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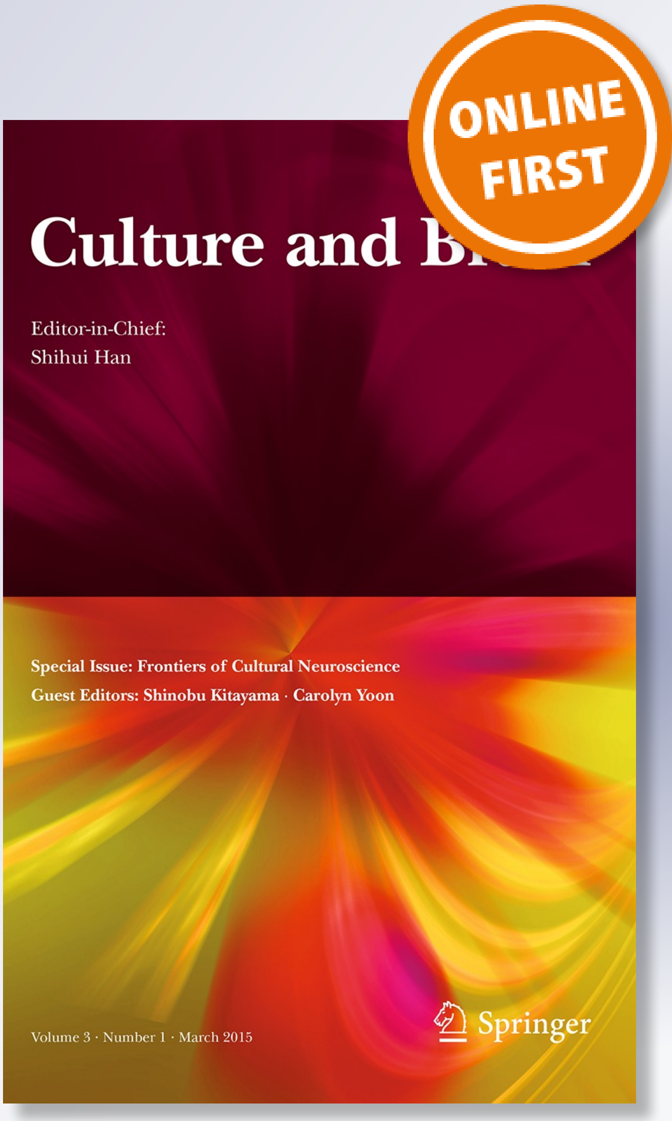

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ORIGINAL RESEARCH

Culture and social judgments: the importance of culture in Japanese and European Canadians' N400 and LPC processing of face lineup emotion judgments

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Abstract Research has shown that East Asians tend to be more influenced by background social information than North Americans. To further examine these findings, we collected event-related brain potentials (ERP) during a face lineup emotion rating task where participants were asked to rate the emotions of central persons of five person emotion lineups. Lineups were either *congruent*, with all faces showing similar emotions, or *incongruent*, with central face emotions differing from background face emotions. The behavioral results replicated previous findings, showing that Japanese ratings were more influenced by background information than European Canadians. The ERP data showed incongruity effects, showing increased processing of socially incongruent brainwaves (than congruent lineups) in early (the N400) and late (the LPC) meaning-based processing of stimuli. Differences in processing were not seen between the two conditions for European Canadians. Furthermore, independence social orientation beliefs explained these incongruity effects: (1) Independence social orientation beliefs moderated the two cultures' early processing patterns, showing a negative relationship between independence and European Canadians' N400 incongruity effects, while East Asians generally processed social incongruence early, and (2) independence social orientation beliefs were negatively related with both groups' later processing of social incongruence. The importance of culture in social judgments is discussed.

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Introduction

Cultural psychological research supports that cultural differences in social orientation lead to the adoption of differing attentional strategies (Varnum et al. 2010). On the one hand, *independent cultures* (e.g., North Americans) celebrate the individual and emphasize their uniqueness. This social orientation has been related to an *object-oriented mode of attention*, where attentional focus is put on focal objects without their contextual background. On the other hand, *interdependent cultures* (e.g., East Asians) emphasize the importance of the group and their harmonious existence within that group. This social orientation has instead been related to a *context-oriented mode of attention*, where attention is spread between focal objects and embedding contexts (Markus and Kitayama 1991; Morling and Masuda 2012; Nisbett and Masuda 2003; Nisbett and Masuda 2003; Nisbett and Miyamoto 2005; Nisbett et al. 2001).

These differences in modes of attention are quite robust, generalizing across various non-social domains, influencing how independent and interdependent cultures make visual judgments, make decisions, view scenes, create narratives, and make memory judgments (Chua et al. 2005; Ji et al. 2000; Li et al. 2014a, b; Masuda and Nisbett 2001, 2006; Masuda et al. 2008b; Nand et al. 2014; Senzaki et al. 2014a; Senzaki et al. 2014b; Wang et al. 2012). Furthermore, they have been shown to generalize to the neural domain (e.g., Goto et al. 2010, 2013; Lewis et al. 2008; Masuda et al. 2014; Na and Kitayama 2011).

