IN Cognitive Neuroscience (2014), 5, 17-25. doi:10.1080/17588928.2013.831819

N400 Incongruity Effect in an Episodic Memory Task Reveals Different Strategies for Handling Irrelevant Contextual Information for Japanese than European Canadians.

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Abstract

East Asians/Asian Americans show a greater N400 effect due to semantic incongruity between foreground objects and background contexts than European Americans (Goto et al., 2010). Using analytic attention instructions, we asked Japanese and European Canadians to judge, and later, remember, target animals that were paired with task-irrelevant original (congruent), or novel (incongruent) contexts. We asked: 1) whether the N400 also shows an episodic incongruity effect, due to retrieved contexts conflicting with later-shown novel contexts, and 2) whether the incongruity effect would be more related to performance for Japanese, who have been shown to have more difficulty ignoring such contextual information. Both groups exhibited episodic incongruity effects on the N400, with Japanese showing more typical N400 topographies. However, incongruent-trial accuracy was related to reduction of N400s only for the Japanese. Thus, we found that the N400 can reflect episodic incongruity which poses a greater challenge to Japanese than European Canadians. (149 words)

Acknowledgements

This research was supported in part by SSHRC Standard Research Grants 410-2010-0720, awarded to the first author; Natural Science and Engineering Research Council of Canada grant rgpin #341662, and Alberta Ingenuity Fund grant #200800568 awarded to the last author. We thank Taeeun Ahn, Nathan Bartlett, Claudia Gasior, Dayna Leskiw, Julia Russell, and Sawa Senzaki, from the Culture and Cognition Laboratory at the Department of Psychology, University of Alberta, for their assistance.

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A plethora of cultural-psychology research has reported fundamental cultural differences in thinking styles between East Asians and North Americans. For example, East Asians tend to view the world holistically, seeing the world as a complex web of phenomena, where everything is interrelated, whereas North Americans tend to view the world analytically, as separate, discrete phenomena (Nisbett, 2003). One facet of these differential patterns of thinking is differing levels of attention towards context. East Asians, as holistic thinkers, are more likely than North Americans, as analytic thinkers, to be sensitive to context (Nisbett & Masuda, 2003; Nisbett & Miyamoto, 2005; Nisbett, Peng, Choi, & Norenzayan, 2001). These findings are quite robust, with East Asians being more likely than their North American counterparts to attend to context during memory tasks, whether task-relevant or not (Masuda & Nisbett, 2001; Chua, Boland, & Nisbett, 2005), change detection tasks (Masuda & Nisbett, 2006; Miyamoto, Nisbett, & Masuda, 2006), the frame and line task (Kitayama, Duffy, Kawamura, & Larsen, 2003), the rod and frame task (Ji, Peng, & Nisbett, 2000), facial-expression judgments (Masuda, Ellsworth, Mesquita, Leu, Tanida, & Van de Veerdonk, 2008; Masuda, Wang, Ishii, & Ito, 2012), production of photographs and drawings (Masuda, Gonzalez, Kwan, & Nisbett, 2008), poster and website design (Wang, Masuda, Ito, & Rashid, 2012), and even when choosing self-portraits for Facebook (Huang & Park, 2012). The systematic nature of these findings suggests that cultural variations in the perception of context are deeply rooted and may affect quite basic cognitive processes[1].

Functional magnetic resonance imaging (fMRI) findings (Goh, Chee, Tan, Venkatraman, Hebrank, Leshikar et al., 2009; Gutchess, Welsh, Boduroğlu, & Park, 2006; Hedden, Katey, Ason, Markus, & Gabrieli, 2008) and event-related potential (ERP) findings (e.g. Lewis, Goto, & Kong, 2008), have further supported this notion, accumulating evidence that basic processes are affected by culture in various realms at the neurophysiological level. One of the robust findings in this line of research focuses on N400 activity. The N400 is an ERP with a negative-going deflection that is maximal near electrode Cz around 400 ms following stimulus onset. This deflection is related to processing semantic relationships, and in particular, responds greater to incongruent and unexpected semantic events (Kutas & Federmeier, 2011).

