Culture and neuroscience: How Japanese and European Canadians process social context in close and acquaintance relationships

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Abstract

Recent cultural psychology findings suggest that social orientation affects neural social attention. Whereas independent cultures process people as separate from social context, interdependent cultures process people as dependent on social context. This research expands upon these findings, investigating what role culture plays in people's neural processing of social context for two relationship contexts, close and acquaintance relationships. To investigate, we had European Canadian and Japanese participants rate the emotions of center faces in face lineups while collecting ERP data. Lineups were either *congruent*, with all faces showing similar emotions, or *incongruent*, with center face emotions differing from background faces. To investigate relationship types, we framed face lineups to be in close or acquaintance relationships. We found that for acquaintances, only Japanese processed incongruent social context as meaningful, as seen through N400 incongruity effects. Contrasting with these patterns, only European Canadians showed N400 incongruity effects for close relationships. These patterns were seen whether or not the two groups noticed the emotional conflict, as seen by N2 incongruity effects. Finally, we found that social orientation was differentially related to the neural incongruity effects for the two relationships. These findings further elucidate the nuances of how culture affects neural social attention.

Introduction

As one major cultural difference between North Americans and East Asians, researchers have highlighted that the two cultural groups tend to carry a differing view of the self (e.g., Markus & Kitayama, 1991; Triandis, 1995). These cultural differences relate to North Americans tending to view the self as *independent/individualist*, placing individuals as separate from other people, and East Asians tending to view the self as *interdependent/collectivist*, placing individuals as interconnected with others. For this paper, we go by the *social orientation* terms, independence and interdependence to simplify. These differences in the self are often paired with differences in attention (e.g., Varnum, Grossmann, Kitayama, & Nisbett, 2010). Independent cultures tend to *analytically* attend to focal objects and people, placing them as more separated from their context, and interdependent cultures tend to *holistically* attend to focal objects and people, placing them as related to their context. These findings are quite robust, with East Asians being more likely than their North American counterparts to attend to context in a wide range of non-social tasks, including how the two cultures make visual judgments, make decisions, view scenes, create narratives, and make memory judgments (e.g., Chua, Boland, & Nisbett, 2005; Ji, Peng, & Nisbett, 2000; Li, Masuda, & Russell, 2015; Masuda, Gonzalez, Kwan, & Nisbett, 2008; Masuda & Nisbett, 2001, 2006; Senzaki, Masuda, & Ishii, 2014; Wang, Masuda, Ito, & Rashid, 2012).

Social orientation and social attention

Several studies have also examined how social orientation differences affect social attention (e.g., Masuda, Gonzalez, et al., 2008; Masuda, Wang, Ishii, & Ito, 2012; Russell, Masuda, Hioki, & Singhal, 2015). To test how independent and interdependent culture affects social attention, research by Masuda and colleagues used a face lineup task (Masuda, Gonzalez, et al., 2008, 2012). In this research, North Americans and East Asians were asked to rate emotions of center faces in five-person emotional face lineups. Lineups were either congruent, with emotions of center faces and background faces the same (e.g., center face happy and background faces happy), or incongruent, with emotions of center faces and background faces being different (e.g., center happy and background sad). In line with noted cultural differences in non-social attention, North Americans showed little influence from incongruent background face emotions in their ratings (showing little difference between congruent and incongruent lineup ratings), while East

Asians showed more influence from this social incongruence (showing larger differences between the two types of ratings). This finding suggested that only East Asians integrated background faces' emotional information into their ratings of center persons. Further investigating social attention patterns during this face lineup task, Masuda and colleagues also measured eye-movement patterns when participants viewed these face-lineups in preparation for their rating judgments, and found that North Americans focused their attention more on center persons and East Asians spread their attention more between center and background people (Masuda, Gonzalez, et al., 2008, 2012).

Expanding this research to the neural domain, Russell et al. (2015) investigated ERP patterns when European Canadians and Japanese viewed face lineups (Masuda, Gonzalez, et al., 2008, 2012). They targeted an ERP component called the N400, as it is related to the neural processing of semantic incongruities, with stronger N400s seen to information considered unexpected or incongruent (vs. expected or congruent), which is called the *N400 incongruity effect*. The N400 incongruity effect could be anticipated when people's worldviews placed incongruent emotions as concerning or unexpected. Only Japanese showed a N400 incongruity effect, giving evidence that interdependent cultures only process emotional incongruence as unexpected, which Russell and colleagues interpreted as being due to Japanese interdependence goals related to social harmony. However, while the European Canadians did not classify incongruent emotions as concerning (through the N400), they did still take into account the background person's emotions in their ratings of the center person. This gave evidence that brainwaves and rating behaviors represent different levels of attention, with the N400 findings representing earlier attention processes, as compared to the later ratings (Russell, 2016; Russell et al., 2015).

As a last nuance of these findings, Russell et al. (2015) found that although the Japanese showed stronger influence from incongruent (vs. congruent) emotions in their rating behaviors, European Canadians *also* showed a significant influence from incongruent emotions in their ratings that was not seen in the previous studies (Masuda, Ellsworth, et al., 2008; Masuda, Gonzalez, et al., 2008). Russell et al. (2015) argued that differences in the stimuli may have accentuated the interrelationship between the people in the face lineups. *Expanding upon this finding, this line of research further explores how culture interacts with the framing of relationship context (e.g., whether or not people in face lineups are deemed to be in close or*

acquaintance relationships) to influence social attention neural patterns. Different from previous research that focuses on basic cultural differences in attention, our focus was on how culture influences how people perceive relationship context in their social attention processes.

Culture and relationships

In fact, a plethora of previous research suggests that relationship type influences social processes (e.g., Arriaga, 2013; Doi, 1973; Heine, 2008; Hwang, 1987; Kim & Nam, 1998; Markus & Kitayama, 1991; Uskul, Hynie, & Lolonde, 2004; Wegner, Giuliano, & Hertel, 1985). For rating behaviors, Uskul et al. (2004) gave evidence that both independent and interdependent cultures rate themselves as desiring to be closer to people in close relationships than acquaintances. Because of this, we expected that both independent and interdependent cultures would rate themselves as being more influenced by incongruent emotions from close relationships than acquaintances.

However, our main question for the current research was how emotion incongruence was attended to in earlier neural attention processes.

Culture and acquaintances

We expected that noted social orientation differences would be most salient for acquaintances, due to their combination with other cultural differences (e.g., Kim, Cohen, & Au, 2010; Kim & Nam, 1998; Leung & Cohen, 2011; Slotter & Gardner, 2009). On the one hand, Japanese interdependence is also described as a face culture. *Face* cultures are concerned with "the respectability and/or deference which a person can claim for himself from others by virtue of his or her relative position, in a hierarchy and the proper fulfillment of his/her role." Furthermore, face is thought to be most salient in the public (i.e., with peers, coworkers, etc., but not with close others), where face culture members are concerned with protecting their social image. On the other hand, European Canadian independence is described as a dignity culture. *Dignity* cultures possess "the conviction that each individual at birth possesses an intrinsic value at least theoretically equal to that of every other person." This value is not socially conferred and cannot be taken away from others. In line with these notions, dignity culture members have been shown to actively reject other's views of themselves in public (e.g., Kim et al., 2010; Leung & Cohen, 2011).