Visual social contextual judgments and modes of attention

The influences of modes of attention are also seen for social judgments. To test how attention styles influence visual social contextual judgments, research by Masuda and colleagues used the *face lineup emotion rating task* (Masuda et al. 2008a; Masuda et al. 2012). In this work, North Americans and East Asians were asked to rate the emotional valence of central faces in five person emotion lineups. Lineups were either *congruent*, with emotions of the central face and background faces similar (i.e., the central person was happy and the background people were happy), or *incongruent*, with emotions of the central face and background faces different (i.e., the central person was sad and the background people were happy). In line with mode of attention differences, North Americans showed little influence from background face emotion information in their ratings, while East Asians showed more influence from background face emotion information. This suggests that only East Asians felt the need to integrate background faces' emotional information into their ratings of center persons.

To further understand attention patterns during these face lineup judgments, Masuda and colleagues (2008a, b) also investigated eye-movement patterns. This data revealed that while both cultural groups began by attending to center persons, cultural differences emerged soon after, with North Americans selectively allocating their attention to center persons and Japanese spreading their attention more between center and background people. Given these cultural variations in emotion judgments and the corresponding eye movement patterns, we were interested in exploring North Americans' and East Asians' neural processing of face lineups.

Visual non-social contextual judgments and cultural neuroscience

While no cultural neuroscience research to date had explored our question, several other studies investigated the neural substrates that explain cultural variations in visual non-social contextual judgments (e.g., Goto et al. 2010, 2013; Lewis et al. 2008; Masuda et al. 2014). Common to many of these studies, researchers targeted an event related brain potential (ERP) component called the N400. The N400 is a negative-going deflection ERP that is usually maximal in central-posterior electrode sites (usually Cz) around 400 ms after key stimuli events are presented (Kutas and Federmeier 2011). Particularly, the N400 has been linked to the processing of semantic relationships and responds more to incongruent or unexpected events.

In one of these studies, Goto et al. (2010) used the N400 to explore whether European Americans and Asian Americans showed additional semantic processing of visual non-social incongruence. In their task, participants were asked to rate whether focal objects were animate or inanimate in semantically congruent (i.e., a crab superimposed on a beach), and semantically incongruent images (i.e., a crab superimposed on a parking lot), while ERP data were collected. The results of this study indicated that only Asian Americans showed an incongruity effect, showing a larger N400 to incongruent images (vs. congruent images). This suggested that only East Asians showed semantic processing of the non-social incongruence. Even with participants not being explicitly asked to consider background information, the Asian Americans showed neural processing of the semantic relationship between foreground objects and background information. Furthermore, independence social orientation beliefs were related to the magnitude of the incongruity effect, with more independent individuals tending to have smaller incongruity effects. In other words, more independent people, which are thought to show more object-oriented modes of attention (Varnum et al. 2010), were also less likely to process incongruent visual contextual information (Goto et al. 2010).

The late positive complex (LPC)

An additional ERP of interest in our study was the late positive complex (LPC). This waveform is commonly seen associated with the N400 (e.g., Yao and Wang 2014). The LPC is a positive going ERP component that usually begins around 500 ms, and is maximal in parietal electrodes. It is thought to reflect cognitive resource allocation and stimuli evaluation, and is sensitive to affective incongruence. Opposite of the N400, incongruent stimuli generally result in larger LPCs than congruent stimuli. We were interested in examining whether a LPC difference might also be present for East Asians in the face-lineup task, reflecting a continued attention to and processing of background socially incongruent faces.

Hypotheses

Based on these findings (Goto et al. 2010), and previous findings showing cultural differences in rating behaviors for the face lineup emotion rating task (Masuda et al. 2008a; Masuda et al. 2012), we expected that cultural differences in neural processing should also be at work when rating face lineups. In the case of social face lineup judgments, we assumed that the generally more interdependent East Asians' values for harmonious interpersonal relationships would also direct East Asians to further process social incongruence, as this incongruence could be a potential social threat to their interdependent notions of the world, in contrast to North Americans, which should generally ignore this social incongruence due to their independent cultural values (e.g., Ito et al. 2014; Kim et al. 2008).

To test this hypothesis, we had European Canadians and Japanese engage in the face lineup emotion rating task while collecting ERP data. Behaviorally we expected to replicate previous findings, showing that Japanese judgments were more influenced by incongruent social information than European Canadians. In the neural domain, we expected that: (1) an N400 incongruity effect would be shown for Japanese, reflecting their processing of threats to harmony, but not for European Canadians, and that (2) individuals' social orientation beliefs would explain differences in N400 incongruity effects, as seen in recent related cultural ERP studies (e.g., Goto et al. 2010, 2013; Lewis et al. 2008). We also explored if, (3) there were later occurring processing differences in the form of an incongruity effect for the LPC for the Japanese group, and (4) how social orientation beliefs might relate to this LPC processing.

Methods

Participants

We recruited 42 European Canadian undergraduate students (21 Females, 21 Males; Ages 18.9 ± 2.7, range 17–34 years) from the University of Alberta and 42 Japanese undergraduate students (24 Females, 18 Males; Ages 20.4. ± 4.1, range 18–38 years) from Kobe University. European Canadian participants earned partial course credit and Japanese participants received an honorarium ($10–$12) for their participation. Both written and oral instructions were provided in English for European Canadian participants and Japanese for Japanese participants. English instructions and questionnaires were translated to Japanese and back-translated to English by two fluent bilingual English/Japanese speakers (Brislin 1976).

