = .311$] conditions all demonstrated significant valence by strategy interactions. The main effect of strategy remained significant for both positive [$F(2,32) = 5.77, p = .012, \eta_p^2 = .265$] and negative [$F(2,32) = 5.61, p = .009, \eta_p^2 = .260$] blocks. For positive blocks, significantly more up-reappraisal compared to down-reappraisal was reported [$t(16) = 2.65, p = .017, \eta^2 = .305$]; and significantly more up-reappraisal than suppression [$t(19) = 2.48, p = .023, \eta^2 = .245$]. For negative blocks, however, significantly more down-reappraisal was reported compared to up-reappraisal [$t(16) = 2.59, p = .020, \eta^2 = .295$]; and significantly more down-reappraisal than suppression [$t(19) = 3.02, p = .007, \eta^2 = .324$]. Thus, up-reappraisal was preferentially elevated in positive blocks, whilst down-reappraisal was elevated in negative blocks.

In the comparison between dissimilar and alone conditions, the strategy by valence interaction was further qualified by a three-way interaction with condition [$F(2,32) = 3.64, p = .045, \eta_p^2 = .185$]. The strategy by condition interaction was large and significant for positive blocks [$F(2,32) = 5.83, p = .010, \eta_p^2 = .267$] but negligible for negative blocks [$F(2,32) = .34, p = .668, \eta_p^2 = .021$]. The valence by condition interaction was large and significant for down-reappraisal [$F(1,16) = 5.86, p = .028, \eta_p^2 = .268$] but negligible for up-reappraisal and suppression [$F(2,32) < .82, p > .379, \eta_p^2 < .049$]. Thus, the three-way interaction was primarily driven by a significant decrease in down-reappraisal reported for positive blocks in the dissimilar relative to the alone condition [$t(16) = -2.49$, $p = .024, \eta^2 = .279$].

Thus, in positive blocks, participants reported more up-reappraisal than down-reappraisal or suppression. However, in negative blocks, participants reported more down-reappraisal than the other two strategies. Following positive blocks specifically, participants reported less down-reappraisal in the dissimilar relative to the alone condition.

ERP results[2]

ERP time course data comparing the six different conditions over the whole time course at FPZ (given that some previous studies measuring ERPs in response

[1]Due to a technical fault, up-reappraisal ERQ ratings following negative blocks and down-reappraisal ERQ ratings following positive blocks were not ascertained for three participants.

[2]The comparability of neutral trials presented in blocks with positive versus negative trials was checked using a block (positive, negative) by condition (alone, similar, dissimilar) ANOVAs. The block by condition interaction was not significant for any of the ERP components of interest, supporting the comparability of the neutral trials presented in separate blocks.

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Table 1. Mean scores and standard deviations for self-report measurements of arousal and cognitive up-reappraisal, cognitive down-reappraisal and expressive suppression as measured by the Emotion Regulation Questionnaire (ERQ)

	Similar			Dissimilar			Alone		
Score	Neutral	Positive	Negative	Neutral	Positive	Negative	Neutral	Positive	Negative
Arousal	1.81 (0.49)	2.91 (0.87)	3.62 (0.68)	1.81 (0.50)	2.92 (0.89)	3.61 (0.70)	1.82 (0.51)	2.91 (0.89)	3.57 (0.70)
ERQ up-reappraisal	–	4.85 (1.01)	4.08 (1.38)	–	4.75 (1.07)	4.07 (1.51)	–	4.67 (1.20)	4.21 (1.56)
ERQ down-reappraisal	–	3.93 (1.26)	5.11 (0.93)	–	3.68 (1.31)	5.13 (0.97)	–	4.09 (1.36)	4.93 (0.91)
ERQ expressive suppression	–	4.01 (0.69)	3.85 (1.42)	–	4.02 (0.85)	3.82 (1.59)	–	3.99 (0.70)	3.90 (1.52)

to IAPS stimuli only record data from midline electrodes and FPZ is the most relevant for N1 and frontal LPP clusters for which important results are described below) are presented in Appendix F.

N1: dissimilar versus alone conditions

Figure 1A illustrates the neural activity in the 110–160 ms time window during which N1 was defined over anterior clusters. Assessing responses to positive stimuli, the ANOVA including positive and neutral trials demonstrated a large significant valence by condition interaction over all relevant clusters: left anterior-inferior (LAI): $F(1,19) = 5.08$, $p = .036$; $\eta_p^2 = .211$; left anterior-superior (LAS): $F(1,19) = 5.09$, $p = .036$; $\eta_p^2 = .211$; right anterior-inferior (RAI): $F(1,19) = 4.49$, $p = .047$; $\eta_p^2 = .191$; and right anterior-superior (RAS): $F(1,19) = 4.36$, $p = .051$; $\eta_p^2 = .186$ (borderline). As can be seen in Fig. 1Bi and ii, this interaction was driven by a reduction in the differential N1 amplitude to positive versus neutral stimuli in the dissimilar relative to the alone conditions. The increase in N1 amplitude to positive versus neutral stimuli was large and significant in the alone condition [LAI: $t(19) = 3.08$, $p = .006$, $\eta^2 = .333$; LAS: $t(19) = 2.88$, $p = .010$, $\eta^2 = .304$; RAI: $t(19) = 3.67$, $p = .002$, $\eta^2 = .415$; RAS: $t(19) = 2.61$, $p = .017$, $\eta^2 = .264$]; however, there was no corresponding increase in the dissimilar condition [LAI: $t(19) < -.46$, $p > .668$, $\eta^2 < .011$].