Because East Asian cultures take public representations of themselves to define themselves, we anticipated that they would place emotion incongruence from acquaintances as concerning. In contrast, as North Americans actively reject others views of themselves in the public domain, we anticipated emotion incongruence to not be concerning for acquaintances. We see support for this pattern from previous research, with Japanese only showing ERP patterns that suggest incongruent emotions were concerning (and not European Canadians) for implied acquaintance relationships, such as classmates or coworkers (Russell et al., 2015).

Culture and close others

For close others, social orientation models were less clear on what to expect. On the one hand, they may suggest that Japanese should be generally more concerned with emotion incongruence in all relationships compared to European Canadians, giving evidence that interdependent cultures are always very attentive to all social cues (e.g., Han & Northoff, 2009; Markus & Kitayama, 1991; Triandis, 1995). On the other hand, face and dignity cultural frameworks might predict otherwise. For example, Japanese might be less attentive to social cues in close relationships, as losing face in close relationships is less of a concern (Kim & Nam, 1998), and European Canadians might be more attentive to close relationships, as these relationships are chosen and broken more freely (Schug, Yuki, & Maddux, 2010), and dignity cultures place more importance on their choices (Kim et al., 2010; Leung & Cohen, 2011). Looking to literature, we found support for this second possibility.

On the one hand, North Americans have been noted to be more relationally mobile than Japanese, having more freedom to move between relationships (Schug et al., 2010). These differences in relational mobility have been paired with differences in commitment behaviors in close relationships, with North Americans self-disclosing more in order to strengthen and protect their more mobile relationships (Schug et al., 2010). Along these lines, other research on Western cultures give support that Westerners care greatly about close others, greatly affecting each other to "the extent to which partners affect each other (being) profound and pervasive," and such that both thoughts, emotions, and lives become intertwined (e.g., Arriaga, 2013; Slotter & Gardner, 2009; Wegner et al., 1985). Worried about protecting their highly mobile, chosen relationships, we expected that European Canadians would be very concerned with emotion incongruence in their early attention to close others.

On the other hand, for East Asians we expected that they would be less worried about how they looked to their close others due to noted East Asian cultural constructs, such as the Japanese cultural concept *amae*, and its parallel in Chinese culture of "favoring the intimate" (Doi, 1973; Hwang, 1987). For *amae*, Doi (1973) proposed that Japanese close relationships were buffers from the strict social rules of the public social world. These close relationships allow individuals a diversion from strong social expectations in public by being more permissive. These *amae* behaviours have been shown to be important to Japanese, relating to a greater perceived relationship quality with close others (Marshall, Chuong, & Aikawa, 2011). Thus, we expected that East Asians would not find social incongruence as unexpected in their early attention to close others.

Relational judgements and ERPs

To test our expectations for the two relationships for early attention, we compared neural patterns during a task which followed a similar setup to previous face lineup tasks, where participants rated center face's emotions when these faces were surrounded by *congruent* (the same emotions) or *incongruent* emotions (different emotions; Masuda, Gonzalez, et al., 2008, 2012; Russell et al., 2015). To manipulate key relationships, face lineups were termed to be people in either close or acquaintance relationships. Finally, early attention patterns were measured by two ERPs termed the N400 and the N2.

Relational judgments and the N400

We focused our main ERP analyses on the N400. The N400 is a negative-going deflection ERP that is maximal in central electrode sites (usually Cz) around 400 ms after events are presented during image tasks, such as the face lineup task (e.g., Ganis & Kutas, 2003; Kutas & Federmeier, 2011; Russell et al., 2015). The N400 has been linked to the processing of semantic relationships and responds more to incongruent or unexpected events, called *the N400 incongruity effect*. Previous N400 findings provided evidence that only Asian Americans/Japanese (and not European Americans/European Canadians) show N400 responses when objects (and faces) and contexts do not semantically fit (e.g., Goto, Ando, Huang, Yee, & Lewis, 2010; Goto, Yee, Lowenberg, & Lewis, 2013; Russell et al., 2015).

For the current study, we predicted that we would replicate previous findings from Russell et al. (2015) for acquaintance relationships, with only Japanese experiencing an N400 incongruity effect. This would reflect that they found incongruent emotions to be of concern because of interdependent/face cultural beliefs that place concern on others' views of themselves. We did not expect to see this with European Canadians due to their independent/dignity cultural beliefs that actively reject others view of themselves (Kim et al., 2010; Leung & Cohen, 2011). Conversely, for close relationships we expected that the N400 incongruity effect would only be seen for European Canadians, due to their strong concern for losing these more mobile relationships (Schug et al., 2010). For Japanese, we did not expect a N400 incongruity effect as close relationships are thought be more stable and permissive, making differing emotional states less concerning (Doi, 1973).

The frontal N2

We also explored whether conflict monitoring processes were seen in lieu of N400 differences, as they were suggested in previous studies (Russell, 2016). While the N400 is usually associated with semantic, meaning-based processing, the N2 is associated with earlier conflict monitoring processes (e.g., Yeung, Botvinick, & Cohen, 2004). Like the N400, the N2 is seen as a more negative deflection, peaking somewhere between 200 and 400 ms for incongruent stimuli (vs. congruent stimuli), termed *the N2 incongruity effect*. One task commonly associated with N2 processing is the flanker task, where participants are asked to categorize a central object when it is surrounded by congruent (i.e., < < < < <) or incongruent objects (i.e., < < > < <).

The N2 is relevant to the face lineup task as it can be seen as a form of a flanker task that uses ratings instead of categorization. Recent research with face lineup tasks has provided evidence that a *Frontal N2* is seen to facial emotion incongruence, whether or not semantic N400 components or decision related N2 incongruity effects are seen (Liu, Xiao, & Shi, 2013; Russell, 2016; Russell, Li, Lee, Singhal, & Masuda, 2018). Russell et al. (2018) interpreted this *Frontal N2 incongruity effect* to be part of the early perceptual processing of the incongruent emotions involved in the face lineups, distinct from the behavioral conflict seen in the central neural processing. Our expectation is that we would replicate these findings – people would show Frontal N2 incongruity effects, even if they lacked central N400 incongruity effects. This would

give evidence that people experience conflict from background emotional incongruence (as seen through the N2), whether or not they processed it as meaningful (as seen through the N400). Together this research would provide early evidence that culture differentially affects earlier conflict monitoring neural attention (the Frontal N2), later more semantic neural attention (the N400), and later behavior related attention (ratings).

Hypotheses

Extending previous findings, revealing cultural differences in neural patterns during the face lineup task (Russell et al., 2015), we investigated if neural patterns related to social cue monitoring depended on relationship context. To investigate this question, we had European Canadians and Japanese engage in a relational task while collecting ERP data. Using a modified paradigm based on the face lineup task (Masuda, Gonzalez, et al., 2008, 2012; Russell et al., 2015), participants were asked to rate a center person's emotions when they were surrounded by others with *congruent* (i.e., the same) or *incongruent* (i.e., different) emotions, while keeping the designated relationship between center and surrounding faces in mind (either *close* or *acquaintance*).