Face lineup stimuli

Task stimuli consisted of lineups of five persons' with one central person surrounded by four background people (2 to each side). The central person was either happy or sad, and the background people were all either happy or sad. We chose happy and sad emotions as they showed the largest cultural variations in the

Masuda et al. (2008a) study. Lineups with similar emotions (i.e., the central person and the background people were happy) were classified as *congruent*, and lineups with differing emotions (i.e., the central person was sad, but the background people were happy) were classified as *incongruent* (See Fig. 1 *for example stimuli*). We included 64 images total from the Masuda et al. (2012) and Masuda et al. (2015) studies, where images were validated to be clearly and equally understood between European Canadian and Japanese students in pilot studies (Lineups contained: 32 Caucasian and 32 Japanese lineups, 32 male and 32 female center models, 32 happy and 32 sad expressions for center persons, and 32 happy and 32 sad expressions for background people). We also selected 4 other lineups representing all foreground-background emotion combinations (i.e., happy–happy, sad–happy, etc.) for practice.

Besides the practice images, the task contained 64 different image combinations, with 32 congruent images (16 happy (center)-happy (background) and 16 sad–sad) and 32 incongruent images (16 sad–happy and 16 happy–sad). Participants were assigned to one of two pseudo-random orders of presentation for lineups, where images were arranged such that no more than two congruent or incongruent images were presented sequentially, and that the center models for any two sequentially presented images were not the same.

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 seated 55 cm from a 19" monitor that displayed the face lineup emotion rating task from a computer running E-prime 2.0 Professional (Psychology Software Tools Inc., Pittsburgh, PA). Participants then engaged in the task while EEG data were recorded simultaneously on a separate computer through Acknowledge 4.0 (Biopac Systems Inc., Goleta, CA). The same EEG system was used in both locations. Participants were told that their task was to rate the emotion of the center person as fast as possible by pressing keys (with both hands) on a keyboard, first rating how positive they perceived the center person's emotional state, and then rating how negative they perceived the center person's emotional state, by referring to a 10 point Likert scale (0 = not all to 9 = extremely). After eight practice trials, participants made 64 judgments.[1] On completion, participants answered demographic and survey questions, before being debriefed and dismissed.

Trial timing

Each trial started with a fixation cross (+) for 1000 ms, followed by the presentation of a face lineup image for 4000 ms. At this point, face lineups continued on the screen while participants were provided a rating bar displaying which type of rating to make. First, participants made positive ratings, followed by negative ratings.

[1] Before proceeding to the experimental trials, participants acclimated to the task first through an untimed and then a timed practice session, with four practice judgments each. At this point, participants engaged in the main task where they first viewed and rated 32 lineups, and then were provided a 2 min break, before proceeding to the final 32 judgments.

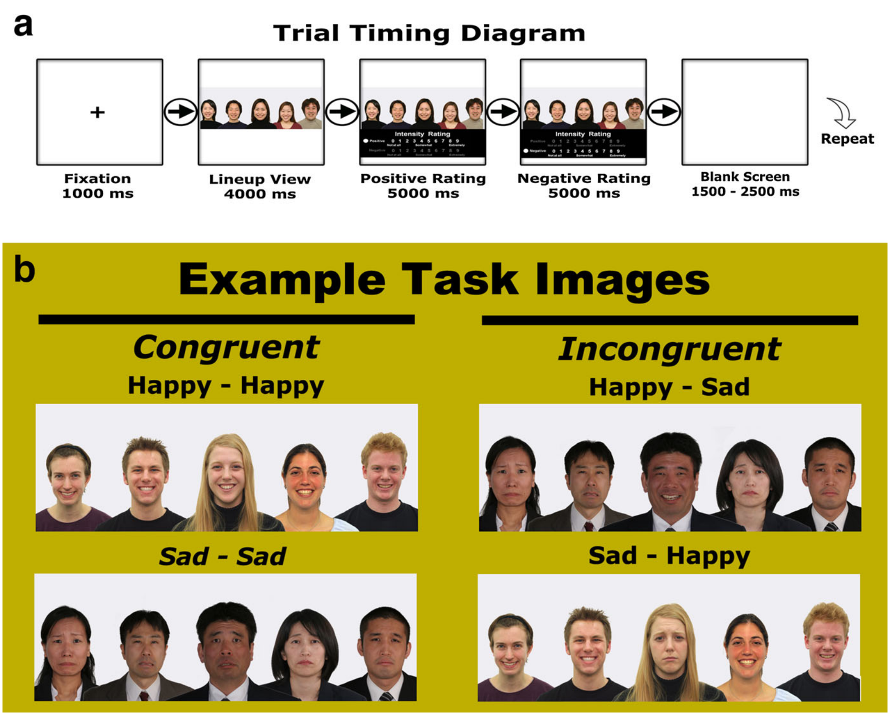


Fig. 1 **a** (*top*) Trial timing diagram for the face emotion rating task. Backgrounds were *black* in actual trials. **b** (*bottom*) Example face emotion rating task stimuli, for the congruent (happy (center)–happy (background) and sad–sad) and the incongruent conditions (happy–sad, and sad–happy)

Ratings were scaled from (0 = not all to 9 = extremely) for both the positive and negative ratings. If participants took more than 5000 ms for either rating, the trial automatically proceeded to the next rating or step. Finally, participants were provided with a short break between trials to rest their eyes, set as a random interval between 1500 to 2500 ms (See Fig. 1 *for trial timing diagram*).