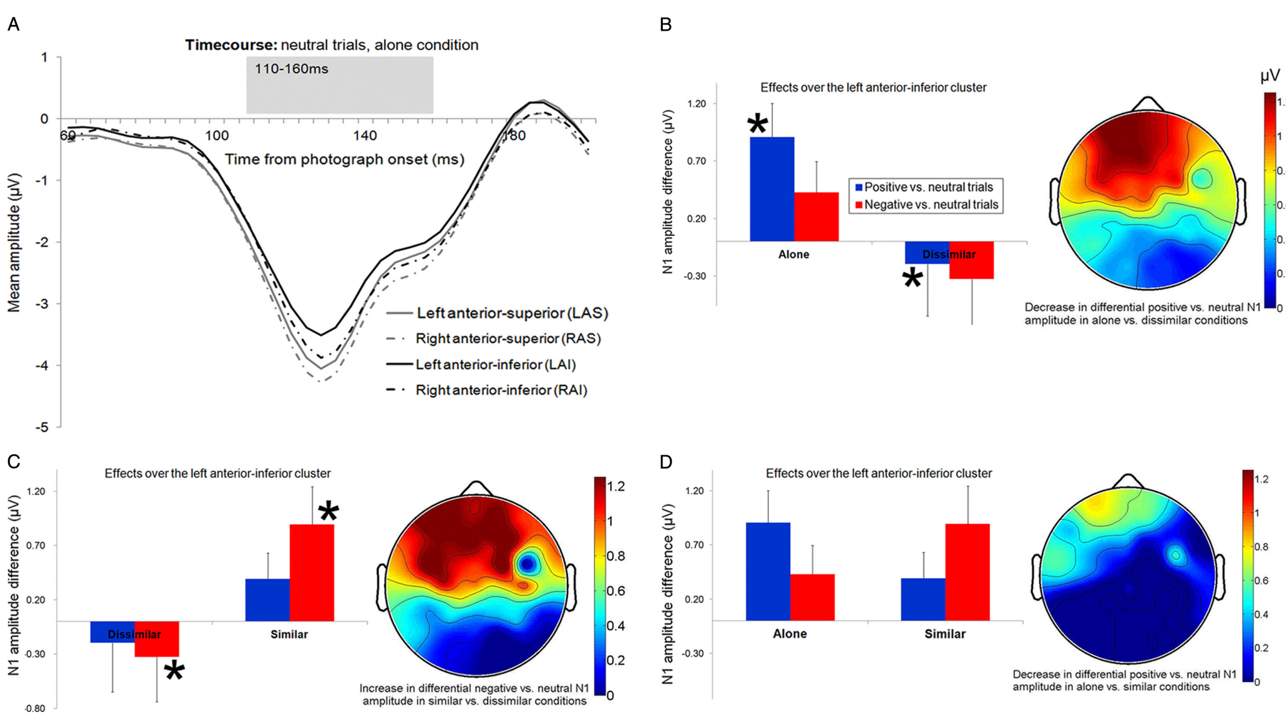

Fig. 1. Effects of context on differential N1 amplitudes. (A) Illustrates the time course of activity within the N1 window (110–160 ms) over left and right anterior-inferior and anterior-superior clusters in response to neutral stimuli in the alone condition. (B–D) Illustrate the comparison of dissimilar versus alone, dissimilar versus similar and similar versus alone conditions respectively and show (i) differential N1 amplitudes to positive relative to neutral and negative relative to neutral stimuli (significant simple effects marked with an asterisk) and (ii) topography maps for the relevant contrast in differential N1 across conditions.

In relation to responses to negative stimuli, the ANOVA including negative and neutral trials demonstrated a small to medium sized valence by condition interaction, but this was not significant [$F(1,19) < 2.97$, $p > .101$; $\eta_p^2 < .135$]. As can be seen in Fig. 1Bi and ii, the differential N1 amplitude to negative versus neutral stimuli was reduced in the dissimilar relative to alone conditions. However, neither the medium sized increase in N1 amplitude to negative relative to neutral trials in the alone condition [$t(19) < 1.68$, $p = .109$, $\eta^2 = .129$], nor the small decrease in N1 amplitude to negative relative to neutral trials in the dissimilar condition [$t(19) < -.80$, $p > .434$, $\eta^2 = .033$] were significant. Thus, the differential N1 amplitude to positive versus neutral stimuli was significantly reduced in the dissimilar relative to alone conditions. The differential N1 amplitude to negative versus neutral stimuli was also decreased in the dissimilar relative to the alone conditions, but this effect was not significant.

N1: dissimilar versus similar conditions

Assessing responses to positive stimuli, the ANOVA including positive and neutral trials demonstrated no significant valence by condition interaction [$F(1,19) < 2.34$, $p > .143$; $\eta_p^2 < .110$]. As illustrated in Fig. 1Ci, in the similar condition there was a medium to large increase in N1 amplitude in response to positive relative to neutral trials [LAI: $t(19) = 1.61$, $p = .124$, $\eta^2 = .120$; LAS: $t(19) = 2.11$, $p = .048$, $\eta^2 = .189$; RAI: $t(19) = 1.82$, $p = .084$, $\eta^2 = .148$; RAS: $t(19) = 1.61$, $p = .124$, $\eta^2 = .12$], which attained or bordered significance over two of the relevant clusters. Thus, the differential N1 amplitude to positive versus neutral stimuli tended to be reduced in the similar relative to alone conditions and this differential amplitude lay between those corresponding to the alone and dissimilar conditions.

In relation to responses to negative stimuli, the ANOVA considering negative and neutral trials demonstrated a large, significant valence by condition interaction [LAI: $F(1,19) = 6.37$, $p = .021$; $\eta_p^2 = .251$; LAS: $F(1,19) = 5.61$, $p = .029$; $\eta_p^2 = .228$; RAI: $F(1,19) = 2.59$, $p = .124$; $\eta_p^2 = .120$; RAS: $F(1,19) = 5.58$, $p = .029$; $\eta_p^2 = .227$; not significant over the right anterior, inferior cluster]. As illustrated in Fig. 1C, this effect arose because there was a large, significant increase in N1 amplitude to negative versus neutral stimuli in the similar condition [LAI: $t(19) = 2.56$, $p = .019$, $\eta^2 = .256$; LAS: $t(19) = 2.77$, $p = .012$, $\eta^2 = .288$; RAI: $t(19) = 2.11$, $p = .049$, $\eta^2 = .189$; RAS: $t(19) = 2.69$, $p = .014$, $\eta^2 = .276$), which contrasted to the small, non-significant decrease in N1 amplitude to negative versus neutral stimuli in the dissimilar condition (described in Section 3.2.1.1)].

Thus, whilst differential N1 amplitude to positive versus neutral stimuli did not significantly differ between dissimilar and similar conditions, differential N1 amplitude to negative versus neutral stimuli was significantly increased in the similar relative to the dissimilar conditions. To increase the specification with which these results could be described, we next compared similar and alone conditions.

N1: similar versus alone conditions

Assessing responses to positive stimuli, the ANOVA including positive and neutral trails showed a medium to large valence by condition interaction over the anterior-inferior clusters, which bordered significance [RAI: $F(1,19) = 4.17$, $p = .055$; $\eta_p^2 = .180$; LAI: $F(1,19) = 1.52$, $p = .233$; $\eta_p^2 = .074$], but was small and non-significant over the anterior-superior clusters [$F(1,19) < .73$, $p > .405$; $\eta_p^2 < .037$]. Thus, whilst the similar condition did not differ significantly from the dissimilar condition in terms of differential N1 responses to positive versus neutral stimuli, the reduction in differential N1 amplitude in the similar relative to the alone condition was smaller and less statistically significant than the corresponding reduction in the dissimilar condition (see Fig. 1D).

In relation to responses to negative stimuli, the ANOVA including negative and neutral trials showed a small to medium valence by condition interaction but this effect was not significant [$F(1,19) < 1.38$, $p > .255$; $\eta_p^2 < .068$]. Thus, the differential N1 amplitude to negative versus neutral stimuli in the similar condition showed a large significant increase relative to the dissimilar condition, and also showed a small to medium, though non-significant, increase relative to the alone condition.