Based on previous findings that attention ERPs and later attention related behaviors sometimes diverge (e.g., Goto et al., 2010, 2013; Russell, 2016; Russell et al., 2015), we analyzed three measures: *emotion ratings*, with a larger rating incongruity effect expected when the participants cared more about the emotion incongruence, *the N400*, with an N400 incongruity effect giving evidence that participants placed emotion incongruence in their early attention as unexpected, and *the Frontal N2*, with an Frontal N2 incongruity giving evidence that participants attended to the emotion incongruence early.

Emotion rating hypothesis

Hypothesis 1-a: *We expected a main effect of culture on the influence from incongruent emotions on ratings, with Japanese showing more influence from incongruent emotions in the face lineup task than European Canadians. This would be in line with previous findings showing social orientation differences between Japanese and European Canadians (Masuda, Gonzalez, et al., 2008, 2012; Russell et al., 2015).*

Hypothesis 1-b: *We also expected that both cultures would report more influence from incongruent emotions from close others than acquaintances, as members from both independent and interdependent cultures have been noted to rate that they desire more closeness from close others than acquaintances (Uskul et al., 2004).*

N400 hypotheses

Hypothesis 2-a: *We expected that for acquaintance relationships, a main effect of culture would be seen for the N400 incongruity effect. Only the Japanese would show a N400 incongruity effect, and not European Canadians. This would give evidence that Japanese place incongruent emotions as more concerning in their public relationships than European Canadians. We expected that for close relationships, a main effect of culture would be seen for the N400 incongruity effect. Only the European Canadians would show a N400 incongruity effect, and not Japanese. This would give evidence that European Canadians show more early concern for incongruent emotions from close others than Japanese. Together this would show an interaction of culture and relationship on N400 incongruity effects.*

Hypothesis 2-b: *In addition, we explored if individuals' social orientation beliefs explained N400 patterns, as associations have been seen in recent related cultural ERP studies (e.g., Goto et al., 2010, 2013; Russell et al., 2015).*

Frontal N2 hypotheses

Hypothesis 3-a: *We explored whether Frontal N2 incongruity effects were seen for European Canadians and Japanese across relationships.*

Hypothesis 3-b: *Finally, we explored if individuals' social orientation beliefs explained the Frontal N2 incongruity effects.*

Methods

This research was approved by the University of Alberta ethics board in accordance to the Declaration of Helsinki.

Participants

We collected data from 57 European Canadian undergraduate students from the University of Alberta and 55 Japanese undergraduate students from Kobe University. For European Canadians, 29 were assigned to the Close condition (16 Females, 13 Males; Ages 19.1 ± 1.7, range = 18–25 years) and 28 were assigned to the Acquaintance condition (16 Females, 12 Males; Ages 18.8 ± 1.5, range = 17–24 years). For Japanese, 27 were assigned to the Close condition (13 Females, 14 Males; Ages 20.6 ± 1.5, range = 18–24 years) and 28 were assigned to the Acquaintance condition (14 Females, 14 Males; Ages 20.1 ± 2.6, range = 18–31 years). In addition, 7 European Canadian (3 Close & 4 Acquaintance) and 10 Japanese (4 Close & 6 Acquaintance) participants took part in sessions, but were rejected due to data collection issues (i.e., electrode issues, movement issues, or not completing the task). European Canadian participants earned partial course credit and Japanese participants received an honorarium (~$10 – $15) for their participation. Both written and oral instructions were provided in English for European Canadian participants and Japanese for Japanese participants. To make instructions equivalent, English instructions and questionnaires were translated to Japanese and back-translated to English by two fluent bilingual English/Japanese speakers (Brislin, 1976). All participants gave us their informed consent.

Face lineup stimuli

Task stimuli consisted of lineups of three schematic faces, with one center face surrounded by two background faces (1 to each side; see Figure 1 for example images). The center face was happy, sad, or neutral, and the background faces were both happy, sad, or neutral. As improvements from the Russell et al. (2015) study, we used schematic faces to simplify neural processes required to identify emotions, and used only three faces (vs. five) to prevent the requirement of large eye movements to view background faces. We also included neutral faces in this study (versus the Happy/Sad format in the Russell et al. (2015) study) to improve data quality; these neutral faces worked as a baseline for happy/sad emotion judgments and varied the task in an effort to increase task concentration, which can improve ERP quality (Luck, 2005). Lineups with similar happy/sad emotions were classified as *congruent* (i.e., the center face and the background faces were happy), and lineups with differing happy/sad emotions were classified

as *incongruent* (i.e., the center face was sad, but the background faces were happy). On the other hand, neutral lineups came in one of three varieties (i.e., the center face was neutral and the background faces were happy, sad, or neutral), as these lineups were not targets of analyses and were only included to increase task rating/ERP quality.
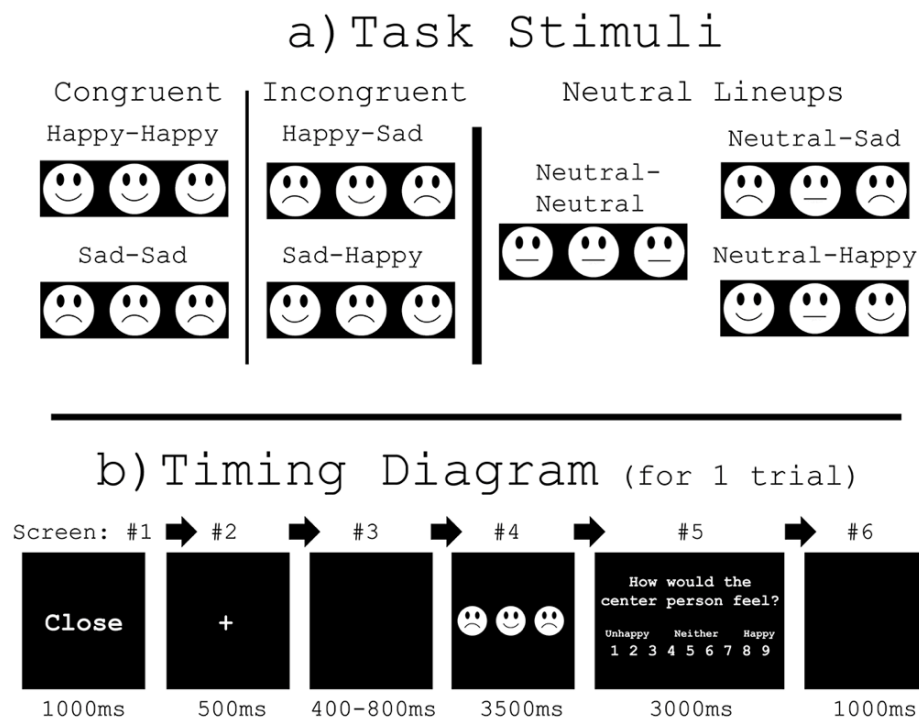
a) Task Stimuli

Congruent | Incongruent | Neutral Lineups

Happy-Happy | Happy-Sad | | Neutral-Sad

Neutral-Neutral

Sad-Sad | Sad-Happy | | Neutral-Happy

b) Timing Diagram (for 1 trial)

Screen: #1 → #2 → #3 → #4 → #5 → #6

Close

+

How would the center person feel?

