RUNNING HEAD: Empathy and context in face-processing ERPs

The effect of empathy and context on face-processing ERPs

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Highlights

- Empathy levels modulate the EPN in response to faces of different characters
- Very low or high empathy is associated with relatively large EPN amplitude
- Low empathy may elicit more distinct EPN amplitudes to different characters

Abstract

The investigation of emotional face processing has largely used faces devoid of context, and does not account for within-perceiver differences in empathy. The importance of context in face perception has become apparent in recent years. This study examined the interaction of the contextual factors of facial expression, knowledge of a person's character, and within-perceiver empathy levels on face processing event-related potentials (ERPs). Forty-two adult participants learned background information about six individuals' character. Three types of character were described, in which the character was depicted as deliberately causing harm to others, accidentally causing harm to others, or undertaking neutral actions. Subsequently, EEG was recorded while participants viewed the characters' faces displaying neutral or emotional expressions. Participants' empathy was assessed using the Empathy Quotient survey. Results showed a significant interaction of character type and empathy on the early posterior negativity (EPN) ERP component. These results suggested that for those with either low or high empathy, more attention was paid to the face stimuli, with more distinction between the different characters. In contrast, those in the middle range of empathy tended to produce smaller EPN with less distinction between character types. Findings highlight the importance of trait empathy in accounting for how faces in context are perceived.

Keywords: Event-related potentials (ERP); face processing; empathy; context.

1. Introduction

Facial expressions convey information crucial for social interaction. The meaning of a facial expression, however, is not obtained from the expression alone, but also from an array of contextual information. Visual context, such as the position of the body (Aviezer, Bentin, Dudarev, & Hassin, 2011), the expression on surrounding faces (Hess, Dietrich, Kafetsios, Elkabetz, & Hareli, 2019), or the scene in which the face appears (Ngo & Isaacowitz, 2015), have all been shown to influence how a face is perceived. Non-visual contextual information, such as knowledge of an individual's recent experiences (Dieguez-Risco, Aguado, Albert, & Hinojosa, 2013, 2015), or their personality or prior behaviours, has also been suggested to influence the visual perception of their face (Abdel Rahman, 2011; Luo, Wang, Dzhelyova, Huang, & Mo, 2016). Additionally, within-perceiver context, including personality traits such as levels of empathy, extraversion, or anxiety, appear to play a role in how other faces are perceived (Balconi & Canavesio, 2016; Canli, Sivers, Whitfield, Gotlib, & Gabrieli, 2002; Muhlberger et al., 2009). This study sought to examine how several types of context are integrated to influence the neural response to faces. Specifically, we investigated how face perception is modulated by the integration of facial expression, information about an individual's behaviours, and the perceiver's level of empathy.

1.1 The influence of facial expression context on face processing

In the absence of any other context, different facial expressions are comprehended differently. For instance, a face with downward turned eyebrows, staring eyes, and tightly pressed lips is typically recognised, both quickly and accurately, as angry or threatening. The fast recognition of such an expression is important to prompt appropriate avoidance or approach actions. The rapid processing of different emotional expressions is reflected in a heightened neural response in comparison to faces with a neutral expression (Hinojosa, Mercado, & Carretie, 2015; Kesler et al., 2001; Wright, Martis, Shin, Fischer, & Rauch, 2002). Furthermore, within a single category of emotional expression (e.g., anger), a more intense expression elicits a more enhanced response (e.g., Muller-Bardorff et al., 2016; Winston, O'Doherty, & Dolan, 2003).

From a neural perspective, the brain response to emotional versus neutral expressions begins to differ early in the automatic sensory perception stage of face-processing, with differences arising by around 150 ms post stimulus onset (Hinojosa et al., 2015), and perhaps even earlier (Luo, Holroyd, Jones, Hendler, & Blair, 2007). The enhanced processing for

emotional faces continues through to later evaluative stages (e.g., Fruhholz, Jellinghaus, & Herrmann, 2011; Rellecke, Palazova, Sommer, & Schacht, 2011). Thus, emotional face expressions produce varying neural responses in the perceiver, even when no other context is provided. However, as noted, expressions are not often viewed in isolation of any other information.

1.2 The influence of character context on face processing

Humans often encounter facial expressions that are interpreted in relation to knowledge of that person's previous behaviours. For instance, a look of anger on the face of a person with a known violent history is likely to be perceived differently to a look of anger on a known pacifist. Indeed, research has shown an influence of prior behavioural knowledge, or 'character context,' on not only the explicit judgment of a person (e.g., Abdel Rahman, 2011), but also the neural response to subsequent observations of that person's face (e.g., Kim et al., 2004; Morel, Beaucousin, Perrin, & George, 2012; Suess, Rabovsky, & Abdel Rahman, 2015). To date, this research has only been conducted using faces with neutral or surprised expressions. It appears that a neutral expression on a face associated with a negative or positive character elicits a neural response akin to that of processing an emotional face expression (e.g., Li, Zhu, Ding, Ren, & Luo, 2019; Luo et al., 2016; Suess et al., 2015). This potentially reflects the rapid, top-down modulation of facial structural perception by the abstract, emotional, character context. That is, the emotional information provided by the character context is integrated with the otherwise neutral expression, so that the face is perceived as more emotional. While some studies suggest that this integration influences early visual processing (e.g., Luo et al., 2016; Morel et al., 2012; Rellecke, Sommer, & Schacht, 2012), others indicate that the influence is on later affective or evaluative stages of face processing (e.g., Abdel Rahman, 2011; Klein, Iffland, Schindler, Wabnitz, & Neuner, 2015; Li et al., 2019).