N2 and P2

The ANOVAs assessing N2 and P2 amplitudes in dissimilar/alone, similar /dissimilar and similar/alone conditions, including positive and neutral, and negative and neutral trials, demonstrated mostly negligible to small valence by condition interactions, none of which obtained statistical significance over any of the relevant clusters [N2: $F(1,19) < 2.98$, $p > 101$, $\eta_p^2 < .136$; P2: $F(1,19) < 2.04$, $p > 169$, $\eta_p^2 < .097$].

Parietal LPP in the 340–500 ms time window: dissimilar versus alone conditions

Figure 2A illustrates the neural activity in the 340–500 ms time window during which the early part of the parietal LPP component was defined over posterior clusters. The ANOVA comparing dissimilar and alone conditions across positive, negative and neutral trials demonstrated a small to medium main effect of condition. This effect was driven by decreases in parietal LPP amplitude in the dissimilar relative to the alone condition for all types of trials (see Fig. 2B); however, it did not attain significance [$F(1,19) < 2.49$, $p > .131$, $\eta_p^2 < .116$].

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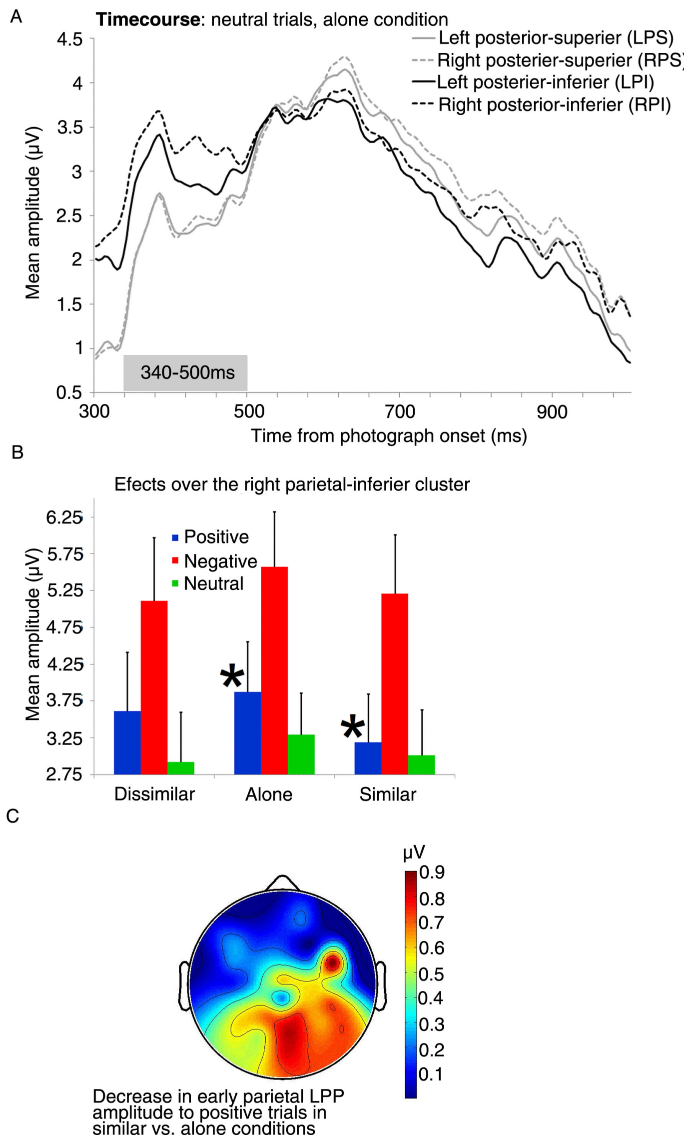

Fig. 2. Effects of context on parietal LPP amplitudes. (A) Illustrates the time course of activity within the earlier parietal LPP window (340–500 ms) over left and right posterior-inferior and posterior-superior clusters in response to neutral stimuli in the alone condition. (B) Illustrates the mean parietal LPP amplitudes across dissimilar, similar and alone conditions for positive, negative and neutral trials (significant simple effects marked with an asterisk). (C) Illustrates the topography map for the amplitude decrease in responses to positive trials in the similar relative to the alone condition.

Parietal LPP in the 340–500 ms time window: similar versus alone conditions

The ANOVA comparing similar and alone conditions across positive, negative, and neutral trials demonstrated a main effect of condition that was large and significant or bordered significance over the two right-sided clusters [posterior-inferior (RPI): $F(1,19) = 5.03$, $p = .037$, $\eta_p^2 = .209$; posterior-superior (RPS): $F(1,19) = 3.44$, $p = .079$, $\eta_p^2 = .153$] and remained medium sized but not significant over the left-sided clusters [posterior-inferior (LPI): $F(1,19) = 2.18$, $p = .156$, $\eta_p^2 = .103$; posterior-superior (LPS): $F(1,19) = 2.84$, $p = .108$, $\eta_p^2 = .130$]. As illustrated in Fig. 2B, there was a reduction in parietal LPP amplitude in the similar relative to the alone conditions in response to positive, negative, and neutral trials. However, this decrease was only significant for positive trials over right-sided clusters [RPI: $t(19) = -2.59$, $p = .018$, $\eta^2 = .261$; RPS: $t(19) = -2.32$, $p = .031$, $\eta^2 = .221$], where the effect was largest (see Fig. 2C).

Parietal LPP in the 340–500 ms time window: dissimilar versus similar conditions

The ANOVA comparing dissimilar and alone conditions across positive, negative, and neutral trials demonstrated negligible main effects of condition [$F(1,19) < .22$, $p > .644$; $\eta_p^2 < .012$]. Thus, whilst parietal LPP amplitudes were decreased in the dissimilar and similar relative to the alone conditions (see Fig. 2B), it was only the decrease in