Researchers have built upon these findings to investigate culture-related target–context semantic relationships, in both the visual and auditory modalities (Goto, Ando, Huang, Yee, & Lewis, 2010; Goto, Yee, Lowenberg, & Lewis, 2013; Ishii, Kobayashi, & Kitayama, 2010; Na & Kitayama, 2011). Goto, et al. (2010) compared semantic congruence versus incongruence between object and background images (e.g., a crab superimposed on a beach versus a crab superimposed on a parking lot, respectively). Asian Americans produced a greater N400 amplitude during incongruent than congruent trials; however, no such incongruity effect on the N400 was found for European Americans. Similarly, Goto, et al. (2013) examined the N400 magnitude between Asian Americans' and European Americans' responses to combinations of emotional facial expressions (happy versus sad) and affective scenes (positive versus negative). Stimuli were congruent (e.g., happy face with positive scene) or incongruent (e.g., happy face with negative scene). Asian Americans showed a greater N400 to incongruent than to congruent trials, but again, no such incongruity effect was observed among European Americans. These findings support the notion that people influenced by East Asian cultural traditions are more sensitive to the relationships between foreground objects and backgrounds (contexts) due to their holistic nature of attention, whereas those more influenced by North American cultural traditions are better at attending to foreground objects, and less affected by contextual background information due to their analytic nature of attention.

These findings in mind, we first postulated that beyond using the N400 to detect incongruity with semantic information, the N400 might also be viable for revealing conflict between expected and observed contextual information in an episodic memory task. Modeling our task after Masuda & Nisbett's (2001) episodic memory task, that pairs foreground images of animals with task-irrelevant naturalistic backgrounds, we sought to use the N400 to test how European Canadian versus Japanese participants handle irrelevant contextual information while trying to recognize foreground target items. In an attempt to disentangle cultural variation in neural processes from those of spontaneous attention strategies, we provided participants with analytic attention instructions, where we told them to focus on remembering foreground animals for a later memory task. A prior study using similar methods, but with holistic attention instructions and no cultural comparisons (Tsivilis, Otten, and Rugg, 2001), did not directly test for the presence of this kind of N400 result, so it was unclear whether the N400 could be found in our task.

Our first hypothesis was that the N400 could also be used to show incongruity effects in our episodic memory task, due to retrieval of prior learned associations of task-irrelevant contextual information. This effect would be seen as an N400 greater in magnitude when background images are incongruent with the prior learned backgrounds than when they are congruent with learned backgrounds, even when semantic congruency is controlled. Because our analytic instructions were expected to minimize differences in behavioral measures between cultures, we expected the N400 effect to replicate for both groups. However, due to differences in spontaneous attention styles, we expected that the N400 incongruity effect would be more coupled with task performance for the Japanese than the European Canadians.

Method

Participants

European Canadian (N=38) and Japanese international and visiting (N=34) students participated in our study. Of these, 7 European and 13 Japanese data sets were excluded due to equipment failure or data collection problems and 3 Japanese data sets were excluded due to insufficient numbers of trials in target conditions. This left 31 European Canadians (15 Male, 16 Female; Ages 19.6±2.4, range=18–30 years) and 18 Japanese (5 Male, 13 Female; Ages 19.7±1.1, range=18–23 years) participants[2]. Canadian participants earned partial course credit, and Japanese participants received an honorarium for their participation. Both written and oral instruction was provided in English for both groups. For Japanese participants, Japanese instruction was provided as needed, with key points always reinforced in Japanese. Practice trials ensured that all participants understood the instructions.

Materials

We modified Masuda & Nisbett's (2001) original stimuli by increasing image quality and by increasing the image pool. In total, we presented 36 images of unique animals paired with unique backgrounds in the study phase: animal evaluation task and 72 images of animals paired with varying backgrounds in the test phase. 18 of the test images were previously seen animals with their original backgrounds (congruent), 18 were previously studied animals with novel backgrounds (incongruent), 18 were novel animals with previously studied backgrounds, and 18 were novel animals paired with novel backgrounds (Figure 1). As Masuda & Nisbett's (2001) study only found Condition X Culture interactions between the congruent and incongruent conditions, we limit our analyses to those two conditions.

(Figure 1 about here)

Procedure

The session took place in an electrically shielded, sound-attenuated chamber. Differing from the original Masuda & Nisbett (2001) task, in which attention was undirected, participants were given analytic attention instructions in this experiment.