It may be that not all types of character context influence face processing equally. Very few studies have examined different types of character beyond general valence. Findings suggest it may be that contextual information that includes social interactions, or information directly relevant to the perceiver, are more likely to modulate face processing at the neural level (e.g., Li et al., 2019; Wieser et al., 2014; Xu, Li, Diao, Fan, & Yang, 2016). This may be because context that highlights social interactions or personally relevant information is considered most important or relevant in forming an overall impression of an

individual. The stronger overall impression of someone as positive or negative in turn may lead to stronger modulation of neural activity in response to that individual's face. One aspect that has not been investigated is whether the *intention* behind the behaviours of the character context also differentiates the neural response to the character's face. The intention behind an action has been shown to influence how we explicitly judge those actions, such that a deliberately harmful action is judged more negatively than the same action conducted without knowledge of the consequences (Chakroff et al., 2016; Cushman, 2008; Young & Saxe, 2011). However, how these judgments might influence later perception of a character's face is unknown.

While no studies have examined the influence of intention in relation to emotional face processing, evidence does show that perceiving intention can modulate neural activity. Decety and Cacioppo (2012) had participants view interactions of two people, in which one person intentionally or unintentionally harmed the other. It was shown that as participants observed the interaction, the neural response differed depending on the intentionality of the characters. This response differed from early information processing stages, within the first 100 ms post-stimulus onset. Results were interpreted as highlighting the importance of the automatic perception of intention in building understanding of social interactions. Similar results have been found for processing intention related to observation of simple actions such as reaching for an object (Iacoboni et al., 2005; Ortigue, Thompson, Parasuraman, & Grafton, 2009), and for processing intention of characters in a written sentence (Van der Cruyssen, Van Duynslaeger, Cortoos, & Van Overwalle, 2009). Overall, findings show that the intention behind actions or behaviours is processed quickly, and can be delineated by the brain's response to those actions. Yet, how and when intention might be integrated into later viewing of those characters is unknown. Given the importance of understanding intention in social situations, it may be that intention information in character context modulates the neural activity elicited by later viewings of the character's face. To examine the influence of intention in character context, and particularly to investigate the *timing* that it might impact face processing, this study made use of the high temporal resolution of electrophysiology (EEG) and event-related potentials (ERPs).

1.3 Face processing event-related potentials (ERPs)

The ERP components sensitive to emotional face processing include the N170, the early posterior negativity (EPN), and the late positive potential (LPP). The N170 shows

enhanced amplitudes between approximately 130 and 200 ms for face relative to non-face stimuli, and is maximal at occipito-temporal sites (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Eimer, 2000; Itier & Taylor, 2004). The N170 is thought to reflect the structural representation of faces (Eimer, 2000). It is sensitive to emotional expression, with larger amplitudes for emotional compared to neutral faces, particularly for expressions of anger and fear (Hinojosa et al., 2015). Larger N170 amplitudes have also been shown for more intense facial expressions (Muller-Bardorff et al., 2016; Recio, Schacht, & Sommer, 2014; Sprengelmeyer & Jentzsch, 2006; Utama, Takemoto, Koike, & Nakamura, 2009).

There is some evidence suggesting that the N170 is also modulated by character context. Two studies have reported a larger N170 for neutral (Luo et al., 2016) or surprised (Li et al., 2019) faces previously paired with brief, negative statements, than faces paired with positive or neutral statements. These results suggest that the negative character information was rapidly integrated with the face, influencing how the face was processed. However, several other studies have not found that the N170 is modulated by character context, with comparable amplitudes for neutral faces associated with negative, positive, or neutral context (Kanunikov & Pavlova, 2017; Klein et al., 2015; Wieser et al., 2014; Xu et al., 2016). Thus, while the N170 is influenced by emotional expression, it is not yet clear under which circumstances it might be influenced by character context.

The EPN occurs after the N170, typically starting around 150-200 ms post stimulus onset. The EPN is a relative negativity, occurring over occipito-temporal sites, for emotionally arousing stimuli, including emotional face expressions (Junghofer, Bradley, Elbert, & Lang, 2001; Rellecke et al., 2011; Schacht & Sommer, 2009; Schupp, Junghofer, Weike, & Hamm, 2003). The EPN is considered to reflect early motivated attention, and facilitated sensory processing, of affective stimuli. As with the N170, the EPN is larger (i.e., more negative) for emotional than neutral face expressions, and this effect may be largest for expressions of anger or fear, and for more intense expressions (Muller-Bardorff et al., 2016; Recio et al., 2014; Schupp et al., 2004).

The EPN appears to be modulated by character context. Neutral faces paired with negative character statements or stories have been shown to elicit an enhanced EPN in comparison to those paired with positive or neutral context (Abdel Rahman, 2011; Luo et al., 2016; Suess et al., 2015; Wieser et al., 2014; Xu et al., 2016). The EPN has also been modulated for positive characters if they are well-known (e.g., Nelson Mandela; Abdel

Rahman, 2011; Suess et al., 2015), or include positive ‘ability’-related context (e.g., “*He mastered five foreign languages skilfully*”; Zhao et al., 2017), though stronger modulation may be elicited by characters with some degree of threatening behaviour (Klein et al., 2015; Schupp et al., 2004). Overall, modulation of the EPN by character context has been interpreted as showing that character context modifies the encoding of the face, and draws attention to the face as an affective stimulus.

The LPP occurs over centro-parietal regions and begins around 300 ms post stimulus onset. It is a long-lasting response that reflects sustained, elaborative, and evaluative processing of emotional stimuli (Hajcak, Dunning, & Foti, 2009; Schupp et al., 2003). In terms of face-processing, larger LPPs are elicited by both positive and negative emotional expressions than neutral expressions (Fruhholz et al., 2011; Schupp et al., 2004). There is some evidence that the LPP is also sensitive to expression intensity, with more intense expressions eliciting a more pronounced LPP (Duval, Moser, Huppert, & Simons, 2013; Recio et al., 2014). Furthermore, evidence suggests that the LPP is sensitive to whether a displayed expression is congruent with expectations, with a larger LPP in response to an expression that is incongruent with the situation (Dieguez-Risco et al., 2013, 2015). Findings are mixed regarding the modulation of the LPP by character context. While some studies have reported larger LPPs for faces associated with negative (Abdel Rahman, 2011; Li et al., 2019; Xu et al., 2016) or positive (Luo et al., 2016) character context, others have reported no effect of character context (Demel, Waldmann, & Schacht, 2019; Klein et al., 2015; Wieser et al., 2014). Given that integrating previous context with a face presumably involves higher-order processing, it might be expected that the LPP is modulated by character context. The null findings reported in some studies possibly reflect methodological differences, such as the particular electrode sites selected or the intensity of the character information. However, taken together it is currently unclear under which circumstances the LPP is modulated by prior character context.