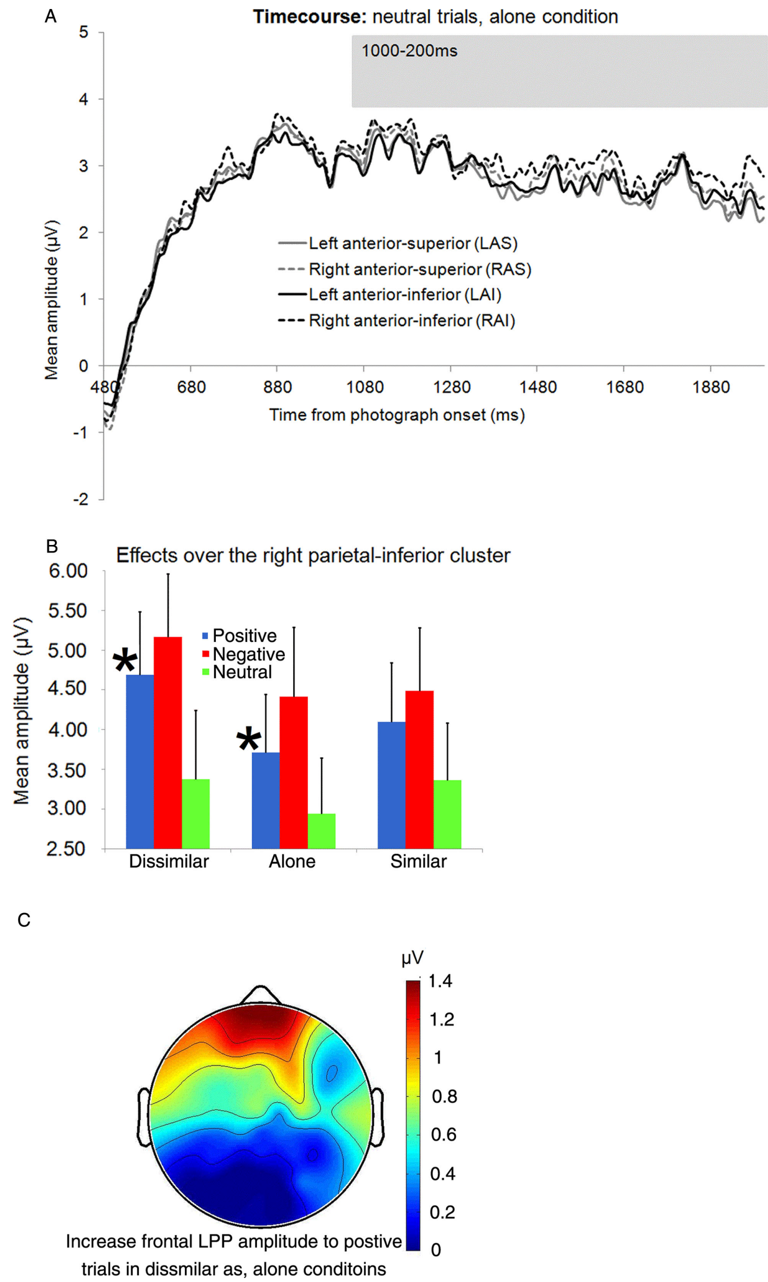

Fig. 3. Effects of context on frontal LPP amplitudes. (A) Illustrates the time course of activity within the later frontal LPP window (1,000–2000 ms) over left and right anterior-inferior and anterior-superior clusters in response to neutral stimuli in the alone condition. (B) Illustrates the mean frontal LPP amplitudes across dissimilar, similar and alone conditions for positive, negative and neutral stimuli (significant simple effects marked with an asterisk). (C) Illustrates the topography map for the amplitude increase in response to positive trials in the dissimilar relative to alone conditions.

the similar relative to the alone condition in response to positive trials which was large and attained significance.

Parietal and frontal LPPs in the 524–1,000 ms time window

The ANOVAs assessing parietal/frontal LPP amplitudes in the 524–1,000 ms time window demonstrated no significant main effects of condition when comparing dissimilar and alone, dissimilar and similar or similar and alone conditions [parietal: $F(1,19) < 1.32$, $p > .265$, $\eta_p^2 < .065$; frontal: $F(1,19) < 1.70$, $p > .207$, $\eta_p^2 < .082$].

Frontal LPP in the 1,000–2,000 ms time window: dissimilar versus alone conditions

Figure 3A illustrates the neural activity in the 1,000–2,000 ms time window during which the later part of the frontal LPP component was defined over anterior clusters. The ANOVA comparing dissimilar and alone

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conditions across positive, negative, and neutral trials demonstrated a large main effect of condition, which was significant over the two relevant right-sided clusters [RAI: $F(1,19) = 4.95$, $p = .038$, $\eta_p^2 = .207$; RAS: $F(1,19) = 4.96$, $p = .038$, $\eta_p^2 = .207$] and bordered significance over the two relevant left-sided clusters [LAI: $F(1,19) = 4.18$, $p = .055$, $\eta_p^2 = .180$; LAS: $F(1,19) = 3.24$, $p = .088$, $\eta_p^2 = .146$; Fig. 3B/C]. As illustrated in Fig. 3B, the frontal LPP amplitudes in response to positive, negative, and neutral trials were all greater in the dissimilar relative to the alone condition. However, *t*-tests revealed the main effect of condition was primarily driven by frontal LPP amplitudes in response to positive trials, which were the only trial type in which the dissimilar versus alone condition simple contrast attained or bordered significance [RAI: $t(19) = 1.67$, $p = .106$, $\eta^2 = .127$; RAS: $t(19) = 2.18$, $p = .042$, $\eta^2 = .200$; LAI: $t(19) = 2.00$, $p = .060$, $\eta^2 = .174$; LAS: $t(19) = 1.88$, $p = .076$, $\eta^2 = .157$; not significant over the RAI cluster].

Frontal LPP in the 1,000–2,000 ms time window: dissimilar versus similar conditions

The ANOVA comparing dissimilar and similar conditions demonstrated a small to medium sized main effect of condition, which did not attain significance [$F(1,19) < 2.21$, $p > .154$, $\eta_p^2 < .104$].

Frontal LPP in the 1,000–2,000 ms time window: similar versus alone conditions

The ANOVA comparing similar and alone conditions demonstrated a small main effect of condition, which did not attain significance [$F(1,19) < 1.03$, $p > .323$, $\eta_p^2 < .051$]. Thus, the frontal LPP amplitude was significantly increased in the dissimilar relative to alone conditions, an effect mainly driven by responses to positive trials. However, frontal LPP amplitudes in the similar condition lay between those shown in the alone and dissimilar conditions, and did not significantly differ from either.

Discussion

Overview of main findings

The present experimental manipulation was successful in influencing participants' perceptions of their interpersonal context. In similar versus dissimilar conditions, participants perceived respectively that they were being accompanied by others who shared a more similar versus less similar cultural background to their own, but who did not differ in other measured personal characteristics. Thus, we were able to manipulate cultural similarity as a relatively specific factor contributing to perceived closeness of affiliation to an interaction partner.

There were no effects of the changing social context on participants self-reported emotional arousal, though in agreement with normative ratings, reported arousal was higher for negative than for positive photographs, which were both higher than that for neutral photographs.

Self-reports of emotion regulation were also primarily influenced by the valence of the photograph, with elevated up-reappraisal in response to positive photographs but elevated down-reappraisal in response to negative photographs. Interestingly, less down-reappraisal was reported in response to positive photographs in the presence of a culturally dissimilar researcher relative to when participants were alone. These findings do not support our hypothesis that increased expressive suppression would be reported in the culturally dissimilar relative to the alone context.

In accordance with the hypothesis that decreased emotional responding would be demonstrated in the culturally dissimilar relative to the alone context, the differential N1 amplitudes in response to valenced relative to neutral stimuli, indexing early attentional capture by emotional stimuli, were reduced when participants were in the presence of a culturally dissimilar researcher relative to when they were alone. However, this reduction was only significant in the case of responses to positive stimuli. Suggesting that the presence of the dissimilar researcher was associated with the effortful engagement of prefrontal cognitive resources in response to positive stimuli, the amplitude of the frontal LPP, was significantly increased between 1,000 and 2,000 ms post stimulus onset in response to positive trials in the dissimilar relative to the alone context.