Unhappy   Neither   Happy
1 2 3 4 5 6 7 8 9

1000ms   500ms   400-800ms   3500ms   3000ms   1000ms

Figure 1. a) Example relational task stimuli for the congruent (happy (center) – happy (background) and sad – sad) and the incongruent conditions (happy – sad, and sad – happy), and for the filler neutral lineups (neutral – neutral, neutral – sad, and neutral – happy). b) Trial timing diagram (for 1 trial) of the relational task.

Types of lineups were randomized with E-prime 2.0 Professional (Psychology Software Tools Inc., Pittsburgh, PA) between sets of 11 lineups, consisting of eight happy/sad lineups (i.e., two sets consisting of all four combinations of happy/happy, happy/sad, sad/happy, and sad/sad) and three neutral lineups (i.e., one set of the three neutral types explained above). In total, besides two practice rounds, which each involved presentations of one set of lineups (each consisting of 11 lineups), the actual task involved 132 lineup presentations. These 132 lineups consisted of 48 congruent lineups (24 happy (center) – happy (background) and 24 sad – sad), 48 incongruent lineups (24 sad – happy and 24 happy – sad), and 36 lineups involving neutral faces (12 for each of the three types).

Procedure

Sessions took place in electrically shielded rooms at the University of Alberta and Kobe University. After providing consent and being prepped for EEG data collection, participants were assigned to either the close or acquaintance condition, and seated approximately 55 cm from a square 19" LCD monitor that displayed task instructions and stimuli from a computer running E-prime 2.0 Professional (Psychology Software Tools Inc., Pittsburgh, PA). EEG data were recorded simultaneously on a separate computer through Acknowledge 4.0 (Biopac Systems Inc., Goleta, CA).

Before collecting EEG data, participants were first instructed on the nature of the task and how/when to make movements. Participants were then told that their task was to rate how the center person would feel if they were surrounded by people of the instructed relationship (on a scale of 1 to 9 (where 1 = very negative, 5 = neutral, and 9 = very positive)). Finally, the target relationship, either close or acquaintance, was described before engaging in practice trials. We stated that "For this set of judgments, we would like you to consider the surrounding faces to be people that…", "…are close or intimate with the center person" (*Close relationship condition*) or "…interact with the center person regularly, but are not close with them" (*Acquaintance relationship condition*). Different from previous versions of the task (e.g, Masuda, Gonzalez, et al., 2008; Russell et al., 2015), we asked participants to consider the individual in context to the surrounding people, as the focus of this task was on relationship context. After all instructions, participants were provided with two practice rounds, 11 trails each (one untimed & one timed), to become accustomed to the task. At this point, participants proceeded to the actual task, where participants were asked to rate lineups while ERP data were collected. At the midway point of these ratings (after 66 ratings), participants were provided with a short one minute break. On completion, participants answered demographic and survey questions, before being debriefed and dismissed.

Trial timing

Each trial included (*in order*): 1) a reminder of the relationship presented for 1000 ms, 2) a presentation of a fixation cross (+) for 500 ms, 3) a brief blank screen randomly jittered between 400 – 800 ms, 4) the presentation of a face lineup for 3500 ms, 5) a rating task screen (limited to

3000 ms), and 6) a brief blank screen for 1000 ms (see Figure 1 for trial timing). The rating task did not include a presentation of the face lineup, and the rating task screen (step #5) disappeared and moved on to a blank screen (step #6) when an answer was provided. Participants were asked to make decisions on their ratings in their heads when the face lineup was presented and to make decisions as fast as possible during the rating task screen (step #5).

Electroencephalography (EEG) recording, preprocessing, and analyses

EEG data were recorded using the same low-density 9-channel Biopac Systems Inc. amplifier (MP150; EEG100C) and electro-cap system (CAP100C) setups in Canada and Japan, with EEG signals recorded at electrodes F3, Fz, F4, C3, Cz, C4, P3, Pz, and P4, as well as vertical eye-blink electrodes set above and below the right eye and horizontal eye-blink electrodes set to both sides of the right eye recorded through EOG100C amplifiers. EEG system amplification was set to a gain of 10,000 and sampled at 1,000 Hz, and electrode impedance reduced to below 7 kΩ. Data were analyzed by custom MATLAB scripts in conjunction with the open-source EEGLAB toolbox (Delorme & Makeig, 2018; http://sccn.ucsd.edu/eeglab). Output EEG signals were initially referenced to the right earlobe and online filtered with analog filters between 0.1 and 35 Hz. After data collection, EEG signals were re-referenced to a mathematical average of the left and right earlobes and digitally bandpass filtered between 0.5–30 Hz. Eye movement trials were removed via visual inspection and residual artifacts corrected by Principle Component Analysis (e.g., Hoffman & Falkenstein, 2008; Luck, 2005). Finally, corrected trials for which voltages deviated greater than 100 μV from baseline or strongly from others were rejected.

For analyses, trials were epoched 200 ms pre- to 700 ms post-presentation of the lineup stimulus (see Figure 1), with trials baseline corrected to the 200 ms preceding this stimulus presentation. The N400 was quantified by taking the mean voltage at electrode Cz for the 250 to 450 ms time window. This time window was based on visual inspection and previous literature, with an earlier N400 (than the Russell et al., 2015 study) likely due to instruction for participants to make decisions in their head during the face lineup presentation (e.g., Kutas & Federmeier, 2011; Luck, 2005; Russell et al., 2015). Similarly, the frontal N2 was quantified by taking the mean voltage by averaging the F3, Fz, and F4 electrodes for the 250 to 350 ms time window, based on visual inspection and typical N2 ranges (e.g., Yeung et al., 2004). Statistical analyses

were carried out using Matlab 7.1 (MathWorks, Natick, MA, USA) and SPSS Statistics for PC, Release Version 18.0.0 (SPSS, Inc., 2009, Chicago, IL). Participants with fewer than 60 surviving trials (and less than 30 trials per each condition) or a lack of sufficient Principle Component quality were removed from final analyses. In addition, participants that had noisy Cz electrodes were dropped from all analyses as Cz was the main target electrode for N400 analyses.

Cultural beliefs: independent and interdependent social orientation

Individuals' independent and interdependent social orientation beliefs were assessed with a 23-item social orientation scale (13 independence items and 10 interdependence items), based on Kim, Kim, Kam, and Shin (2003). An English version was provided to European Canadian participants, and a Japanese version was provided to Japanese participants. Participants rated each item on a Likert-scale ranging from 1 (*Strongly disagree*) to 7 (*Strongly agree*). Sample items for the independence sub-scale are, "I enjoy being admired for my unique qualities," and "I prefer to be self-reliant rather than dependent on others," and sample items for the interdependence sub-scale are, "I am careful to maintain harmony in my group," and "I act as fellow group members prefer I act". Reliabilities for each sub-scale were satisfactory across cultures and conditions (Independence sub-scale: European Canadian Close Cronbach's α = .756, Acquaintance α = .768 & Japanese Close α = .866, Acquaintance α = .836; Interdependence sub-scale: European Canadians Close α = .732, Acquaintance α = .828 & Japanese Close α = .796, Acquaintance α = .829).