1.4 The influence of within-perceiver empathy on face processing

As mentioned, within-perceiver context has also been shown to influence face processing. One variable that may be particularly important is an individual’s level of empathy. Empathy involves both sharing another’s emotions (affective empathy) and understanding another’s experience (cognitive empathy). As facial expressions contain information about an emotional state, the ability to ‘read’ another’s emotions from their facial

expression is tightly linked with one's empathic ability. Research shows that higher empathy is associated with faster (Soria Bauser, Thoma, & Suchan, 2012) and more accurate (e.g., Besel & Yuille, 2010; Lawrence, Shaw, Baker, Baron-Cohen, & David, 2004) identification of emotional face expressions. During emotional face processing, higher empathy is also associated with neural activity that is more distinct to the expression being observed (Chakrabarti, Bullmore, & Baron-Cohen, 2006). Taken together, these findings reflect superior categorising of emotional face expressions by individuals with higher empathy. Very few studies have examined the relationship between empathy and face processing ERPs. Evidence suggests that N170 and LPP amplitudes are enhanced for those with higher empathy (Balconi & Canavesio, 2016; Choi et al., 2014; Choi & Watanuki, 2014). These findings might reflect enhanced salience or sensitivity of emotional stimuli for individuals with higher empathy. While these studies show that empathy and emotional face processing are related, these relationships have not been examined in relation to character context, which seems even more relevant to trait empathy.

Empathy may be associated with enhanced integration of character context in facial emotion processing. Empathic processing in general requires the integration of a range of contextual variables (e.g., Engen & Singer, 2013). The specific details of a situation, such as the behaviours of the people involved, their backgrounds, intentions, capabilities, and emotions, are evaluated in order to elicit an appropriate empathic response. Research has shown that the same outcome, set within different contexts, can elicit different levels of empathy. For example, when observing someone in a physically painful situation, the empathic brain response is greater if the pain was deliberately caused by another (Akitsuki & Decety, 2009), or if the person in pain is considered a fair (Singer et al., 2006; Zheng et al., 2016) or moral (Cui, Ma, & Luo, 2016) character. It may be that individuals with higher levels of empathy are more adept at integrating context to produce empathic responses. Thus, it may follow that the neural response is more sensitive to contextual differences for those with higher empathy.

1.5 The current study

In the current study, the N170, EPN, and LPP were used to examine the neural response to faces paired with different combinations of contextual information. Participants were first shown faces that were matched with vignettes depicting characters who intentionally or unintentionally harmed others, or took part in neutral actions. After learning

the face-character pairings, participants had EEG recorded while they viewed these faces displaying neutral or emotional expressions. Empathy was measured with a commonly used self-report questionnaire.

It was hypothesised that the ERP components would be sensitive to character type, with larger components for the characters who had intentionally harmed others. It was expected that there would be an interaction with expression, such that larger ERP components would be elicited by negative expressions for intentionally harmful characters. It was also hypothesised that the ERP components would differ between conditions more for those with higher than lower levels of empathy.

2. Method

2.1 Participants

There were 46 participants (34 female) recruited into the study. Data from four participants were excluded due to technical problems ($n = 3$) or excessive EEG artefact ($n = 1$). Thus, the final sample included data for a total of 42 participants (30 female). The age of these 42 participants ranged from 18 to 33 years ($M = 24.36$ years, $SD = 3.74$ years). All participants self-reported as right-handed, and with no current or previous diagnosis of developmental or psychiatric disorders. The highest level of education completed was secondary school for 17 participants (15 of whom were undergraduate students at the time of participation), an undergraduate degree for 23 participants (six of whom were postgraduate students at the time of participation), and two participants had completed postgraduate studies.

2.2 Materials

2.2.1 Face stimuli. Face stimuli were taken from the NimStim set of facial expressions (Tottenham et al., 2009). From this set, six models were selected (3 male, 3 female; model numbers 3, 9, 17, 22, 36, 38), and photos of each model depicting anger, disgust, happiness, and neutrality were selected. Anger and happiness were selected to provide key examples of negative and positive emotions, respectively. The additional negative expression of disgust was also selected because it was thought its role as a moral emotion (Haidt, 2003; Pizarro, Inbar, & Helion, 2011) might reveal sensitivity to the moral elements in the character vignettes (see below), and by extension to participant's empathy levels (Decety & Cowell, 2014). Two versions of each expression (one with mouth open, one mouth closed) were

used. This resulted in a total of 48 pictures. Models were chosen to provide a mix of ethnicities, and only models whose expressions were easily recognisable were selected. Specifically, only models whose expressions were correctly rated as the intended expression by at least 80% of respondents in the original validation were used (Tottenham et al., 2009). The photos were shown in colour, with a grey oval mask over the face in order to minimise visible hair and clothing (see Figure 1).

2.2.2 Vignettes. Six vignettes were created, which portrayed the character undertaking intentionally negative behaviour, unintentionally negative behaviour, or neutral behaviour. A male and female character were assigned to each of the three types of character. The negative vignettes each portrayed the character violating the moral foundations of harm (i.e., causing physical harm on another person) and fairness (Graham et al., 2011). For example, negative characters intentionally or unintentionally pushed other people over, and cheated on tests. Neutral characters were depicted undertaking regular tasks (painting, unpacking boxes). Full vignettes are presented in the Appendix. Each story was read by an adult female and recorded for later presentation to participants. The duration of each recording was approximately 34 seconds.