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), with EEG signals recorded at electrodes F3, Fz, F4, C3, Cz, C4, P3, Pz, and P4, as well as one vertical eye-blink electrode set above and below the right eye (recorded through an EOG100C amplifier). EEG system amplification was set to a gain of 10,000 and sampled at 1000 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 and Makeig 2004, http://sccn.ucsd.edu/eeglab). Output EEG signals were initially referenced to a forehead electrode and online filtered with analog filters between 0.1 and 35 Hz. After data collection, EEG signals were average re-referenced and digitally bandpass filtered between 0.5 and 30 Hz.

Artifacts were initially corrected by Independent Component Analysis (e.g., Hoffman and Falkenstein 2008; Makeig et al. 1996), with data with increased signal to noise ratios (as seen by poor Individual Components) first put through an automatic BSS Sobi algorithm to decrease noise (Begam and Thilakavathi 2014). Finally, trials for which voltages deviated more than 100 μV from baseline were rejected.

For analyses, trials were epoched 200 ms pre- to 700 ms post-presentation of the initial 4000 ms display of the lineup stimulus (see Fig. 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 350–500 ms time window. This time window was based on previous literature, as well as initial peak peaking analyses that revealed that some participants had later N400 processing, around 500 ms (e.g., Kutas and Federmeier 2011). The LPC was quantified by taking the mean voltage at electrode P4 for the 500–700 ms time window. Electrode P4 was chosen as it was the maximal point for LPC differences (e.g., Picton et al. 2000). 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 45 surviving trials (and less than 20 per each condition) or lack of sufficient Individual Components were removed from final analyses.[2]

Cultural beliefs: independence and interdependence social orientation

As measures of individuals' independent and interdependent social orientation beliefs, participants were administered a 23-item social orientation scale (13 independence items and 10 interdependence items) based on items used in the (Kim et al. 2003) paper. 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 (English version) 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 (Independence sub-scale: European Canadians, $\alpha = .746$, Japanese, $\alpha = .813$; Interdependence sub-scale: European Canadians, $\alpha = .821$, Japanese $\alpha = .712$).

Results

Behavioral data: emotion ratings

To be consistent with ERP analyses, we collapsed all model factors (i.e., model gender, culture group, etc.) for target lineups and focused on analyses of

[2] This resulted in a loss of 4 participants for the European Canadian group and 3 participants for the Japanese group, leaving 38 European Canadians (17 Females and 21 Males) and 39 Japanese (22 Females and 17 Males) for ERP analyses.

participants' ratings during the congruent and incongruent conditions. We further averaged positive ratings of central happy faces with negative ratings of central unhappy faces (which were split in previous studies' analyses) for both the congruent and incongruent conditions.[3] In a mixed 2 (Culture: European Canadians and Japanese) X 2 (Condition: Congruent Lineups vs. Incongruent Lineups) repeated-measures ANOVA, with ratings as the measure, we found a significant main effect of Condition, $F(1, 82) = 36.27$, $p < .001$, $\eta p^2 = .307$, revealing that in general participants were influenced by social incongruence, having greater emotion ratings for congruent lineups than incongruent lineups, (Congruent $M = 7.26$, $SD = .90$, Incongruent $M = 6.19$, $SD = 1.38$). However, this effect was qualified by an interaction between Culture and Condition, $F(1, 82) = 7.41$, $p < .01$, $\eta p^2 = .083$. The results of simple effect analyses revealed that while European Canadians showed influence of social incongruence in their ratings; $t(41) = 3.17$, $p < .005$, this influence was stronger for Japanese; $t(41) = 5.12$, $p < .001$ (See Table 1 *for means and SD*). The main effect of Culture was not significant ($p > .1$). This interaction replicates previous findings (Masuda et al. 2008a; Masuda et al. 2012).

ERP/N400 analyses

To yield sufficient trial quantities for the ERP analyses, we collapsed all model factors and focused on the ERP averages of the congruent and incongruent conditions (See Fig. 2 *for 9 electrode grand-averaged waveforms, and* Fig. 3 *for larger grand-averaged waveforms at Cz*).[4] In an initial analysis, we found a main effect of culture on the mean amplitude of N400 ERPs during the 350–500 ms time window, $t(75) = 2.78$, $p < .01$, reflecting that European Canadians generally had larger N400s than Japanese (European Canadians $M = -1.75$ µV, $SD = .78$, Japanese $M = -1.25$ µV, $SD = .78$).