Results

Behavioral data: emotion ratings

For our behavioral measures, we focused on a single rating measure, reflecting how much participants perceived center faces to be influenced by incongruent surrounding faces. This measure was calculated as the difference between participants' ratings during the congruent and incongruent conditions, which we call *the rating incongruity effect*. To calculate the rating incongruity effect, we took the average of the difference between congruent and incongruent

lineup ratings for each participant (the congruence was based on the center face's emotion and averaged between congruence/incongruence subtractions for happy and sad center emotions). In a 2 (Culture: European Canadians vs. Japanese) by 2 (Condition: Close vs. Acquaintance) ANOVA, with the rating incongruity effect as the measure, we found a significant main effect of Condition, $F(1, 108) = 9.83$, $p = .002$, partial $\eta^2 = .08$, revealing that participants generally reported larger perceived influence from social incongruence in their ratings for the close, than for the acquaintance condition, (Close $M = 2.89$, $SD = 1.87$, Acquaintance $M = 1.93$, $SD = 1.87$). We also found a significant main effect of Culture, $F(1, 108) = 53.11$, $p < .001$, partial $\eta^2 = .33$, revealing that European Canadians generally reported perceiving more influence from social incongruence than Japanese, (European Canadians $M = 3.46$, $SD = 1.92$, Japanese $M = 1.32$, $SD = 1.19$; see Table 1 for means and SDs split by culture and condition). The interaction of Culture and Condition was not significant, $F(1, 108) = 1.90$, $p = .37$, partial $\eta^2 = .08$.

Table 1. Means (**standard deviations**) for the rating incongruity effect (larger = stronger), the N400 incongruity effect (larger = stronger), and the N2 incongruity effect (larger = stronger), as a function of culture and condition. (Table view)

	Rating Incongruity	
Culture	Close	Acquaintance
European Canadians	4.04 (**1.65**)	2.86 (**2.02**)
Japanese	1.65 (**1.19**)	1.00 (**1.11**)
	N400 Incongruity	N400 Incongruity
Culture	Close (µV)	Acquaintance (µV)
European Canadians	.48 (**.71**)	−.24 (**1.11**)
Japanese	−.073 (**1.20**)	.70 (**1.47**)
	N2 Incongruity	N2 Incongruity
Culture	Close (µV)	Acquaintance (µV)
European Canadians	.27 (**.63**)	.29 (.**57**)
Japanese	.039 (**.60**)	.40 (.**67**)

The main effect of condition gives evidence that both cultures care more much about emotion incongruence in close relationships than acquaintances. Beyond this finding, the main effect of culture deviates from previous research, which showed larger context effects for East Asians (Masuda, Gonzalez, et al., 2008, 2012; Russell et al., 2015). Regardless of these behavioral patterns, we were interested in exploring the neural patterns as a measure of early attention, as previous culture and attention neuroscience research have often revealed cultural differences in

neural attention patterns, independent of behavioral attention patterns (e.g., Goto et al., 2010, 2013; Russell et al., 2015).

ERP/N400 analyses

To yield sufficient trial quantities for N400 analyses, we collapsed the ERP averages for the congruent and incongruent conditions, separately (e.g., we collapsed the happy-happy & sad-sad trials together for the congruent condition; see Figure 2 for the 9-electrode grand-averaged waveforms for the close and acquaintance conditions, and Figure 3 for expanded grand-averaged waveforms at Cz). To focus on our hypothesized ERP differences, we further created N400 difference waves by subtracting the averaged incongruent ERP waveforms from the congruent ERP waveforms at electrode Cz (for the 250–450 ms time windows; see Figure 4 for difference waveforms; e.g., Luck, 2005), reflecting the N400 incongruity effect. Using a 2 (Culture: European Canadian vs. Japanese) by 2 (Condition: Close vs. Acquaintance) ANOVA, with the N400 difference wave voltage as a measure, we found an interaction of Culture and Condition, $F(1, 108) = 11.69$, $p < .001$, partial $\eta^2 = .10$. The main effect of Culture and the main effect of Condition were not significant (respectively $F(1, 108) = .78$, $p = .38$, partial $\eta^2 = .007$ and $F(1, 108) = .01$, $p = .91$, partial $\eta^2 < .001$).
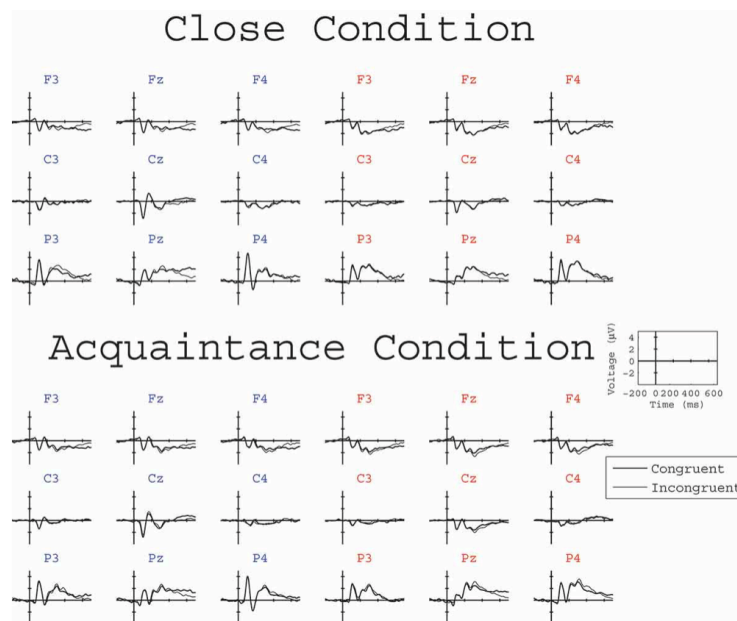