Three sets of model-vignette combinations were made. Male and female models were randomly assigned as pairs, and each pair was assigned to a different vignette type in each of the three sets. Thus, in one set a pair of male and female models were associated with the intentionally negative character, in another set the same two models were associated with the unintentionally negative character, and in the final set with the neutral character. Participants were allocated a set randomly. This was to control for possible biases towards any particular model.

2.2.3 Face emotion processing task

2.2.3.1 Familiarisation phase. The face emotion processing task began with a familiarisation phase. Participants were informed that they would learn information about six different individuals, and that they needed to remember which person was which.

Participants were first shown a screen with six faces (all displaying neutral expressions), which was displayed for 4000 ms. Next, each neutral face (mouth closed) was shown on screen and the accompanying vignette was presented in both written form on screen, and auditory form played over speakers. Each face and vignette pair was displayed for 40 seconds. The order in which the characters were presented was randomised. After all

six characters had been displayed, participants were able to revise the information by clicking back through the screens that showed the face and written story, or continue immediately to the test phase (8 participants revised the information before continuing to the test phase).

To ensure that the participants had learned which face was associated with which story, a test phase followed. Participants were shown one of the six faces in the centre of the screen. The face was surrounded by shortened versions of each of the six vignettes. Participants were required to click on the vignette that matched the face on screen. If the wrong vignette was selected, participants were asked to try again. This continued until all six faces had been correctly associated with the vignettes. Nine participants made one ($n = 7$) or more ($n = 2$) errors before reaching 100% accuracy.

As a final check, participants indicated how positively or negatively they felt towards each character. One face was shown on screen, along with a scale asking participants to rate their “overall impression of this person” on a 7-point scale from -3 (*very negative*) to +3 (*very positive*).

A pilot study was undertaken before the main study to ensure that the vignettes had the intended explicit effect (i.e., that the intentionally negative character was considered more negative than the other character types). Fifteen adults (9 female; mean age 31 years [$SD = 4.93$]), none of whom participated in the main study, took part. Participants were shown a picture of each of the models, each displaying a neutral expression. One face was shown at a time, followed by a scale asking participants to rate their “overall impression of the person” on a scale from -3 (*very negative*) to +3 (*very positive*). Participants were then shown each face, this time with the accompanying vignette written on screen. Participants were asked to read the information about the person, and then to rate their overall impression of the person again. This was completed for each of the six face-vignette pairs. Ratings for the intentionally negative character were significantly more negative after reading the vignette (pre-vignette: $M = -0.60$ [$SD = 0.54$]; post-vignette: $M = -2.73$ [$SD = 0.63$]; $t(14) = 8.66$, $p < .001$). The neutral character was rated significantly more positively after their story (pre-vignette: $M = -0.43$ [$SD = 0.59$]; post-vignette: $M = 0.43$ [$SD = 0.82$]; $t(14) = -4.52$, $p < .001$). Ratings for the unintentionally negative character did not significantly differ post information (pre-vignette: $M = -0.07$ [$SD = 0.42$]; post-vignette: $M = 0.20$ [$SD = 0.53$]; $t(14) = -1.74$, $p = .104$). Thus, the vignettes broadly appeared to have the desired effect on the impression of the characters.

2.2.3.2 Face processing phase. In the main task, participants were seated so that their eyes were approximately 65 cm from the computer screen. Each trial began with a fixation screen that comprised a black fixation cross on a grey background. The fixation screen was displayed for 500-650 ms (within this range the duration was randomly selected on each trial). One of the 48 face stimuli were then displayed in the centre of the screen for 500 ms. A response screen then appeared. The response screen comprised the words ‘Angry’, ‘Disgust’, ‘Neutral’, and ‘Happy’. The participant was required to press a corresponding button to indicate which expression was displayed on the face on the preceding screen. The words were presented in the same location on every trial. The response screen was shown until a response was made, and no feedback was provided. An overview of a trial is shown in Figure 1. This explicit emotion categorisation task was used in order to determine whether the character context and participant’s empathy levels influenced how the facial expressions were perceived.

Figure 1. Timing of a single trial. Each trial comprised a fixation screen, the face stimulus, and a response screen.

Trials were presented in three blocks. Each block contained 144 trials. In each block, each of the 48 face stimuli (two photos displaying each of the four emotions, for each of the six characters) were shown three times. The order the faces were shown was random.

After the first and last blocks, participants completed the test phase from the familiarisation task again. This was to ensure that participants recalled which faces were

associated with which story (in each test phase, a maximum of 6 participants made one or more incorrect responses before reaching 100% accuracy). Participants took a self-timed break between blocks. E-prime 3.0 software (Psychology Software Tools, Pittsburgh, PA) was used to present the task and collect the behavioural responses.

2.2.4 Empathy Questionnaire

The 40-item version of the Empathy Quotient (Baron-Cohen & Wheelwright, 2004) was used to provide an indication of participants' overall empathy levels. The self-report questionnaire contains items that are considered to assess cognitive empathy, emotional reactivity, and social skills (Lawrence et al., 2004). The total score represents global empathy, and was the score used in the current study. Responses to each item are collected on a 4-point Likert scale ranging from strong disagreement to strong agreement. Responses are scored such that a higher score indicates a higher level of empathy, and the maximum possible score is 80. The Empathy Quotient has been shown to have high test-retest reliability, and moderate correlations with other self-report and experimental indicators of empathy (Baron-Cohen & Wheelwright, 2004; Lawrence et al., 2004).