In line with the hypothesis that there would be increased emotional responding in the culturally similar relative to the dissimilar context, the differential N1 amplitude to positive relative to neutral trials, was reduced in the similar context relative to the alone context to a lesser extent than the corresponding reduction in the dissimilar context. The frontal LPP amplitude to positive trials was correspondingly increased in the similar relative to the alone context to a lesser extent than the increase in the dissimilar condition, indicating reduced engagement of cognitive resources. However, in response to positive stimuli, the amplitude of the parietal LPP component, indexing motivational relevance, was significantly decreased between 340 and 500 ms post stimulus onset in the similar relative to the alone context, an effect that was not demonstrated in the contrast between dissimilar and alone conditions.

Finally, further in line with the hypothesis that the culturally similar context would be associated with increased emotional responding than the dissimilar context, the differential N1 amplitude in response to negative versus neutral trials was significantly increased in the similar relative to the dissimilar context and tended to be increased in the similar relative to the alone context. These findings will be discussed in turn below.

Self-reports of arousal and emotion regulation

Previous research investigating emotional responding in the presence of strangers has generally supported stronger effects on emotional expression than experience (Buck et al., 1992; Jakobs et al., 2001; Lee & Wagner, 2002; Matsumoto & Kupperbusch, 2001). Thus, one possible interpretation of the present results which fail to demonstrate an effect of social context on self-reports of arousal is that this aspect of subjective emotional experience was not influenced by the present manipulation of social context. However, it must also be noted that other studies using similar paradigms, that evidence changes in subjective reports of emotional arousal being influenced by the semantic context in which photographic stimuli have been presented (e.g. Foti & Hajcak, 2008; Macnamara et al., 2009, 2011; Mocaiber et al., 2010), have applied between subjects designs. Participants in the present study were presented with all photographs in each of the three social contexts. It is therefore possible that experiment demand characteristics encouraged across condition consistency in participants' ratings of arousal. We presented the same stimuli in each condition in order to ensure that ERP data across conditions were directly comparable and because IAPS stimuli were limited due to our exclusion of stimuli with potentially confounding social cultural content. However, future research employing a between subjects design or different sets of stimuli in each condition could help to address this possibility.

The decrease in down-reappraisal of positive emotion reported in the presence of a dissimilar researcher relative to when participants were alone is somewhat surprising given the decrease in emotional expression in the presence of strangers that has been reported (Buck et al., 1992; Jakobs et al., 2001; Lee & Wagner, 2002). However, studies comparing emotional responding when the social partner is visible or not (e.g. interacting via computer) have demonstrated increased expression of emotions when the partner is visible, even when the partner is a stranger (Bruder et al., 2012; Yamamoto & Suzuki, 2006). A positive bias in emotional expression in the presence of a researcher has also been reported (Matsumoto & Kupperbusch, 2001). Although these studies pertain more to emotion expression than experience, and cognitive reappraisal is known to affect experience more than expression (Goldin et al., 2008), taken together these data suggest the possibility that the present participants were consciously engaging in a set of emotion regulation strategies (only some of which we measured) that would have allowed a positive bias in emotional expression in the presence of the dissimilar researcher. There was no corresponding effect demonstrated in the presence of a similar researcher, but also no significant differences between the two researcher conditions. Thus, the present data do not allow us to draw conclusions about the differences in self-reported emotion regulation between the two researchers. The overall valence linked pattern of increased up-reappraisal of positive emotions and increased down-reappraisal of negative emotions is consistent with previously reported differences in people's reported emotion regulation (Gross & John, 2003).

The effect of the dissimilar context on responding to positive emotions

We hypothesised that the dissimilar context would be associated with decreased emotional responding relative to when participants were alone. The effects of the dissimilar context on the ERP N1 component provide support for this hypothesis with respect to responses to positive stimuli. The reduction in differential N1 amplitude to positive relative to neutral stimuli in the presence of a dissimilar researcher suggest that the dissimilar researcher social context reduced the attentional capture that was otherwise elicited by the positively arousing stimuli (Foti et al., 2009). The previously discussed study that demonstrated corresponding reductions in differential N1 amplitude in response to a directed broadening compared to a narrowing of attentional focus (Gable & Harmon-Jones, 2011), directed attention using Novon figures presented before positively arousing photographs, with a task to identify the global or local letter. Thus, a possible interpretation of the present results is that the presence of the culturally dissimilar researcher initiated a more global attentional focus during the presentation of positive stimuli.

Another study demonstrating modulation of differential N1 amplitude in response to emotionally arousing stimuli did so using a contextual manipulation of the semantic meaning of stimuli presented before the photographs (Foti & Hajcak, 2008), with reduced differential N1 when negative photographs were construed less negatively. This study did not investigate responses to positively arousing stimuli. However, it is possible that the present results represent an alteration of the way in which positively stimuli were construed, in that they were perceived less positively in the presence of the dissimilar researcher. This interpretation would also be in line with the present increase in frontal LPP amplitude demonstrated in the presence of a dissimilar researcher relative to when participants were alone in response to positive stimuli. Such an increase in frontal LPP amplitude has been demonstrated in a design manipulating semantic context presented before emotional photographs similar to the Foti et al. (2009) study (Macnamara et al., 2009). In this case, the increase in frontal LPP amplitude was demonstrated when the preceding context presented additional information relative to that which could be ascertained from the photograph alone, leading the authors to argue that the increase was associated with increased demands on prefrontal cognitive control resources. Thus, in the present study, the presence of a dissimilar researcher may have initiated a cognitively

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demanding less positive interpretation of stimuli, comprising information from the stimulus itself and additional information perhaps based on the dissimilar researcher's behaviour or specific demand characteristics in their presence. Future research investigating these possible interpretations may gain fruitful insights from examination of participants' eye movements, to help to inform on the focus of attention, and by employing additional measures indexing emotional arousal that may be more sensitive than the present self-report.

The effect of the dissimilar context on responding to negative emotions

Although the effects of the dissimilar context on responses to negative stimuli were similar to those on responses to positive stimuli, these were not significant. Previous research has demonstrated reductions in the expression of both positive and negative emotions in the presence of strangers (Buck et al., 1992; Hess et al., 1995; Jakobs et al., 1999, 2001; Yamamoto & Suzuki, 2006), thus it is perhaps surprising that our data demonstrated less evidence for modulation of emotional responding to negative versus positive stimuli in the dissimilar context. However, two studies have demonstrated that emotional expressions to negative films (Matsumoto & Kupperbusch, 2001) or recounted events (Lee & Wagner, 2002) were actually masked in the presence of an unknown researcher and accompanied by (not experienced) expressions of positive emotion. Given the relative scarcity of literature on masking, particularly in terms of associated effects on ERP components, we cannot make hypotheses as to how a masking profile would have been illustrated in the present data. Thus, future research on this issue may be informative.