More importantly, to focus on our hypothesized condition differences, we created N400 difference waves by subtracting the averaged incongruent ERP waveforms from the congruent ERP waveforms at electrode Cz (for the 350–500 ms time window) (*See* Fig. 4 *for difference waveforms;* e.g., Luck 2005). Comparing N400 difference waves for each culture, an independent samples t test revealed a difference in N400 processing, $t(75) = 2.02$, $p < .05$. Further analyzing this difference with one-sample t tests for each culture (comparing the difference waves to 0), revealed that European Canadians did not show a difference in N400 processing for the two conditions, $t(37) < 1$, ns, but that Japanese did, $t(38) = 2.16$, $p < .05$, reflecting more N400 processing for incongruent face lineups (See Table 1

[3] Similar behavioral findings were found when averaging all four congruent and incongruent condition ratings, averaging reverse scored ratings of emotions of center persons when their emotions were opposite of the rating type (i.e., happy center faces and negative ratings) with ratings of similar ratings and emotions (i.e., happy center faces and positive ratings).

[4] Trials surviving ERP preprocessing for the congruent and incongruent conditions did not differ between cultures, conditions, or have a significant interaction between culture and condition (European Canadians Congruent $M = 28.21$, $SD = 2.26$, Incongruent $M = 28.37$, $SD = 2.21$; Japanese Congruent $M = 28.03$, $SD = 2.23$, Incongruent $M = 27.64$, $SD = 2.19$).

Table 1 Means (standard deviations) for ratings (top), N400 difference waves (bottom-left) and LPC difference waves (bottom-right), as a function of culture and condition. Difference waves were calculated by subtracting averaged incongruent lineup N400s from congruent lineup N400s in the 350–500 ms time window

Average ratings (from 0–9)		
Culture	Congruent	Incongruent
European Canadians	7.11 (**.79**)	6.53 (**1.04**)
Japanese	7.40 (**.98**)	5.86 (**1.60**)
	N400 Difference Wave (μV) (Congruent–Incongruent)	LPC Difference Wave (μV) (Congruent–Incongruent)
Culture		
European Canadians	−.043 (**.43**)	.064 (**.69**)
Japanese	.17 (**.49**)	−.28 (**.67**)

Bold values indicate standard deviations

for Means and SD).[5] The replicates previous findings and supports that neural processing patterns during social judgments are also influenced by cultural differences in modes of attention, with Japanese only processing social incongruence (Goto et al. 2010, 2013).

ERP/LPC analyses

Exploring for LPC differences, we again collapsed all model factors and focused on the ERP averages of the congruent and incongruent conditions (*See* Fig. 3 *for grand-averaged waveforms at P4*). In an initial analysis, we did not find a main effect of culture on the mean amplitude of LPC ERPs during the 500 to 700 ms time window.

More importantly, to focus on our hypothesized condition differences, we created LPC difference waves by subtracting the averaged incongruent ERP waveforms from the congruent ERP waveforms at electrode P4 (for the 500-700 ms time window) (*See* Fig. 4 *for difference waveforms;* e.g., Luck 2005). Comparing LPC difference waves for each culture, an independent samples t test revealed a difference in LPC processing, $t(75) = 2.22$, $p < .05$. Further analyzing this difference with one-sample t tests for each culture (comparing the difference waves to 0), revealed that European Canadians did not show a difference in LPC processing for the two conditions, $t(37) < 1$, ns, but that Japanese did, $t(38) = 2.60$, $p < .05$, reflecting more LPC processing for incongruent face lineups (See Table 1

[5] Means for the N400 for the two culture were: European Canadians Congruent $M = -1.77$ μV, $SD = .88$, Incongruent $M = -1.72$ μV, $SD = .74$; Japanese Congruent $M = -1.16$ μV, $SD = .83$, Incongruent $M = -1.34$ μV, $SD = .80$, and means for the LPC for the two cultures were: European Canadians Congruent $M = 1.64$ μV, $SD = 1.04$, Incongruent $M = 1.57$ μV, $SD = 1.00$; Japanese Congruent $M = 1.15$ μV, $SD = .96$, Incongruent $M = 1.43$ μV, $SD = 1.02$.