2.3 EEG acquisition and processing

During the face processing phase of the task, EEG was recorded using a 64-channel geodesic sensor net (Electrical Geodesics, Inc., Eugene, OR, USA). Figure 2 shows the electrode placements for the sensor net, which includes EOG electrodes. Data were acquired via NetStation 5.0 software, at a sampling rate of 1000 Hz, with Cz as the online reference. Before recording began, impedances were reduced to under 50 k Ω . In order to allow grouping of trials during offline processing, triggers corresponding to the type of trial (character type, expression displayed) were sent from E-prime to NetStation online. A photosensor attached to the experimental computer monitor also sent a trigger each time a face stimulus was displayed. Due to its precise timing, the photosensor trigger was used to define stimulus onset for offline processing.

Figure 2. Diagram of electrode placements in the 64-channel sensor net. The eight occipito-temporal channels (circled in red) were averaged for the N170 and EPN components. The eight centro-parietal electrodes (circled in green) comprise the LPP channels.

Offline EEG data processing was undertaken using MATLAB R2018a (The MathWorks Inc., Natick, MA, USA), and EEGLAB 2019.0 (Delorme & Makeig, 2004) and ERPLAB 7.0.0 (Lopez-Calderon & Luck, 2014) toolboxes. The EEG data were first downsampled to 500 Hz, and a bandpass filter of 0.5 – 30 Hz was applied. Stimulus-locked epochs were generated from the continuous data, from -150 ms to 600 ms referenced to stimulus onset. Channels were identified as bad via visual inspection, or if the kurtosis value was more than five standard deviations from the mean. These channels were interpolated from surrounding channels, using a spherical interpolation. Epochs containing data that exceeded ± 500 μ V were excluded, and data were re-referenced to the common average. To identify ocular and non-ocular artefacts, independent components analysis was undertaken, with bad components identified with assistance from the ICLabel plugin (Pion-Tonachini, Kreutz-Delgado, & Makeig, 2019). The EEG signal was corrected by the removal of components that were deemed artefactual. Any epochs that contained data that exceeded ± 100 μ V in amplitude were rejected. Remaining epochs were averaged, using the 150 ms pre-

stimulus onset as baseline. The average number of trials remaining for use in analyses was 409 (95% of trials).

To determine time-windows to identify components, the grand averaged waveform, averaged across all trial types, was inspected. For the N170 and EPN components, the grand average was inspected for combined occipito-temporal channels (TP9, TP10, P7, P8, PO9, PO10, O1, O2; see Figure 2). The N170 peak was defined for each participant as the most negative sample within the time window 100-180 ms post-stimulus onset. The EPN was defined as the average voltage within the 200-320 ms window, based on visual inspection as well as previous literature (Hammerschmidt, Sennhenn-Reulen, & Schacht, 2017; Luo et al., 2016). For the LPP component, centro-parietal electrodes were selected (C1, Cz, C2, CP1, CP2, P1, Pz, P2; see Figure 2). Based on visual inspection as well as previous literature (Fruhholz et al., 2011; Li et al., 2019), the average voltage within the window 320-570 ms was defined as the LPP, which can be considered an early LPP. The grand average waveform with the windows highlighted is displayed in Figure 3.

Figure 3. Grand average waveforms for occipito-temporal channels (left panel) and centro-parietal channels (right panel). Shaded areas represent the time-window in which the peak (N170) was identified, or the time-window that voltage was averaged across (EPN, LPP).

2.4 Procedure

The face processing task (including both the familiarisation phase and the main task) was completed in a single session. Participants were fitted with the EEG cap before commencing the familiarisation phase. The Empathy Quotient was completed after the face processing task. All participants provided written informed consent before taking part, and

all received a \$20 voucher for their participation. Ethical approval for the study was obtained from the Deakin University Human Research Ethics Committee (2018-036).

2.5 Data Analysis

Behavioural measures from the task were reaction time and accuracy. Reaction time measured the time (ms) taken from the onset of the response screen to any response. Only reaction times from accurate responses were included in analyses. Given that participants had to wait until the response screen to make the response, and that the response likely also involved cognitive processing in order to match the label on screen to the correct button, reaction time in this task may not be a sensitive indicator of emotional face processing speed. Furthermore, it is acknowledged that the location of the response options was the same for all participants, and thus there is the possibility of a response bias influencing results. Despite these limitations, behavioural data are reported here for completeness. One participant had very low accuracy (mean accuracy 52%), and their behavioural data (both reaction time and accuracy) were therefore excluded from analyses.

The dependent variables of reaction time, accuracy, and the three ERP components (N170, EPN, LPP), were each submitted to a linear mixed model, with participant ID entered as a random intercept, and gender as a covariate. The three fixed effects were Character Type (intentionally negative, unintentionally negative, neutral), Expression (neutral, angry, happy, disgusted), and Empathy. Each fixed effect as well as all combinations of their interactions were included in the models. Omnibus *F* tests were conducted to determine whether each fixed effect and interaction were significant predictors of the dependent variable. Where appropriate, significant findings were followed up with inspection of figures and comparisons of coefficients, or pairwise comparisons of means (*z*-tests).

It was observed that the relationship between Empathy and some of the dependent variables was not only linear, but appeared to also contain a quadratic component. Thus, we used a likelihood ratio test to formally examine whether including both linear and quadratic terms for Empathy resulted in a better fitting model than a nested model that only included a linear term (both models included participant ID as random intercept). A significant difference between the two models provided support for the inclusion of the quadratic term in the model. Based on this approach, only the model for EPN was found to be significantly improved by the addition of the quadratic term ($\chi^2(2) = 8.38, p = .004$), with little evidence to

support including a quadratic effect in models for any other dependent variables. Analyses were conducted in Stata 13 (StataCorp., 2013).

3. Results

Mean and standard deviation values reported by character type and expression, for behavioural data and ERPs, are presented in Supplementary Materials.