The effect of the similar context on responding to positive emotions

For responses to positive stimuli, the effects of the similar context on the N1 and frontal LPP components were in the same direction but of reduced magnitude to those effects demonstrated in the dissimilar context. Thus, attentional capture of positive emotional stimuli was affected to a lesser extent in the similar context. If we follow a line of reasoning that this reduction in attentional capture by emotional stimuli would ultimately be linked to decreased emotional experience or observable emotional expressions, then these results would be in line with the general association that has been demonstrated between increased closeness of affiliation to a social partner and increased emotional responding (Bruder et al., 2012; Diefendorff et al., 2010; Matsumoto et al., 2008; Yamamoto & Suzuki, 2006). It must be noted (and will be discussed in more detail below) that the present researcher manipulation could not exclude all factors not constituting cultural similarity. However, these data that lie in agreement with previously demonstrated findings on closeness of affiliation, suggest that even if non cultural similarity factors were driving the present effects (e.g. novelty; perceived expectancies), these factors may also be relevant to differences in closeness of affiliation.

In the similar context in response to positive stimuli, there was also a reduction in the amplitude of the parietal LPP component, which was not significant in the dissimilar context. This component is thought to reflect the motivational relevance of stimuli and has shown an association with emotional arousal (e.g. Hajcak & Nieuwenhuis, 2006). We know from work on instructed emotion regulation that some explicit emotion regulation strategies can have greater effects on emotional expression than experience, and others can show the reverse pattern (e.g. Goldin et al., 2008; Gross & John, 2003), and these two aspects of emotional responding exist within multiple interacting response systems (Urry, 2009). Thus, it is possible that the effect of the similar researcher on emotional responding to positive stimuli was not just quantitatively different to that of the dissimilar researcher, but also qualitatively different affecting a different combination of emotion response systems. In line with this interpretation, when compared directly, changes in self-reports of emotional experience have been demonstrated in the presence of more closely affiliated (friends) but not less closely affiliated (strangers) partners (Hess et al., 1995), suggesting that one aspect of emotional experience may be modulated specifically by the presence of closely affiliated partners.

The effect of the similar context on responding to negative emotions

Contrary to responding to positive stimuli, the differential N1 amplitude to negative stimuli was increased in the presence of the similar researcher, reflecting increased attentional capture of negative stimuli, in the presence of the similar relative to the dissimilar researcher. If we assume that the comparative presence of a culturally similar relative to a dissimilar researcher increases perceived closeness of affiliation, then this finding is in line with the social facilitation of sadness that has been demonstrated in the presence of friends (Fridlund et al., 1992; Gehricke & Fridlund, 2002; Gehricke & Shapiro, 2000, 2001; Yamamoto & Suzuki, 2006)

A possible interpretation of this result is in line with the account, suggesting that the presence of a social partner can initiate a different interpretation of the emotional stimulus (Section 4.3), which affects attentional capture by the stimulus. It has been demonstrated that people are more accurate at perceiving the facial expressions of individuals from their own cultural group than those from a different cultural group (Adams et al., 2010; Dailey et al., 2010). Thus, it is possible that increased information was available to participants on the similar researcher's negative emotions compared to the dissimilar researcher's emotions, resulting in a more negative interpretation of the negative stimuli in the similar context only. However, it must be remembered that in the present design, participants were not looking at the researchers during stimulus presentation so detailed information on the researchers' behaviour was not available on a trial by trial basis. It remains possible, however, that participants' previous experience with members of their own cultural group allowed them to imagine the similar researcher's emotional behaviour more than that of the dissimilar researcher. Alternatively, further in line with the similar context-linked increase in attentional capture specifically for negative stimuli, it has been demonstrated that increased willingness to express negative emotions is associated with increased quality and quantity of social relationships (Graham, Huang, Clark, & Helgeson, 2008) but that in addition to perception of facial expressions of emotion, perception of empathy is also enhanced in people from the same compared to a different cultural group (Hein, Silani, Preuschoff, Batson, & Singer, 2010; Xu, Zuo, Wang, & Han, 2009). Thus, the similar researcher may have proportioned a specific set of perceived expectations or goals to participants that led to a more negative interpretation of negative stimuli.

Concluding remarks and limitations

ERP-indexed changes in emotional responding across social contexts, indicated context-linked modulation in attentional capture by emotional stimuli. For positive stimuli, decreased attentional capture was demonstrated in the presence of both culturally similar and dissimilar researchers and there was a corresponding increase in an ERP component assumed to index increased engagement of cognitive control resources, but this effect was stronger in the dissimilar context. We propose that the presence of a social partner may have initiated a more global focus of attention or provided additional information which was included by participants in their construal of stimuli and resulted in a different interpretation. Changes in an ERP component indexing reduced motivational experience of emotion specifically in the presence of positive stimuli in the similar context, suggest that culturally similar versus dissimilar social contexts may initiate alterations on emotional response systems with qualitative differences. Contrary to response to positive stimuli, in the presence of a culturally similar researcher there was a specific increase in attentional capture by negative stimuli. This may relate to an altered interpretation of negative stimuli in line with participants' expectations about the similar researcher's behaviour or preferences.

The present study relied on self-report and ERP measurements. Against a backdrop of the complexity of emotional responding, which comprises changes to multiple response systems, relying on these two measures in the absence of other physiological or behavioural data could be viewed as a limitation. However, other studies on emotional responding that have employed an array of different measures have often not demonstrated high correspondence between these (Bernat et al., 2011; Urry, 2009). We did video record participants' facial expressions during the present procedure but preliminary inspection of these data revealed too few observable facial movements in any condition to perform any informative analyses. Directly measuring facial electromyographic signals to index facial expression may be a better approach for future studies in this line.

An additional limitation which should be highlighted is the assumed capacity of the present manipulation to alter perceived degree of cultural similarity to social partners at the exclusion of other differences between the interpersonal contexts that could potentially have affected the results. Although the present manipulation check ratings showed that only characteristics linked to degree of similarity in cultural beliefs and values, and not other personal characteristics measured, significantly differed between the two researchers, it is possible that the researchers differed in an unmeasured characteristic that may have affected results. In addition, participants rated the Chinese researcher as significantly more familiar than the British researcher. Participants' level of exposure to researchers was controlled as far as possible, although some verbal instruction by the Chinese researcher could not be avoided and this may have contributed to the difference in familiarity ratings. Although familiarity scores were not associated with the neural effects reported, the differences in reported familiarity suggest that the British researcher may have been perceived as more novel than the Chinese researcher. Thus, future research employing alternative methods to control for differences in interpersonal context that are not linked to cultural similarity would further our understanding of this phenomenon.

Due to time restrictions, we did not assess participants' attitudes towards British people therefore we cannot draw inferences about the degree to which idiosyncratic attitudes about British may have influenced participant's responding. Anecdotally, there does not appear to be a strong differential opinion adhered to about British people by those from mainland China. In fact there is a word in standard Chinese that is often used to refer collectively to people from Europe and the US. Thus, we would not predict differential attitudes to people from specific European countries to play a strong role in participants' responding. It is, however, very possible that participants' attitudes towards European/European American people in general may be an important factor feeding into individual differences in emotional responding observed in the present study and this is an important area for future research.