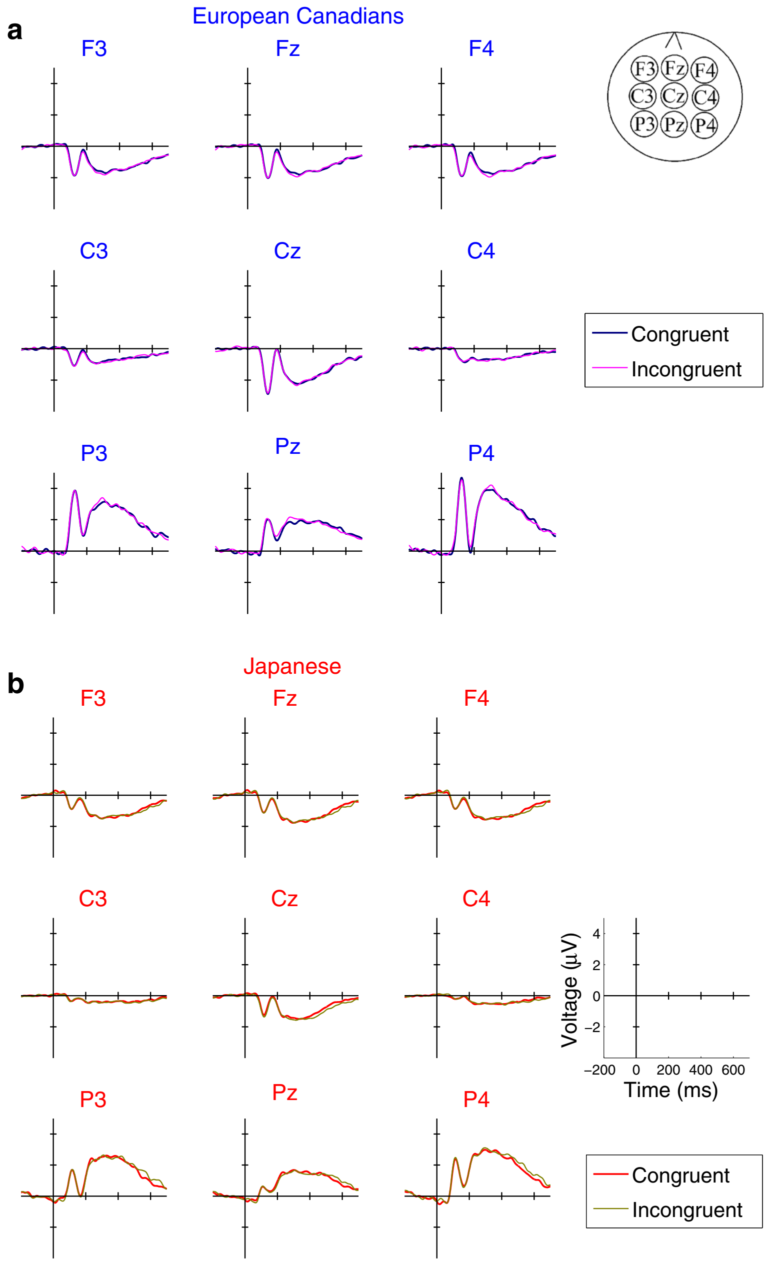


Fig. 2 Congruent and incongruent condition grand averaged ERP waveforms for European Canadians (*top* 9 electrodes) and Japanese (bottom 9 electrodes) for electrodes F3, Fz, F4, C3, Cz, C4, P3, Pz, & P4. Probe stimulus onset was at t = 0 ms, and the 200-ms pre-stimulus baseline is also shown

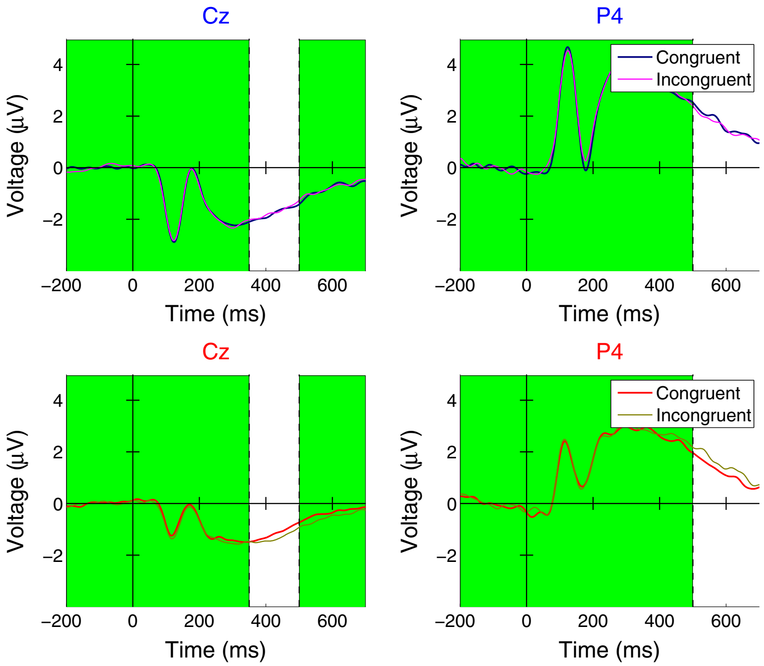


Fig. 3 Expanded congruent and incongruent condition grand averaged ERP waveforms for European Canadians (*top*; *blue*) and Japanese (*bottom*; *red*) at electrodes Cz and P4. Time windows for ERP analyses are set on white backgrounds (Cz: 350–500 ms for N400 analyses; P4: 500–700 ms for LPC analyses). Probe stimulus onset was at t = 0 ms, and the 200-ms pre-stimulus baseline is also shown. (Color figure online)

for Means and SD).[6] This finding is novel and suggests that the processing differences for the Japanese continue into the 500-700 ms time range, perhaps reflecting continued attention to and processing of social incongruence.