3.1 Behavioural data

Participants rated their overall impression of the intentionally negative character as the most negative ($M = -1.64$ [$SD = 0.59$]), followed by the unintentionally negative character ($M = 0.52$ [$SD = 1.05$]), and the neutral character was rated the most positively ($M = 1.38$ [$SD = 1.10$]).

3.1.1 Reaction Time. Reaction time data were log-transformed to correct for non-normality. As outlined above, the fixed terms included in the model were Empathy, Character Type, and Expression, with gender as a covariate, and participant ID as a random intercept. The only significant main effect was for Expression ($\chi^2(3) = 24.65, p < .001$). None of the interactions, nor other main effects, significantly influenced reaction times (all $ps \geq .236$).

Pairwise comparisons compared reaction times for each pair of expressions. All comparisons were significant (all $ps < .001$), with the slowest responses shown for angry expressions, followed by disgust, then neutral, and the fastest responses were to happy faces.

3.1.2 Accuracy. Accuracy for neutral and happy expressions was near ceiling, and could not be transformed to reach a normal distribution. Thus, accuracy was collapsed across the four expressions, and an arcsine transformation was applied to adjust for negative skew. None of the main effects nor interactions significantly contributed to accuracy. There was a trend towards an interaction between Empathy and Character Type ($\chi^2(2) = 5.56, p = .062$), due to a tendency for accuracy for the intentionally and unintentionally negative characters to increase with increasing empathy. The rate of this increase was significantly greater for the unintentionally negative versus neutral character ($p = .018$), with the other comparisons non-significant ($ps \geq .230$).

3.2 ERP Data

3.2.1 N170 Peak. The N170 data from one participant were considered outliers, with the peak values over 3 standard deviations larger than the mean, and the N170 values for this participant were excluded.

Analyses returned a significant Empathy by Character Type interaction ($\chi^2(2) = 6.80$, $p = .033$), as well as a significant main effect of Expression ($\chi^2(3) = 7.89$, $p = .048$). The main effect of Character Type was also significant ($\chi^2(2) = 8.47$, $p = .015$). Figure 4 depicts the interaction between empathy and character type. The figure shows a tendency for the N170 to become larger (i.e., more negative) with increasing empathy, which is stronger for the intentionally negative and neutral characters than the unintentionally negative character. Pairwise comparisons on the coefficient of the slope confirm the visual inspection, with a significant difference between intentionally and unintentionally negative characters ($z = -2.29$, $p = .022$), and between neutral and unintentionally negative characters ($z = -2.22$, $p = .026$), but not between the neutral and intentionally negative characters ($z = 0.07$, $p = .944$).

Figure 4. The interaction between character type and empathy in predicting N170 amplitude. The coefficient for the slope for the unintentionally negative character was $b = -.018$ ($SE = 0.041$), for the intentionally negative character $b = -.038$ ($SE = 0.041$), and for the neutral character $b = -.038$ ($SE = 0.041$).

However, examination of Figure 4 also suggests that data from the participants with relatively extreme Empathy scores may be having excessive influence on the slopes. Removing data from one participant (whose data is clustered at the bottom right of the figure), rendered the Empathy X Character Type interaction non-significant ($p = .103$). The main effects of Expression and Character Type remained significant.

The main effect of Character Type was due to a trend for a larger N170 for the unintentionally negative character ($M = -2.77 \mu V$ [$SE = 0.370$]) than the intentionally negative ($M = -2.64 \mu V$ [$SE = 0.370$]) or neutral ($M = -2.65 \mu V$ [$SE = 0.370$]) characters. Pairwise comparisons, however, did not reach statistical significance ($ps \geq .117$). To investigate the main effect of Expression, pairwise comparisons were conducted. The N170 elicited by disgusted and angry faces did not significantly differ from each other ($p = .413$), but all other pairs differed ($ps \leq .003$). The largest N170 was for disgusted and angry expressions, followed by happy, and then neutral.

3.2.2 EPN. As mentioned, a quadratic term for Empathy was required for the model predicting EPN amplitude. Thus, for this model, linear and quadratic terms for Empathy, as well as Character Type, Expression, and all interactions were entered as fixed effects (as above, gender was entered as a covariate, with participant ID as a random intercept). Analyses showed a significant Character Type by Empathy interaction with the linear component of Empathy ($\chi^2(2) = 6.95, p = .031$), and marginally with the quadratic term ($\chi^2(2) = 5.57, p = .062$). The main effects of Character Type ($p = .013$), and Empathy (linear: $p < .001$; quadratic: $p = .001$) were also significant, though must be interpreted in light of the interaction. To explore the interaction, Figure 5 depicts the relationship between Empathy and EPN amplitude for each of the three characters. Inspection of the figure shows that the EPN for all three characters tended to be larger (i.e., more negative) for those with very low empathy levels, smallest for those with empathy in the mid-range, and became larger for those with higher empathy. The figure also shows that differences between the three character types are evident mostly for those with low empathy and large EPN. Finally, it is also the case that the unintentionally negative character appears to elicit the largest EPN for those with lower empathy, but the neutral character elicits the largest EPN for those with higher empathy.

Figure 5. The modelled relationship between Character Type and Empathy on EPN amplitude. The unstandardised coefficient describing the average rate of change for the EPN and Empathy for the neutral character was $b = .065$ ($SE = .033$), for the unintentionally negative character $b = .084$ ($SE = .033$), and the intentionally negative character $b = .056$ ($SE = .03$). The average coefficient was significantly different for the unintentionally negative character compared to both the neutral ($p = .028$) and the intentionally negative character ($p = .001$).

3.2.3 LPP. The LPP data for one participant were considered outliers, with amplitudes more than 3 standard deviations outside the mean, and so LPP data for this participant were excluded. None of the fixed effects nor their interactions significantly contributed to LPP amplitude (all $ps \geq .703$).