Study phase: Animal Evaluation Task. Each participant had 3 practice trials (excluded from analyses) followed by 36 experimental trials. Each trial began with a fixation that was jittered with an uniform-random interval between 1500–2000 ms, followed by an animal–background image, presented for 5000 ms. Both animals and backgrounds were drawn at random without replacement from the image pools. Participants then rated how much they liked each animal. The rating task was an orienting task to ensure continual attention to the images throughout the trials and was excluded from analyses. For this task, participants were instructed to focus on the animal and ignore the background for the duration of trials

Distractor phase. The study phase was followed by a two-minute-long distractor task involving simple computation.

Test phase. Participants were then given a recognition-memory task, 6 practice trials (excluded from analyses) and 72 experimental trials (as described in the Materials Section), were presented pseudo-randomly. Each trial began with a fixation that was jittered with uniform-random interval between 1500–2000 ms followed by the target image which remained on the screen until a response was made. Participants were told to judge whether they had seen the animal before without taking into account its background and were encouraged to respond as accurately and quickly as possible (Figures 1 and 2).

(Figure 2 about here)

Electroencephalography (EEG) Recording and Analyses

EEG was recorded using a high-density 256-channel Geodesic Sensor Net (Electrical Geodesics Inc., Eugene, OR), amplified at a gain of 1000 and sampled at 250 Hz. Impedances were kept below 50 kΩ. EEG was initially referenced to the vertex electrode (Cz) but digitally average re-referenced. Data were analyzed by custom MATLAB scripts in conjunction with the open-source EEGLAB toolbox (Delorme & Makeig, 2004, http://sccn.ucsd.edu/eeglab). Signal was digitally bandpass filtered between 0.5–30 Hz. Artifacts were corrected via Independent Component Analysis. Trials for which voltage deviated more than 300 µV from baseline were rejected. Participants with fewer than 8 surviving accurate trials in each condition of the interests were removed from the final analyses. Trials were referred to a 200-ms pre-stimulus baseline. The N400 was quantified at electrode Cz as mean voltage over the 300–500 ms time window post-stimulus. 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).

Results

Behavior

Accuracy and response time (RT) means are reported in Table 1. In a mixed 2 X 2 repeated-measures ANOVA with Accuracy as the measure, Culture as a between-subjects factors and Condition as a within-subjects factor, a significant main effect of Condition, $F(1, 47) = 39.02$, $p < .001$, revealed higher accuracy in the congruent than incongruent condition (Congruent $M = 87.4\%$, $SD = 11.1$, Incongruent $M = 74.6\%$, $SD = 11.8$). The main effect of Culture and Culture X Condition interaction were not significant ($p > .1$) [3].

A second ANOVA with RT as the measure found a main effect of Condition, $F(1, 47) = 28.79$, $p < .001$, with faster RTs for the congruent than incongruent condition (Congruent $M = 1550$ ms, $SD = 537$, Incongruent $M = 1880$ ms, $SD = 796$). As with Accuracy, the main effect of

Culture and interaction were not significant (*p* > .1).

Mean N400s

With mean N400 voltage as the measure, an ANOVA with the same design as that used for Accuracy and RT revealed a significant main effect of Condition, *F*(1,47) = 9.62, *p* = .003, with the incongruent condition having a more negative (i.e., larger) N400 than the congruent condition. This is our predicted N400 incongruity effect due to a mismatch between the (presumably) retrieved context and the shown, novel–stimulus context. However, the main effect of Culture and interaction were non-significant (p > .1). Despite the interaction being non-significant, we broke down the condition effects by culture due to our a priori hypotheses, finding that N400 difference scores were slightly stronger for Japanese, *t*(17) = 3.84, *p* = .001, than for European Canadians, *t*(30) = 1.84, *p* = .076 (Table 1 and Figure 1). Thus, although we lack sufficient sensitivity, this leaves open the possibility that Japanese participants have a greater N400 incongruity effect. The topography of the difference of the incongruence and congruence conditions (Figure 3) is in line with N400 effects (Kutas and Federmeier, 2011) for Japanese participants, but for European Canadians, the topography suggests an additional, more anterior source, perhaps related to the FN400 found in recognition-memory studies (Rugg & Curran, 2007).