Cultural beliefs and incongruity effects

As previous studies have shown relationships between social orientation beliefs and the magnitude of N400 incongruity effects, we then explored the relationship between social orientation beliefs and our observed incongruity effects (e.g., Goto et al. 2010, 2013; Lewis et al. 2008; Na and Kitayama 2011). We calculated three incongruity measures: (1) *the rating incongruity effect*, as the difference between individuals' congruent and incongruent condition rating averages (with a larger score denoting a larger change of ratings from congruent to incongruent lineups), (2) *the N400 incongruity effect*, as the difference wave computed by subtracting incongruent N400 waveforms from congruent waveforms (with a positive score denoting more N400 processing for incongruent lineups), and the (3) *the LPC incongruity effect*, as the difference wave computed by subtracting incongruent LPC

[6] See Footnote 5

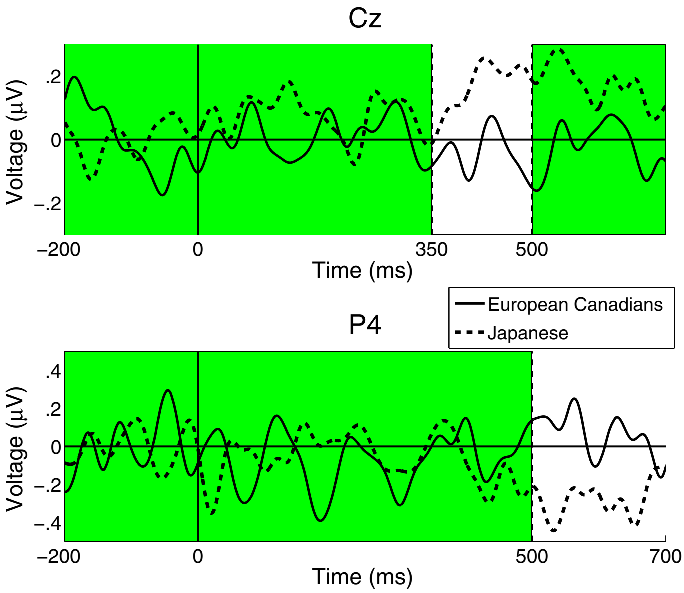


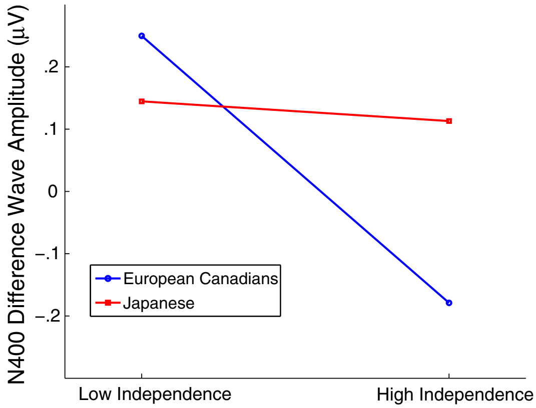
Fig. 4 Difference waves (the congruent condition *minus* the incongruent condition) for European Canadians and Japanese at electrode Cz and P4. Time windows for ERP analyses are set on white backgrounds (Cz: 350–500 ms for N400 analyses; P4: 500–700 ms for LPC analyses). Probe stimulus onset was at t = 0 ms, and the 200-ms pre-stimulus baseline is also shown

waveforms from congruent waveforms (with a negative score denoting more LPC processing for incongruent lineups).

We then quantified differences in independence and interdependence social orientation beliefs for the two groups. Using an independent sample *t* test, testing for differences in independence beliefs between the two cultures, we found a significant difference between the two cultures' independence social orientation beliefs, $t(81) = 3.17$, $p < .01$ (European Canadian $M = 5.46$, $SD = .73$; Japanese $M = 4.97$, $SD = .68$). On the other hand, there was no difference between culture for interdependence social orientation beliefs, $p > .5$ (European Canadian $M = 4.50$ $SD = .70$; Japanese $M = 4.42$ $SD = .90$). These findings replicate previous findings, showing cultural differences in social orientation (e.g., Markus and Kitayama 1991), while suggesting that these differences might be more salient in the independence social orientation domain.

Next, we investigated the relationship between social orientation beliefs (independence and interdependence) and the two incongruity effect measures for possible correlation, mediation, and moderation effects. We found 2 such relationships. The first was between independence social orientation beliefs and the N400 incongruity effect. Using hierarchal linear regression to model the interaction of culture and independence social orientation beliefs on the prediction of the N400 incongruity effect, we found a significant interaction, $\beta = 2.00$, $p < .05$. Breaking down this finding into simple slopes, we found that European Canadians' independence beliefs showed a negative relationship with the N400 incongruity

Fig. 5 Simple slopes using independence social orientation beliefs to predict difference waves over the 350–500 ms time window for European Canadians and Japanese



effect, with less independent European Canadians showing greater N400 incongruity effects, $R^2 = .24$, $p < .01$, with no such relationship found for the Japanese, $R^2 = .001$, $p > .5$ (See Fig. 5).[7] The second relationship of interest was a significant negative correlation between the LPC incongruity effect and independence social orientation beliefs, r(76) = −.23, p < .05. Regardless of cultural group, individuals with greater independence beliefs showed weaker LPC incongruity effects.

In regards to these findings, the moderation finding replicates previous findings in North American contexts showing a relationship between social orientation beliefs and N400 incongruity effects in European American and Asian American populations (e.g., Goto et al. 2010, 2013; Lewis et al. 2008; Na and Kitayama 2011). However, the Japanese finding for N400 incongruity effects is novel, suggesting something different about the Japanese cultural context. As one possible explanation, the value put on the individual in North America may afford European Canadian participants to better follow their own social orientation beliefs in early social judgment processing, while pressures in Japan to not violate group norms (combined with less focus on individuals' beliefs) may force Japanese participants to generally notice social incongruence early. However, the LPC findings contrast with these findings, suggesting that social orientation beliefs do generally relate to ERP incongruity effects in later social incongruence processing (e.g., Goto et al. 2010, 2013; Lewis et al. 2008; Na and Kitayama 2011).