4. Discussion

This study investigated the influence of character context, face expression, and within-perceiver empathy on face processing ERPs. The hypothesis that character type and facial expression would interact to influence the N170, EPN, and LPP was not supported. While face expression moderated the N170 component, this did not differ depending on the type of character. The hypothesis that the ERP components would be sensitive to character type was partially supported. EPN differences dependent on character type were revealed when also taking the perceiver's empathy levels into account. However, these differences did not align with the third hypothesis, which predicted that differences would be clearer for

those with higher than lower empathy. The relationship between empathy and character type on the EPN were complex, with the suggestion for larger EPN for individuals with either very high or very low empathy levels, and clearer differences between characters for those with lower empathy. Overall, the findings highlight the importance of within-perceiver trait empathy on the influence of character context in face perception, and suggest that this factor should be considered when examining emotional face processing.

A key finding of this study is that character type differences on ERPs were revealed when within-perceiver empathy levels were considered. There was a significant character type by empathy interaction for the EPN component. This suggests that the character information was incorporated with the face to influence how the face was perceived, but that this was different depending on the participant's level of empathy. For individuals with empathy in the middle range for the sample, character type did not appear to influence EPN amplitude. Interestingly, however, for those with either low or high empathy, the EPN was larger and differed between characters. It may be that empathy plays a role in the processing of character information in different ways for those with low versus high empathy levels.

For those at the lower range of empathy, the EPN to all characters was relatively large. Furthermore, the EPN tended to be largest for the unintentionally negative character. Taken together, these results suggest that all of the faces, and particularly those of the unintentionally negative character, required greater attention or effort to process the emotional content by those with lower empathy. This might indicate that individuals with lower empathy use more attentional effort when processing socio-emotional information. It appears that this is particularly the case when the information contains some contradiction or complexity, as in the unintentionally negative character context.

The EPN also tended to be generally larger for individuals with *higher* levels of empathy. It may be that for individuals at either the low or high end of the empathy scale, the larger EPN reflects the need for greater attentional effort to process the information. Alternatively, it may be that for those with higher empathy, the larger EPN reflects the inclination or motivation to allocate more attention to information perceived as emotional or socially relevant. It is difficult to reconcile the finding that at the high end of the empathy scale, the neutral character tended to elicit the largest EPN. Perhaps the neutral character was considered a more ambiguous character, or a character in need of more attentional processing, given that any emotional aspect of this character was not overt. While further

research is required to tease apart these alternatives, the results point to the importance of trait empathy in face processing.

Unexpectedly, for those in the middle range of empathy, results did not show a strong effect of character type on the amplitude of the EPN. Furthermore, neither the N170 nor the LPP were strongly influenced by character type. This was the case even though the intentionally negative character was rated more negatively than the other characters, indicating that the vignette had its intended effect on explicit judgments of character. It was also evident that participants did remember which vignette was associated with each face, ruling out a lack of character-face association as the reason for the null result. Together, these findings suggest that for individuals with mid-range empathy, character context – at least of the type used in this study – is processed independently of the associated face. That is, while an individual might be explicitly recognised as a ‘negative’ person, this does not necessarily mean that their face is automatically perceived to be more negatively emotional, though this may be the case for those with particularly low or high empathy.

This result is not in line with previous studies that have reported modulation of N170, EPN, and LPP by character context. One suggestion is that the type of character context used may account for the contrasting findings. Some previous studies have presented character vignettes that detail extremely cruel behaviours, such as the mass murder of innocent people (Abdel Rahman, 2011; Suess et al., 2015). Other studies have presented less extreme characters, but present the information in a single statement (e.g., “*Betrayed friends for money*”; Luo et al., 2016) rather than a detailed story (e.g., Li et al., 2019; Luo et al., 2016; Wieser et al., 2014; Xu et al., 2016). Perhaps these two different types of character context facilitate the integration of character and face perception more readily than the character context in the current study. For instance, a character who has taken part in extreme atrocities on other people elicits strong emotions in a perceiver, and these emotions cannot be processed independently of the character’s face. The character information in the current study, however, may not have been strong enough to evoke such emotion. It may be that, at least in a laboratory setting, less extreme behaviours are integrated with the character’s face only when the information is simple and unambiguous. A second suggestion is that the type of task may have minimised the differences between characters. Previous studies have shown that when participants respond to whether a facial expression is congruent or incongruent with expectations for that type of character or situation, larger ERP differences are found (Aguado, Parkinson, Dieguez-Risco, Hinojosa, & Itier, 2019). Thus, future research that

combines the current task design with an emotional congruency task may be more sensitive to differences in character type.

Neither character, expression, nor empathy influenced LPP amplitude. It was expected that the combination of characters and expressions would require the higher-order, elaborative processing reflected by the LPP. The findings are thus in contradiction to some previous studies in which negative characters elicit larger LPPs than neutral characters (Abdel Rahman, 2011; Li et al., 2019; Xu et al., 2016). As mentioned, it may be that the lack of LPP modulation was due to the type of character information or task design used in this study. In addressing the lack of an effect of empathy on the LPP, this may highlight how empathy influences face processing. That is, the finding that that empathy levels were important for the EPN, but not the LPP, may be due to the importance of empathy in the earlier, more automatic stages of face and emotion processing (reflected by the N170 and EPN), while empathy is less important for the later, more elaborative processing stages.

Results also revealed that facial expression did not interact with character type to influence ERPs. It was expected that a negative expression on the face of the intentionally negative character would lead to the face being perceived as more intensely emotional, and thus result in larger ERPs. That this interaction did not occur may indicate that the two types of context are not processed simultaneously during the observation of a face. Given that expression differences were shown for the N170, and character type differences for the EPN, it may be that expressions are processed first, followed by character information. However, it must also be noted that the NimStim face stimuli used in this study include expressions that are strong in intensity (Tottenham et al., 2009). It may be that less intense expressions are more readily influenced by character context, whereas the intense expressions used in this study were so extreme as to be unable to be modified by character context. This is one area for future research to investigate.