Figure 2. Close (*top*) and Acquaintance (*bottom*) condition congruent and incongruent condition grand averaged ERP waveforms for European Canadians (*blue; left*) and Japanese (*red; right*) for electrodes F3, Fz, F4, C3, Cz, C4, P3, Pz, & P4. Probe stimulus onset was at t = 0 ms, and the 200-ms pre-stimulus baseline is also shown.
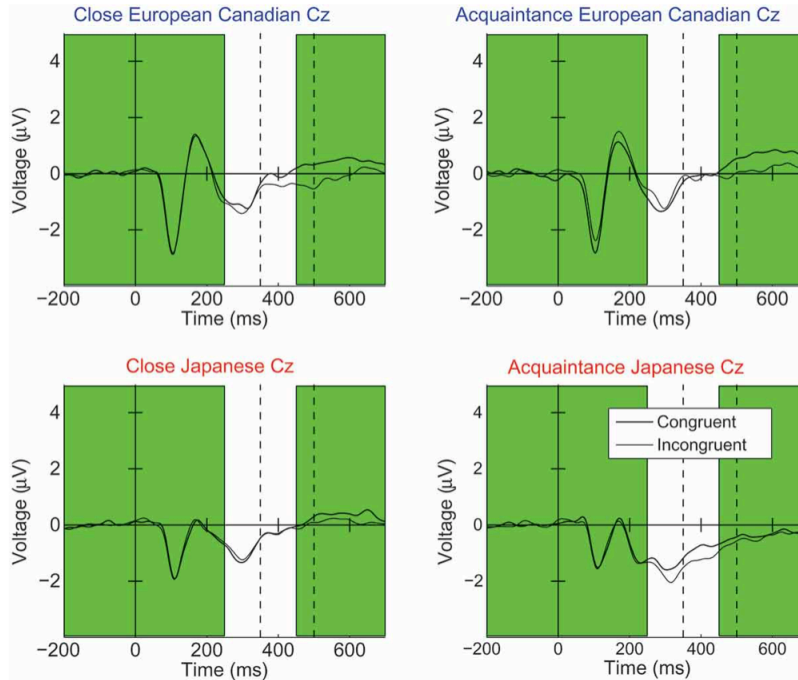
Figure 3. Expanded congruent and incongruent condition grand averaged ERP waveforms for European Canadians and Japanese at electrodes Cz, for the close and acquaintance conditions. Time windows for N400 analyses are set on white backgrounds (250–450 ms). Probe stimulus onset was at t = 0 ms, and the 200-ms pre-stimulus baseline is also shown.
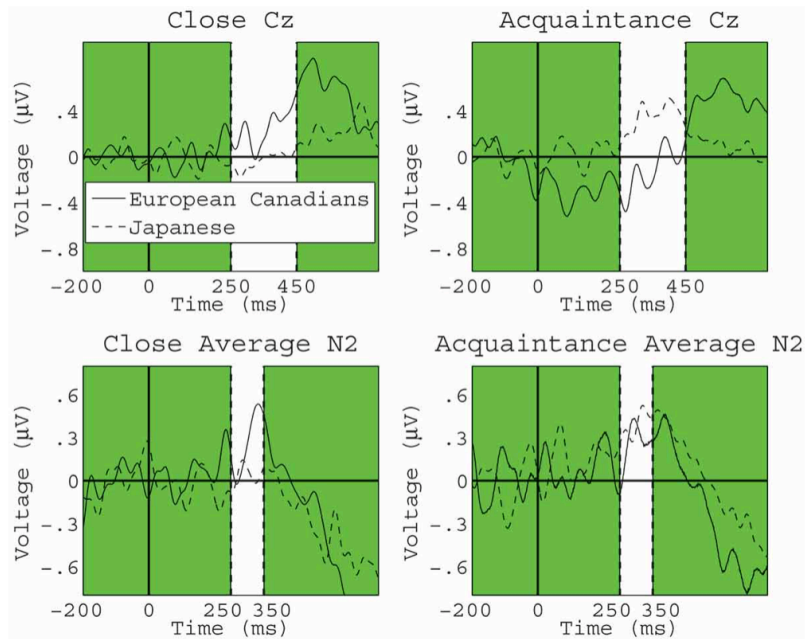

Figure 4. Difference waves (the congruent condition minus the incongruent condition) for European Canadians and Japanese at electrode Cz and at the averaged N2 electrodes (averaged F3, Fz, and F4). Time windows for ERP analyses are set on white backgrounds (Cz: 250–450 ms for N400; Average N2: 250–350 ms for N2). Probe stimulus onset was at t = 0 ms, and the 200-ms pre-stimulus baseline is also shown.

Breaking down the interaction by condition, we found that for the close condition European Canadians showed a stronger N400 incongruity effect than the Japanese, $t(41.65) = 2.07, p = .04$, and for the acquaintance condition the Japanese showed a stronger N400 incongruity effect than European Canadians, $t(54) = 2.69, p = .009$. Similarly, breaking down by Culture, we found that European Canadians showed a stronger N400 incongruity effect in the close than the acquaintance condition, $t(55) = 2.92, p = .005$, and Japanese showed a stronger N400 incongruity effect in the acquaintance than the close condition, $t(53) = 2.13, p < .04$.

Finally, to directly investigate the magnitude of this N400 incongruity effect, we compared the N400 difference wave magnitude to 0 with one-sample t-tests for each culture and condition. In this analysis, we found that that whereas European Canadians showed a N400 incongruity effect for the close condition, $t(28) = 3.63, p < .001$, they did not for the acquaintance condition, $t(27) = 1.14, p = .27$. On the other hand, Japanese did not show a N400 incongruity effect for the close condition, $t(26) = .32, p = .75$, but did for the acquaintance condition, $t(23) = 2.51, p = .02$ (see Table 1 for Means and SDs).

These results give evidence that for acquaintance relationships only Japanese found incongruent social context as unexpected, replicating previous findings (Russell et al., 2015), but for close relationships this pattern actually reverses, with only European Canadians being concerned with incongruent social context. Furthermore, the fact that Japanese did not show a N400 incongruity effect for close relationships, but did show a stronger rating incongruity effect for close relationships than for acquaintances, may reflect that Japanese do indeed care more about close relationships, but do not find these emotions to be concerning in their early attention, perhaps due to these relationships being more permissive (Doi, 1973).

ERP/frontal N2 analyses

Next, exploring frontal N2 differences, we collapsed the ERP averages of the congruent and incongruent conditions, averaging over 3 electrodes (F3, Fz, F4; see Figure 2 for the 9 electrode grand-averaged waveforms for the close and acquaintance conditions). Focusing on our hypothesized condition differences, we created N2 difference waves by subtracting the averaged incongruent ERP waveforms from the congruent ERP waveforms (for the 250–350 ms time window; see Figure 4 for averaged N2 difference waves), reflecting the N2 incongruity effect.

Using a 2 (Culture: European Canadian vs. Japanese) by 2 (Condition: Close vs. Acquaintance) ANOVA, with N2 difference wave voltage as a measure, we did not find an interaction of Culture and Condition, $F(1, 108) = 2.10$, $p = .15$, partial $\eta^2 = .02$, nor main effects of Culture ($F(1, 108) = .34$, $p = .63$, partial $\eta^2 = .002$) or Condition ($F(1, 108) = 2.73$, $p = .10$, partial $\eta^2 = .03$).

However, as we wanted to explore if frontal N2 incongruity effects were seen across conditions as part of our hypotheses, we still compared the N2 difference wave magnitude to 0 with one-sample t-tests for each culture and condition, to directly look at the magnitude of N2 incongruity effects. In this analysis, we found that that European Canadians showed significant N2 incongruity effects for both the close condition, $t(28) = 2.26$, $p = .03$, and the acquaintance condition, $t(27) = 2.68$, $p = .01$. On the other hand, the Japanese did not show an N400 incongruity effect for the close condition, $t(26) = .34$, $p = .74$, but did for the acquaintance condition, $t(27) = 3.19$, $p = .004$ (see Table 1 for Means and SDs). Furthermore, while comparisons between cultures for the two conditions did not yield significant differences, an independent samples t-test comparing Japanese processing for the two conditions did show a significant difference in processing between the conditions, $t(53) = 2.12$, $p = .04$.