Discussion

Summary and implications

In summary, we found that culture affects how people process visual social contextual judgments. Replicating previous behavioral findings, Japanese showed

[7] One outlier was excluded from the moderation analysis due to it being greater than 3 standard deviations from regression lines. However, we should note that both with and without this outlier, the moderation interaction was still significant.

more influence from social incongruence in their ratings than European Canadians (Masuda et al. 2008a; Masuda et al. 2012). In terms of neural processing, the object-oriented European Canadians did not show a difference in how they processed social congruence and incongruence, but the context-oriented Japanese did. That is, Japanese showed more social incongruence processing in both earlier processing (N400) and later processing (LPC). Furthermore, independent social orientation beliefs moderated these neural processing patterns for earlier neural processing: Independence beliefs explained European Canadians' earlier processing patterns, while Japanese generally processed social incongruence during earlier processing periods, suggesting a normative pressure for Japanese to process social incongruence. However, independence social orientation correlated with these neural processing patterns for both culture groups later neural processing, with less independent individuals generally showing stronger incongruity effects.

Overall, these patterns suggest that cultural differences in modes of attention are also seen in the neural domain for visual social contextual judgments. Even in the brain's early processing of face lineups, cultural differences emerged with North Americans tending to show little influence from social incongruence and East Asians tending to show influence from this incongruence. We maintain that these brain patterns are attributable to differences in social orientation between the two cultures: North Americans are more likely than their East Asian counterparts to be independent, and therefore tend to ignore social incongruence. In such, North Americans are generally less likely to process potential social harmony threats, which are more salient to East Asians (Ito et al. 2014; Kim et al. 2008).

Limitations and future research

Although the interaction pattern for the behavioral data replicates previous findings (Masuda et al. 2008a; Masuda et al. 2012), we found that both groups were significantly influenced by social incongruence. However, in previous studies European Canadians did not show influence from social incongruence (e.g., Masuda et al. 2008a; Masuda et al. 2012). We think that the reason that they also showed an influence from background emotion information in this study may have been due to the fact that we combined face lineup stimuli from two studies (Masuda et al. 2012, 2015). As a key difference in the two studies, while the first contained lineups in casual clothing (Masuda et al. 2012), the second contained lineups in business suits (Masuda et al. 2015). This mixing may have increased attention to background persons, resulting in an influence from background figures in both cultures, although it was still stronger for Japanese.

Also, we should note that the rating incongruity effect was not correlated with either ERP incongruity effects.[8] We reason that while the current paradigm encouraged participants to process stimuli as fast as possible, rating decisions were not necessarily completed during the initial face lineup viewings that corresponded in time to the target ERPs. In such, we consider the elicited ERP patterns to reflect

[8] We also analyzed correlations between the rating incongruity effect and the N400 incongruity effect, and the rating incongruity effect and the LPC incongruity effect, finding no significant correlations when combining or separating the two culture's data ($p > .2$).

attention and cognitive processing that occur earlier than the complete processing required by the face lineup's ratings task. This is also an important limitation of ERP research in that it reflects regular, relatively early cognitive/neural processes. Future studies should attempt to comprehensively capture multiple stages of social cognitive processes across the time scale of their processing with measures that might better address later time periods, such as electroencephalography (EEG) oscillations or fMRI (e.g., Kitayama and Park 2010; Klimesch 2012). Along these lines, a limitation of the current design was that participants were required to make two judgments (both positive and negative) for each face lineup in a set order. This pattern may be partially responsible for the lack of a relationship between brain and behavior, as well as possibly affecting how the two cultural groups processed the face lineup stimuli. To solve this possible confound, future research should either counter balance the order of these judgments or have participants make simpler, single judgments.

Finally, we should note that beyond the cultural differences in the N400 and the LPC, we saw other promising ERP components such as the N200, which is related to error processing, and the N170, which is related to face processing. However, the trial quantities in our study were below what is considered acceptable to obtain reliably measurable N200/N170 components (e.g., Luck 2005). Moreover, these components were not the primary ERPs of interest in the current study. Future studies could design their trial quantities to be greater in order to investigate additional interesting and important research questions related to our study.

Conclusion

In conclusion, this research highlights the importance of looking to neuroscience to give detailed descriptions of processes at work in cultural differences. Previous cultural psychology research has established a wealth of cultural theories, but it is now the time to add more neuroscience support to these findings to further understand the brain processes underlying these cultural differences (e.g. Han and Northoff 2009; Han et al. 2013; Kitayama and Park 2010; Kitayama and Uskul 2011). As culture is inherently social, we believe that research explaining social processes is the natural direction for future cultural neuroscience research. Our social realities are complex and nuanced, and we believe that process oriented methods, such as cultural neuroscience, are a welcome tool to help us explore these complexities.

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Compliance with ethical standards

Ethics Statement This research was approved by the University of Alberta ethics board in accordance to the 1964 Declaration of Helsinki and its later amendments. All participants gave us their informed consent.

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