(Table 1 about here)

(Figure 3 about here)

Accuracy–N400 relationship

As different strategies might have been adopted by the two cultural groups to obtain high performance in the task, we further tested what could be driving the N400 effects for the two groups, performing multiple regression analyses of accuracy and mean N400 voltages for the two cultures. Using a hierarchical linear regression model for the interaction of culture and accuracy on prediction of mean N400 voltages for the congruent condition, we found no significant interaction, *b* = .96, *t*(45) = .23, *p* = .82. Furthermore, the combined model, regressing the main effects of culture and mean N400 voltages on accuracy, was not significant. Applying the same analysis to the incongruent condition, there *was* a significant interaction of culture, *b* = 11.12, *t*(45) = 2.70, *p* = .01. Probing the interaction with simple slopes (Figure 4), we found that the interaction was primarily driven by the Japanese, R^2 = .348, *b* = 8.45, *t*(16) = 2.92, *p* = .01, although a trend was found for European Canadians, R^2 = .047, *b* = -2.673, *t*(29) = -1.19, *p* = .24. Whereas the Japanese participants had a fairly strong positive relationship between accuracy and mean voltage, the European Canadians had a weak negative relationship.

(Figure 4 about here)

Discussion

Masuda & Nisbett (2001) found an interaction between accuracy in the congruent and incongruent condition between cultures, with Japanese showing stronger effects in the incongruent condition and even lower accuracy. Because our participants received analytic attention instructions, our participants showed no significant culture interactions in mean accuracy or RT. Both Japanese and European Canadians performed better when they judged images of previously viewed animals with their original backgrounds than when they judged images of previously viewed animals with novel backgrounds. Japanese and European Canadians' behavioural data suggest that the analytic attention instructions worked, removing significant cultural differences in mean performance. The analysis of mean N400 voltage supports this notion, showing a robust incongruity effect, with no interaction with culture.

Despite equivalent performance and N400 incongruity effects on average, individual variability revealed a striking difference between the ways in which each culture incorporated this episodic contextual incongruity into their recognition-memory judgments. In the incongruent condition, the Japanese participants had a strong positive relationship between accuracy and mean N400 voltage, signifying that they performed better when the N400 was reduced in amplitude (i.e., less negative) whereas the European Canadians had a weak relationship in the opposite direction. Relating these findings to the prior work on cultural differences in attention, we suggest that both groups were attending to the target objects and ignoring the background images to the same degree on average, but likely in different ways. During the recognition test, participants may have covertly retrieved the previously presented context, and some more than others. In the incongruent condition, European Canadians may then have been able to keep the foreground and background information separate, and this may have prevented the mismatching retrieved context from interfering with the recognition judgment. Japanese participants, on the other hand, may have been less effective in ignoring retrieved prior contexts at test, and thus, the N400, explaining the amount of conflict between retrieved background and novel background, may explain variance for this group. Those Japanese participants who had a large N400 may have been subject to more confusing information on incongruent trials leading to lower accuracy, whereas Japanese participants who had a weaker N400 may have simply had less interference to resolve, making their task easier and their accuracy greater. Building upon previous findings (e.g. Goto et al. 2010; 2013, Ishii et al, 2010; Kutas & Federmeier, 2011), this study advances discussion of the viability of the N400 as a marker for cross-cultural neuroscience studies. Furthermore, as Japanese are more influenced by natural holistic tendencies, the ability to suppress these effects seems to be essential for increased accuracy in this kind of task.

While typical N400 incongruence effects are driven by semantic memory or pre-experimental knowledge, our findings suggest that expectation in an episodic memory task can produce similar effects. Tsivilis's et al., (2001) study used similar methods. Their participants also studied foreground–background pairs, but were instructed to attend to both foreground and background images and devise narrative associations between them. Participants then had a surprise recognition-memory test for the foreground objects. It is not possible to directly compare their results with ours, as they did not report the critical comparison (between our congruent and incongruent conditions). The difference they did report, collapsing several different congruence and incongruence conditions together (300 ms–500 ms) had a more anterior topography, resembling the recognition-memory FN400 (Rugg & Curran, 2007) and which may be related to the anterior effects visible in our European Canadian participants (Figure 3). It is possible that Tsivillis et al. (2001) obtained a posterior N400 in the contrast between old objects with paired vs. novel contexts and did not present it, in which case our finding would be in line with their data. Alternatively, a posterior N400 may not be present in their study, in which case we suggest that the nature of the instructions given in our study and Tsivillis's et al. (2001) may be a crucial factor that differentiates their study from ours.