Overall, these neural findings give evidence that the N400 (as a meaning error detector) and the frontal N2 (as a simple conflict detector) may be independent processes. European Canadians seem to notice the conflict offered by social incongruence, as seen by a frontal N2, whether or not they actually process this conflict as unexpected, as they only show a N400 in the close condition. For Japanese, when congruity was detected, it was then processed as unexpected, with both N2 and N400 seen together or not at all.

Cultural beliefs and neural incongruity effects

As previous studies have shown relationships between social orientation beliefs and neural incongruity effects, we also explored these relationships (e.g., Goto et al., 2010, 2013; Lewis, Goto, & Kong, 2008; Na & Kitayama, 2011; Russell et al., 2015). For this investigation, we looked at the correlation between social orientation beliefs and the two neural incongruity effect measures: 1) the N400 incongruity effect (with a larger positive score denoting stronger N400 processing for incongruent lineups and more conflict), and 2) the frontal N2 incongruity

effect (with a larger positive score denoting stronger N2 processing for incongruent lineups and more conflict). For this analysis, we quantified differences in independence and interdependence beliefs for the two groups for both conditions. Using a 2 (Culture: European Canadian vs. Japanese) by 2 (Condition: Close vs. Acquaintance) ANOVA, with independence beliefs as a measure, we found a main effect of Culture, $F(1, 108) = 12.39$, $p < .001$, partial $\eta^2 = .10$ (European Canadian $M = 5.58$, $SD = .65$; Japanese $M = 5.05$, $SD = .91$). We did not find a main effect of Condition or an interaction of Culture and Condition (respectively $F(1, 108) = .02$, $p = .90$, partial $\eta^2 < .001$ and $F(1, 108) = .53$, $p = .47$, partial $\eta^2 = .005$). Using a similar model, with interdependence beliefs as a measure, we found no interaction of Culture and Condition ($F(1, 108) = .61$, $p = .44$, partial $\eta^2 = .006$) and no main effects of Culture or Condition, (respectively $F(1, 108) = .56$, $p = .45$, partial $\eta^2 = .005$ and $F(1, 108) = 1.35$, $p = .17$, partial $\eta^2 = .02$). These findings replicate those showing cultural differences in social orientation between East Asians and North Americans (Markus & Kitayama, 1991), and suggest that conditions are comparable within cultures, as no social orientation differences were seen in this domain.

Finally, we investigated the relationship between social orientation beliefs (independence beliefs, interdependence beliefs, and social orientation scores) and the two neural incongruity effect measures for possible correlation, mediation, and moderation effects. While we found no mediation or moderation effects, we did find a difference in correlations between incongruity effects and social orientation for the two conditions (see Table 2 for a summary of correlations). For the close condition, there was a significant negative correlation between frontal N2 incongruity effects and interdependence, $r(56) = -.28$, $p = .04$. This suggests that less N2 conflict (conflict monitoring) was experienced for more interdependent individuals. However, for the acquaintance condition, there was a significant negative correlation between the frontal N2 incongruity effect and independence, $r(56) = -.27$, $p = .046$. This suggests the opposite pattern for the acquaintance condition. Less N2 conflict (conflict monitoring) was experienced for more independent individuals. A similar, but non-significant pattern was seen with the N400 incongruity effect (as for the N2) for the acquaintance condition, with independence scores relating negatively to N400 incongruity effects, $r(56) = -.17$, $p = .21$; less independent individuals found incongruence more unexpected. The correlation between N400 processing and social orientation beliefs for the acquaintance condition is similar in magnitude and direction to

that of the LPC (reflecting later meaning-based processing) in the previous face lineup study (Russell et al., 2015), although we lacked sufficient sensitivity in this study to reach significance.

Table 2. Correlations between independence beliefs and interdependence beliefs, and the N400 and N2 incongruity effects, collapsed across cultures and split for the close and acquaintance conditions. Positive correlations reflect more N2 (conflict monitoring) and N400 (unexpectedness) experienced for more of the listed cultural belief. (Table view)

Close Condition	Independence Beliefs	Interdependence Beliefs
N400 Incongruity Effect	.071	.17
N2 Incongruity Effect	−.043	−.28*
Acquaintance Condition	Independence Beliefs	Interdependence Beliefs
N400 Incongruity Effect	−.17	.17
N2 Incongruity Effect	−.27*	.15

*: $p < .05$.

Together these findings add to growing evidence that individuals' social orientation beliefs relate to neural patterns (e.g., Goto et al., 2010, 2013; Lewis et al., 2008; Na & Kitayama, 2011; Russell et al., 2015).

Discussion

Summary

In summary, we found that relationship type affects how European Canadians and Japanese process incongruent social contextual cues. First off, (*Hypothesis 1-a*) in contrast to expectations and previous findings, European Canadians showed stronger rating incongruity effects than Japanese (e.g., Masuda, Gonzalez, et al., 2008, 2012). However, (*Hypothesis 1-b*) in line with hypotheses and previous literature, both groups rated more influence from incongruence from close others than acquaintances (Uskul et al., 2004).

Findings were in line with expectations for the N400. For acquaintances (*Hypothesis 2-a*), European Canadians did not show a N400 incongruity effect, but Japanese did. This pattern replicates previous face lineup neuroscience findings (Russell et al., 2015). On the other hand,

patterns reversed for close relationships, with only European Canadians engaging in increased N400 meaning-based processing of social incongruence. These patterns also showed weak correlations with social orientation beliefs (*Hypothesis 2-b*).

Finally, for frontal N2 processing (*Hypothesis 3-a*). European Canadians showed patterns suggesting they noticed incongruent social context (seen as a Frontal N2 incongruity effect), whether or not they showed N400 incongruity effects. However, Japanese only showed this processing pattern when they also showed N400 incongruity effects. Social orientation beliefs correlated with Frontal N2 incongruity effects, providing evidence that conflict processing relates to social orientation (*Hypothesis 3-b*).

Implications

Ratings

For ratings, we found that both cultures care more about social incongruence for close vs. acquaintance relationships. This is in line with previous literature showing that both cultures desire to be closer to close others than acquaintances (Uskul et al., 2004). However, as an unexpected finding, we found that North Americans showed more influence from social incongruence in their judgments than East Asians. This is in contrast to noted cultural differences in attention and previous face lineup task studies where East Asians have been shown to have more context sensitivity (e.g., Masuda, Gonzalez, et al., 2008, 2012; Nisbett, 2003; Russell et al., 2015; Varnum et al., 2010). While it may be that North Americans actually perceive more influence from conflicting emotional context, we believe that this is partially due to a limitation of the current design. That is, as the focus of the current study was on early attention to relationships, we explicitly instructed participants to make judgments of center persons in relation to the surrounding people, versus other studies that left how to take into account social context less explicit (Masuda et al., 2012; Masuda, Ellsworth, et al., 2008; Russell et al., 2015). This in turn may have lead North Americans to rate more influence from surrounding others. Furthermore, as North Americans have been shown to extreme score and East Asians to score moderately, ratings might have become stronger for North Americans than East Asians (e.g., Heine, Lehman, Peng, & Greenholtz, 2002). Regardless, because the instruction to consider the center person in relation to surrounding others made North Americans sensitive to how others

influence them, it does suggest that social context affects people from independent cultures as well. This may mean that previous findings are better interpreted as showing that culture influences how much social thoughts come to surface, making them less salient for independent cultures (Masuda et al., 2012; Masuda, Ellsworth, et al., 2008; Russell et al., 2015). Future research is needed to understand the boundary conditions of when noted cultural differences in attention become salient (e.g., Do less explicit manipulations lead North Americans to not take into account surrounding social context?).