There were gross increases in reported arousal for negative versus positive stimuli. These differences are in line with previously published normative ratings (Lang et al., 2005) and thus support the experimental integrity of the

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present paradigm. However, it must be noted that the present differences reported between responses to positive and negative stimuli could potentially be driven by differences in arousal rather than valence. Given that in general larger effects were reported here for the positive (less arousing) stimuli, this interpretation seems less likely. Future research employing positive and negative stimuli matched on ratings of arousal would help to address this issue.

Finally, the present study was conducted against a Chinese (collectivist) cultural backdrop whereas the vast majority of previous research on emotional responding across social context and emotion regulation has been conducted in European/European American (individualist) cultural contexts. Research has demonstrated that display rules differ across individualist versus collectivist cultural contexts (e.g. Matsumoto et al., 2008), as may emotion regulation processes (Murata et al., in press). Thus, it is possible that the profile of social context driven changes in emotional responding suggested by the present data is influenced by the specific social emotional learning that is an integral part of Chinese culture. Future research with other cultural groups and cross-cultural comparisons would help address this question.

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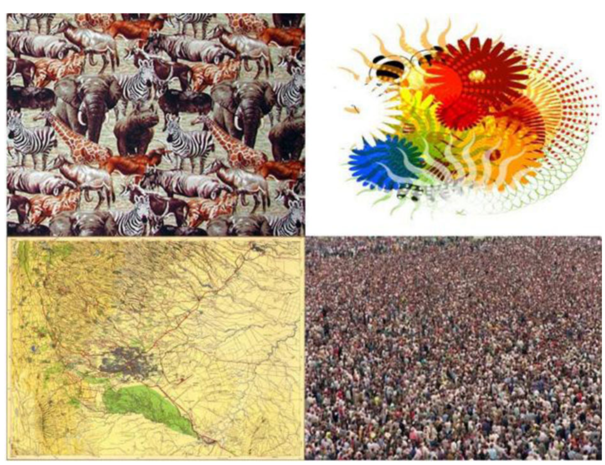
Appendix A

Figure A1 shows the four task irrelevant images that were obtained from the World Wide Web and presented to participants, one at the beginning of each block, in the same random order across superblocks for one participant, but in a different random order for each participant.



Appendix B

Block 1: Negative: 9265; 9419; 3061; 9560; 9480; 9409; 9901; 9611; 2703; 9433; 9425; 9570; 6570; 3140; 6260; 9635.1; 3068; 6510; 3500; 3010; mean arousal: 6.03; mean valence: 2.30

Neutral: 7175; 7080; 7100; 7059; 7205; 7052; 7500; 7043; 7190; 7054 mean arousal: 3.05; mean valence: 5.13

Block 2: Negative: 9041; 9340; 9426; 2800; 9495; 3101; 9571; 9490; 9042; 2691; 3015; 9620; 6834; 6210; 9921; 3102; 3266; 3130; 9410; 3080; mean arousal: 6.02; mean valence: 2.35

Neutral: 7187; 7041; 7025; 7140; 7009; 7170; 7186; 7242; 7042; 7188; mean arousal: 3.25; mean valence: 5.12

Block 3: Negative: 9561; 6610; 6825; 9520; 9427; 3062; 6555; 9120; 9420; 9500; 9902; 9405; 6415; 3064; 9600; 6300; 3530; 3100; 3069; 3000; mean arousal: 6.01; mean valence: 2.36

Neutral: 7010; 7006; 7150; 7050; 7700; 7055; 7039; 7184; 7237; 7046; mean arousal: 3.04; mean valence: 4.90

Block 4: Negative: 9180; 9470; 9140; 9181; 6831; 9925; 9428; 9230; 9040; 3016; 6212; 9630; 2683; 9050; 6370; 3110; 3120; 3071; 3060; 6230; mean arousal: 6.05; mean valence: 2.40

Neutral: 7950; 7060; 7040; 7900; 7038; 7002; 7130; 7590; 7182; 7248; mean arousal: 3.17; mean valence: 5.03

Block 5: Positive: 2304; 2310; 2395; 2306; 5982; 5994; 5820; 7488; 5830; 7330; 1722; 5628; 2303; 5260; 5833; 5470; 8192; 5629; 5950; 8030; mean arousal: 5.29; mean valence: 7.09

Neutral: 7004; 7491; 7090; 7233; 7053; 7034; 7036; 7037; 7044; 7247; mean arousal: 3.09; mean valence: 4.97

Block 6: Positive: 5781; 1500; 1740; 1810; 2154; 5890; 7430; 4625; 1811; 5600; 1710; 2345; 5910; 5700; 8380; 7640; 8193; 8501; 8180; 8400; mean arousal: 5.27; mean valence: 7.19

Neutral: 7110; 5130; 7035; 7179; 7030; 9210; 7207; 7236; 7096; 7095; mean arousal: 3.19; mean valence: 5.06

Block 7: Positive: 5611; 1750; 1510; 5990; 2373; 1731; 2344; 5660; 7289; 1720; 5480; 1560; 2389; 7270; 7502; 8170; 8190; 8191; 8178; 5621; mean arousal: 5.34; mean valence: 7.06

Neutral: 7020; 7000; 7185; 7224; 7234; 7183; 7192; 7595; 7249; 7211; mean arousal: 3.23; mean valence: 4.96

Block 8: Positive: 1600; 2222; 1460; 5300; 1721; 5455; 1590; 1463; 7260; 1640; 2346; 5270; 7600; 8090; 5450; 5460; 8185; 1650; 8080; 8186; mean arousal: 5.32; mean valence: 7.07

Neutral: 7031; 7217; 7705; 7235; 7161; 7056; 7057; 5120; 7058; 7238; mean arousal: 3.06; mean valence: 5.06

Appendix C: Online ERQ

Positive Version

1. I wanted to feel more positive emotion (such as joy or amusement), so I changed what I was thinking about
2. I kept my emotions to myself
3. When I was feeling positive emotions, I was careful not to express them
4. I was faced with a stressful situation, so I made myself think about it in a way that helped me stay calm
5. I controlled my emotions by not expressing them
6. I wanted to feel more positive emotion, so I changed the way I was thinking about the situation
7. I controlled my emotions by changing the way I thought about the situation I was in
8. I wanted to feel less positive emotion (such as joy or amusement), so I changed what I was thinking about
9. I wanted to feel less positive emotion, so I changed the way I was thinking about the situation

Expressive Suppression of Positive Emotion:

- Mean of P2, P3 & P5

Up-reappraisal of Positive Emotion:

- Mean of P1 & P6

Down-reappraisal of Positive Emotion:

- Mean of P8 & P9

Negative Version

1. I kept my emotions to myself
2. I wanted to feel less negative emotion (such as sadness or anger), so I changed what I was thinking about
3. I was faced with a stressful situation, so I made myself think about it in a way that helped me stay calm
4. I controlled my emotions by not expressing them
5. I controlled my emotions by changing the way I thought about the situation I was in
6. When I was feeling negative emotions, I made sure not to express them
7. I wanted to feel less negative emotion, so I changed the way I was thinking about the situation

8. I wanted to feel more negative emotion (such as sadness or anger), so I changed what I was thinking about
9. I wanted to feel more negative emotion, so I changed the way I was thinking about the situation

Expressive Suppression of Negative Emotion:

– Mean of N1, N4 & N6

Up-reappraisal of Negative Emotion:

– Mean of N8 & N9

Down-reappraisal of Negative Emotion:

– Mean of N2 & N7

Appendix D: Manipulation Check Questionnaire

Indicate your agreement with the following times in a 9-point Likert-type format. 1 = strongly disagree, 9 = strongly agree. Higher scores for each item indicate that you agree more strongly with the statement.