The presence of trend-level findings, or findings influenced by a small number of observations, suggest that sample size may be a limitation of this study. Based on previous studies, it was expected that differences between characters would have been larger, and so our study would have been sufficiently powered to detect these effects. However, perhaps due to the apparently complex or ambiguous nature of the character types in this study, a larger sample size may be required to detect differences more clearly within and between conditions.

Conclusion

To our knowledge, this is the first study to examine the combined influence of expression, character context, and within-perceiver empathy on face-processing ERPs. Results highlight the importance of considering trait empathy in the role of processing faces with character context. Along with previous research, the findings also suggest that different ways of presenting character context may influence how the context is integrated in face processing. A valuable step for future research may be to examine how empathy relates to neural responses elicited by scenarios that are more extreme, or that are more likely to be accounted in daily life.

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Appendix (Character vignettes)

Character Type	Male character	Female character
Intentionally negative	<p>This is Ben. Recently, Ben was on a train and running late for work. As an elderly man stepped off the train onto the platform, Ben angrily shoved him in the back to hurry him up. The old man fell over and his head hit the ground quite hard. As passers-by stopped to help, Ben sniggered at the man's attempts to get up, stepped over the old man and walked off. When he got to work, the receptionist made a joke about Ben being late. To get her back for her comment, Ben told his boss a lie about seeing the receptionist stealing from the company, knowing this would get her fired.</p>	<p>This is Amy. Recently, Amy drove to an important exam. She saw an empty car park close to the entrance, however another student pulled into the park before Amy reached it. As Amy walked to the exam room entrance, she saw the other student anxiously reading her study notes. Amy accused the student of taking the carpark Amy was after, and then threw her cup of coffee in the other student's face before continuing into the exam room. At the end of the exam, Amy managed to secretly swap her answer sheet with another student's so that she would receive a higher mark.</p>
Unintentionally negative	<p>This is Adam. Recently, Adam attended his friend's wedding. As he was waiting for service at the bar, an altercation among some guests broke out behind him, and Adam was pushed. He lost his balance and toppled into the bride, knocking her over and spilling red wine on her dress. Adam was mortified, and as people rushed to help the bride, Adam quickly left in shame. Back at his table, he told the other guests what had happened. Unnoticed by Adam, some guests misinterpreted his explanation, and spread the story that the bride was too drunk to stand.</p>	<p>This is Sarah. Recently, Sarah played a game of basketball with her team. During the game, she threw the ball to a teammate, but the teammate did not catch it. Instead, the ball flew into the face of a spectator. Sarah went to apologise and help, but the team called her back onto the court while other spectators helped the injured person. In the final minutes of the game, a key decision by the umpire was required. The umpire was a friend of Sarah and their decision incorrectly went Sarah's way, ultimately leading to a win for her team.</p>
Neutral	<p>This is Gordon. Recently, Gordon attended an art class. Before the class began, Gordon chatted with some of the other attendees about their other hobbies, and their reasons for joining the class. During the class, Gordon tried out the techniques the teacher demonstrated, and felt that he improved. He discussed an area of difficulty with the teacher, and got some pointers from another student as well. At the end of the class, Gordon packed up his things and drove home. As he stepped into his house he realised he still had paint on his hands, so he washed his hands before preparing his dinner.</p>	<p>This is Jenny. Recently, Jenny moved house to be closer to university. Removalists took large items of furniture, while Jenny and her friend each took smaller items in their cars. At the new house, Jenny's new housemates helped to unpack boxes and decide where furniture would fit best. Jenny accidentally broke a light bulb, so she swept up the glass before replacing the bulb with a new one. At the end of the day, most of her things were unpacked, though some belongings would need to be unpacked the following day.</p>

Supplementary Materials

Summary data: Means and standard deviations [M (SD)] for behavioural and ERP data, by character type and expression.

Neutral Character

	Neutral	Happy	Angry	Disgust
Accuracy (%)	96.76 (5.05)	96.78 (5.95)	86.00 (12.11)	89.39 (11.63)
Response Time (ms)	594.56 (271.88)	461.97 (204.49)	725.83 (339.63)	673.35 (375.87)
N170 peak (uV)	-2.12 (2.79)	-2.48 (2.50)	-3.00 (2.61)	-3.01 (2.88)
EPN (uV)	0.94 (2.12)	0.62 (2.40)	0.57 (2.34)	0.33 (2.25)
LPP (uV)	2.46 (1.79)	2.46 (1.95)	2.41 (1.78)	2.25 (1.56)

Intentionally Negative Character

	Neutral	Happy	Angry	Disgust
Accuracy (%)	96.80 (4.55)	97.00 (4.78)	85.24 (13.42)	90.02 (10.35)
Response Time (ms)	594.11 (247.62)	440.17 (175.02)	725.76 (318.21)	677.46 (365.26)
N170 peak (uV)	-1.94 (2.31)	-2.63 (2.56)	-2.85 (2.63)	-3.13 (2.56)
EPN (uV)	1.01 (2.15)	0.63 (2.06)	0.56 (2.31)	0.38 (2.25)
LPP (uV)	2.41 (1.74)	2.63 (1.90)	2.11 (1.62)	2.25 (1.54)

Unintentionally Negative Character

	Neutral	Happy	Angry	Disgust
Accuracy (%)	96.15 (6.61)	96.63 (5.61)	85.29 (15.60)	89.07 (8.11)
Response Time (ms)	590.88 (247.55)	435.85 (181.85)	739.44 (318.98)	682.50 (330.78)
N170 peak (uV)	-2.29 (2.62)	-2.85 (2.82)	-3.01 (2.43)	-2.96 (2.46)
EPN (uV)	0.91 (2.23)	0.31 (2.48)	0.49 (2.31)	0.47 (2.25)
LPP (uV)	2.11 (1.83)	2.56 (2.09)	2.44 (1.65)	2.04 (1.67)