ERP patterns

For N400s, our findings suggest that culture interacts with relationship type to influence how people place meaning on incongruent social contextual cues. For acquaintances, in line with cultural differences in attention (e.g., Nisbett, 2003; Varnum et al., 2010), East Asians processed social incongruence as concerning and North Americans did not. We interpret these findings to reflect that East Asians have concern for social incongruence with acquaintances due to harmony goals related to interdependence/face culture, and that North Americans did not find emotion differences concerning as they place themselves as more autonomous based on their independence/dignity culture (e.g., Kim et al., 2010; Leung & Cohen, 2011; Schug et al., 2010). Contrasting with these findings, patterns reversed for close relationships. We explain the North American patterns in terms of increased intimacy behaviors and the mutual influence they experience with close others, and a concern for incongruent social context to preserve these relationships (e.g., Arriaga, 2013; Schug et al., 2010; Wegner et al., 1985). Conversely, we take the Japanese lack of N400 processing with close others to reflect less concern for differing emotions with close others, as this relationship has been noted to be more permissive and to have less concerns for face (e.g., Doi, 1973; Hwang, 1987; Kim & Nam, 1998). These cultural differences in N400 patterns are a novel addition to the field in that they propose that culture-related attention processes are situational and operate based on relationship context. This is in line with recent research showing that culture-related neural patterns are situational and able to be activated through priming (Fong et al., 2014). Most importantly, these N400 findings provide context to current cultural psychology theory. One current explanation of cultural differences in attention is that they are based in social orientation differences (Varnum et al., 2010). In contrast, our findings suggest that social orientation may also lead to opposite patterns of attention in

certain relationship contexts (e.g., close relationships). With this nuance in mind, we believe that additional research is needed to better understand what aspects of social experience lead to seen attention differences (e.g., Do certain types of relationships, like acquaintances, drive noted cultural differences in attention?).

Next, the frontal N2 neural patterns also suggest cultural differences in how North Americans and East Asians notice incongruent social context. While European Canadians showed evidence of experiencing conflict from social incongruence (via the Frontal N2) regardless of whether or not they placed it as unexpected (via the N400), Japanese only showed conflict related to social incongruence when they placed it as unexpected. This suggests that semantic and conflict processing may potentially be independent processes. It also suggests that North Americans and East Asians may show different overall uses of neural information. East Asian's neural processes for the tasks were all or none, while North American neural processes separated processed information from the meaning placed on it. Such patterns may relate to noted cultural differences in holistic and analytic attention (Nisbett, 2003), although this topic requires future investigation.

Finally, we found a relationship between social orientation and incongruity effects. On the one hand, independence's negative relationship with the context experienced through the Frontal N2 for acquaintances supports that the link between social orientation and attention may be most salient for acquaintances. Those that are less independent tend to process social context less, which is in line with noted cultural differences (Markus & Kitayama, 1991; Varnum et al., 2010). On the other hand, we found a negative relationship between interdependence and the Frontal N2 for close relationships – those with more interdependent tendencies actually show less processing of incongruent emotions in close relationships. These findings further support that social orientation differentially affects social attention in close and acquaintance relationships. Furthermore, these findings suggest that the Frontal N2 may be an additional marker of neural social orientation differences for face lineup tasks, although a weaker relationship was still found between social orientation and the N400. These findings add to findings showing that neural patterns often relate to individual differences in social orientation beliefs, with a weaker relationship between cultural beliefs and cultural differences in behavior (e.g., Goto et al., 2010, 2013; Na et al., 2010; Russell et al., 2015).

Together these findings give support that cultural differences in the self, often discussed under the frameworks of individualism/independence and collectivism/interdependence, may be more nuanced than previously suggested (e.g., Markus & Kitayama, 1991; Triandis, 1995), with relationship context affecting whether or not East Asians and North Americans are concerned with social incongruence. We believe that various contextual factors like relationship distance might be influential to how people attend to their worlds, and such, contextual factors may help explain discrepancies in recent findings (e.g., Senzaki, Masuda, Ishii, 2014).

Diverging attention processes

The current study gives evidence of a divergence of attention processes, as was seen in earlier studies (e.g., Goto et al., 2010, 2013; Russell, 2016; Russell et al., 2015). We take this as early evidence that different attention measures may measure different attention processes, converging or diverging depending on the task (Russell, 2016). We argue that ERP neural patterns describe earlier, more automatic attention, as these processing patterns are too early to involve a great deal of thought, intermediate attention patterns (i.e., eye-tracking) describe active attention processes that support eventual decisions, and rating behaviors describe more effortful, intentional processes, taking into account various information sources, as well as conscious appraisals of this information.

As part of the novel nature of this study, we measured culture's effect on multiple measures across the attention process and found that culture differentially influences attention across time. The seen lack of coherence between attention processes provides evidence that culture's effect on attention may be more nuanced than currently suggested. We propose that culture's effect on attention depends on how aspects of culture line up with each attention process. The Frontal N2 may relate to learned simple perceptual attention, the N400 to expectations and experiences of how people behave around us, and ratings to more conscious narratives about how people interact. While a simple story, that culture influences our attention in a single way would be nice, the human mind is complex. Because of this reality, we should also expect that culture influences the human mind in complex ways. What this means for future cultural neuroscience research is that there are many future directions for research to show where, when, and how culture affects the human thought process.

Limitations and future research

First off, one limitation of this research is that the relationship descriptions in this study may have added noise to the design. While relationships were made open intentionally to allow participants to avoid imagining relationships that might not fit the intended close/acquaintance definitions, this might have led to some differences in interpretations of the relationships or an inability for some participants to imagine relationships. To prevent such noise, future research could have participants provide in-depth descriptions of relationships, to ensure relationships were taken into mind. In addition, future research should target other relationship types to determine the boundary conditions of where North Americans and East Asians process social incongruence as meaningful, targeting friends, strangers, etc. Other relationship differences are likely to be found according to differences proposed in cultural models (e.g., Heine, 2008). Finally, as our current neural findings only relate to very basic early attention processes, future research should investigate more realistic settings in future studies, such as when people interact with others of different relationship types. These behavioral differences have great implications as one important goal of cultural psychology should be to understand real life behavior.

Conclusion

The current research expands upon findings showing that social orientation also affects social attention. In contrast to recent theories, stating that cultural differences between North Americans and East Asians unilaterally lead to attention differences, we found evidence that culture affects social attention patterns in a more nuanced fashion. These findings are important as they give caution to current directions in cultural psychology that oversimplify cultural differences related to social orientation. Social attention is goal directed and multifaceted, and should be investigated with this reality in mind.

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