1. The Chinese researcher who I met today is from a similar cultural group as me
2. The British researcher who I met today is from a similar cultural group to me
3. The traditions and customs that I usually follow are similar to those followed by the Chinese researcher who I met today
4. The traditions and customs that I usually follow are similar to those followed by the British researcher who I met today
5. I probably have similar beliefs and values to the Chinese researcher I met today
6. I probably have similar beliefs and values to the British researcher I met today
7. I probably had similar experiences while growing up to the Chinese researcher I met today
8. I probably had similar experiences while growing up to the British researcher I met today

Similarity to Chinese researcher

– Mean of 1, 3, 5 & 7

Similarity to British researcher

– Mean of 2, 4, 6 & 8

Appendix E: Background Questionnaire

Please answer the questions below using the specified formats where these are given.

Participant ID number

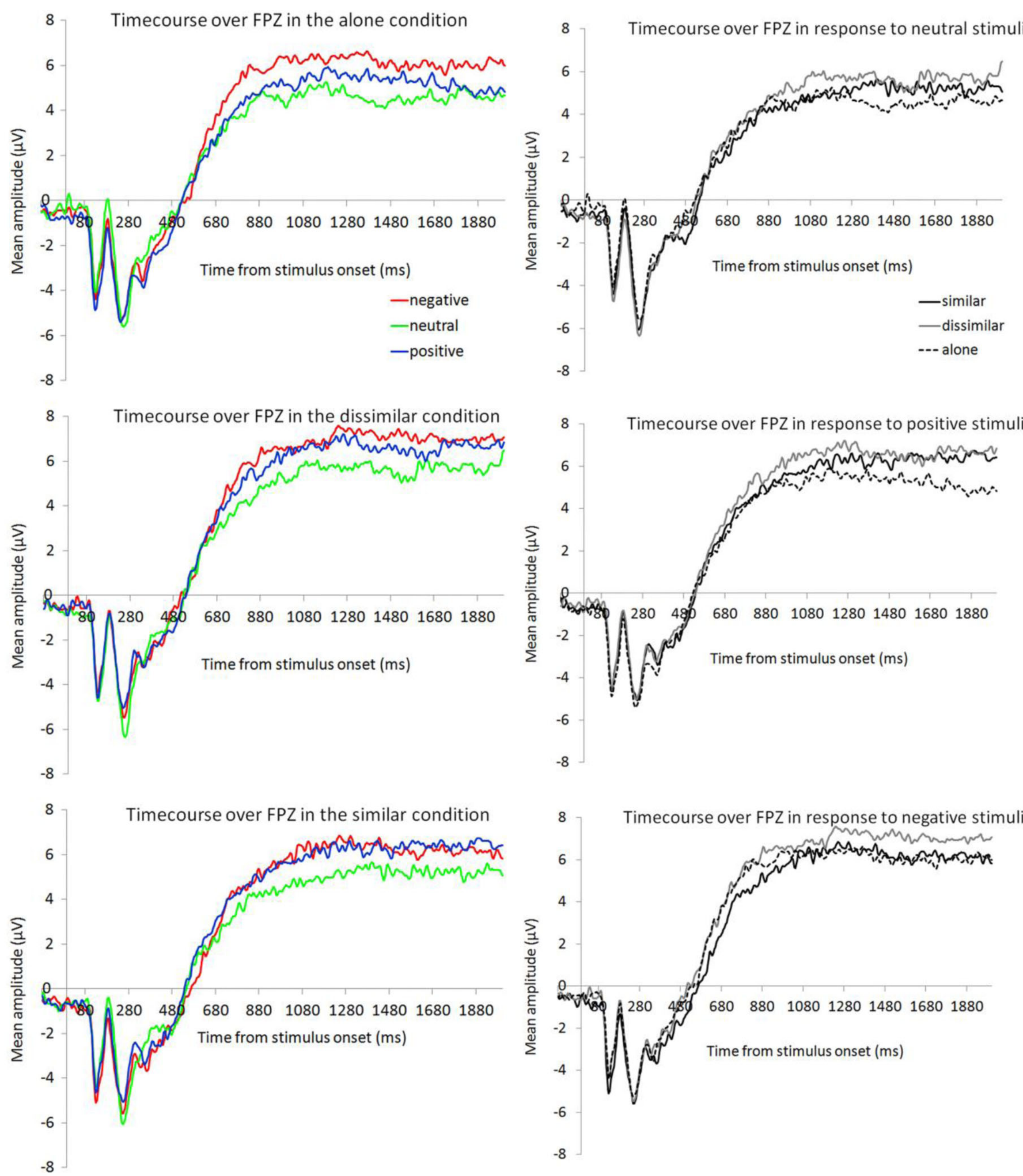
1. What is your gender (male/female)?
2. What is the date today? (yyyymmdd)
3. What is your date of birth? (yyyymmdd)
4. What is your nationality?
5. What is your native (first) language?
6. Are you right handed or left handed?
7. How long have you spent in China (including Hong Kong, Macao and Taiwan)? (years, months)
8. How long have you spent in other countries in East Asia (including Japan, Korea and Mongolia)? (years, months)
9. How long have you spent in Europe, the United States or Canada? (years, months)
10. Have you lived anywhere else in the world? if "yes" please go to question 12, if "no" please go to question 13
11. Which other countries (not in East Asia, Europe, the United States or Canada) have you lived in and for how long (years, months)?
12. Where do you consider to be your "home town" (the place where you are from)? (Town, City, Country)
13. Are you a fluent English speaker? (yes, no) if "yes" go to question 15, if "no" go to question 16

14. How many years have you been a fluent speaker of English?
15. Are you a fluent Chinese speaker (including any regional Chinese language/dialect)? if “yes” go to question 17, if “no” go to END
16. Which Chinese language(s) do you speak fluently?
17. How long have you been a fluent speaker of Chinese?

END

Appendix F

Figure F shows the ERP time course over FPZ comparing responses to positive, negative and neutral stimuli in alone, dissimilar and similar conditions respectively; and comparing responses in alone, dissimilar and similar conditions to neutral, positive and negative stimuli respectively.



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