A strength of this study was the analytic instructions, which led to performance that was well matched between cultural groups, as well as a N400 measure that did not differ significantly between groups. Future research could be directed toward explaining cultural differences when Japanese and European Canadians are asked to take a holistic attention strategy, which is a strategy more dominant in East Asia, as well as when participants are not instructed. Also, as cultural-related scales, such as self-construal orientation, have been related to brain response in previous neuroscientific studies (Goto et al, 2010; 2013; Ishii et al. 2008; Lewis et al. 2008; Na & Kitayama, 2011), those scales should also be targets of future studies.

In conclusion, our findings show that the N400 responds to episodic incongruence due to mismatches between covertly retrieved contextual information and newly presented contextual information, even when that contextual information is irrelevant to the task. Although mean performance measures did not differ between cultures, this kind of incongruity is unrelated to European Canadians' accuracy on the task, but represents a critical source of interference for Japanese participants, and its suppression may be a major determinant of performance for these participants, perhaps due to their tendency to allocate attention more holistically. Current trends support continued reframing of theoretical frameworks defined in cognitive neuroscience within cultural contexts, allowing researchers to comprehensively examine to what extent findings are universally supported, and where cultural variations in cognition are observable.

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Footnotes

[1] Applying the definition of culture shared by many researchers (e.g. Bruner, 1990; Miller, 1994; Shweder, 1991), and sampling criterion used in previous research (Masuda & Nisbett, 2001), we define culture as a meaning system shared by people in a given society. We focused on European Canadians in Canada and Japanese in Japan, assuming that they represent dominant members of the respective culture groups, who share meaning systems (Analytic vs. Holistic), nationality (Canada vs. Japan), ethnic background (European descendent Canadians vs. Japanese), and linguistic community (English vs. Japanese).

[2] Reported statistics correct for the mismatched sample sizes in European Canadian and Japanese groups. Further analyses, comparing a randomly chosen European Canadian subset of 18 participants to the Japanese group, did not show a different pattern from the reported statistics.

[3] We also computed d' and bias (C) values of old and new backgrounds, and applied 2 (Culture) X 2 (Background: Original vs. New) ANOVAs to these values. The ANOVA of the d' values indicated a significant main effect of Condition, $F(1, 47) = 5.56$, $p < .05$, with higher accuracy in the old background condition ($M = 1.88$, $SD = .50$) than the new background condition ($M = 1.68$, $SD = .44$). The main effect of Culture was also significant, with European Canadians ($M = 1.87$, $SD = .42$) performing better than Japanese ($M = 1.63$, $SD = .29$). The Culture X Background interaction was not significant ($p > .1$). The ANOVA of the bias (C) values indicated only a significant main effect of background, $F(1, 47) = 31.63$, $p < .001$, revealing that more conservative criteria are applied to the old background condition than to new background condition (Old-C $M = .12$, $SD = .25$, New-C $M = -.14$, $SD = .26$).

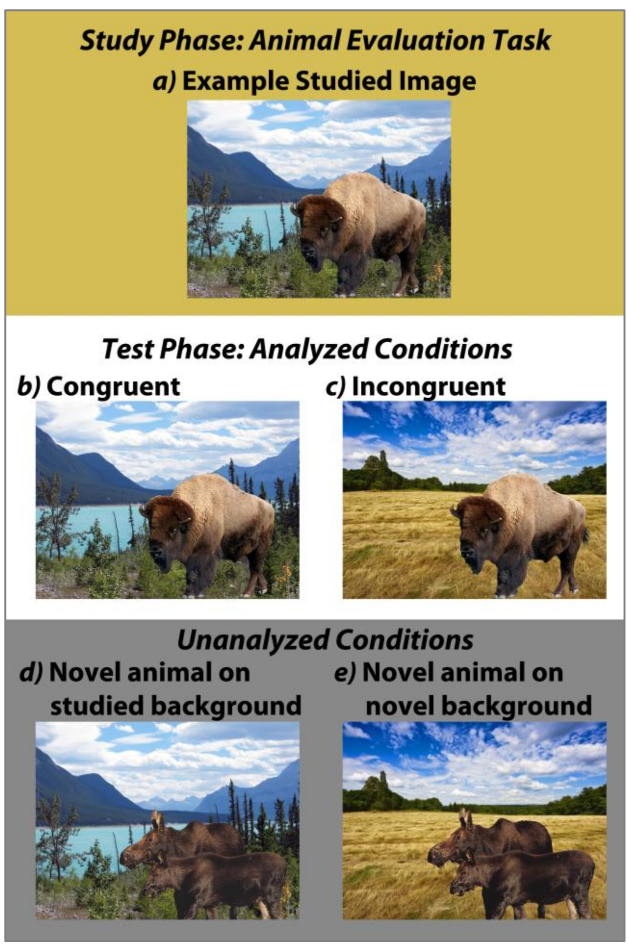
Figure Captions

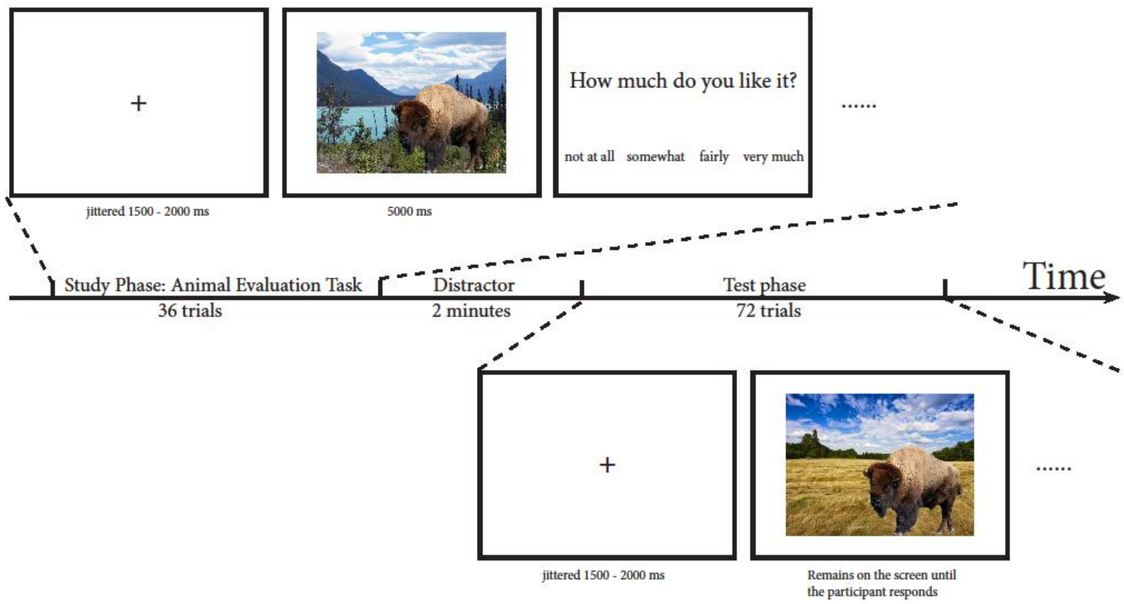
Figure 1: (a) Example study phase image and respective test phase images for this image, for the analyzed condition (b) congruent and (c) incongruent images, and the unanalyzed condition (d) novel animal on studied background and (e) novel animal on novel background images.

Figure 2: Time diagram of the experiment showing the three consecutive phases. The study phase: animal evaluation task, the distractor task, and the test phase.

Figure 3: 1) Congruent and incongruent condition grand averaged ERP waveforms for Japanese (left) and European Canadians (right) at electrode Cz. Probe stimulus onset was at t=0 ms, and the 200-ms pre-stimulus baseline is also shown. 2) Topographic spline maps showing the difference between congruence and incongruence conditions (incongruence minus congruence). For Japanese participants, this topography is quite consistent with previous N400 findings (Kutas and Federmeier, 2011), but for European Canadians, the posterior portion of the pattern (typical of N400 findings) appears weaker, and there may be an additional source, perhaps related to the recognition-memory FN400 (Rugg & Curran, 2007) in the earlier time windows.

Figure 4: Simple slopes using accuracy to predict mean N400 voltage of the incongruent condition for Japanese and European Canadians.

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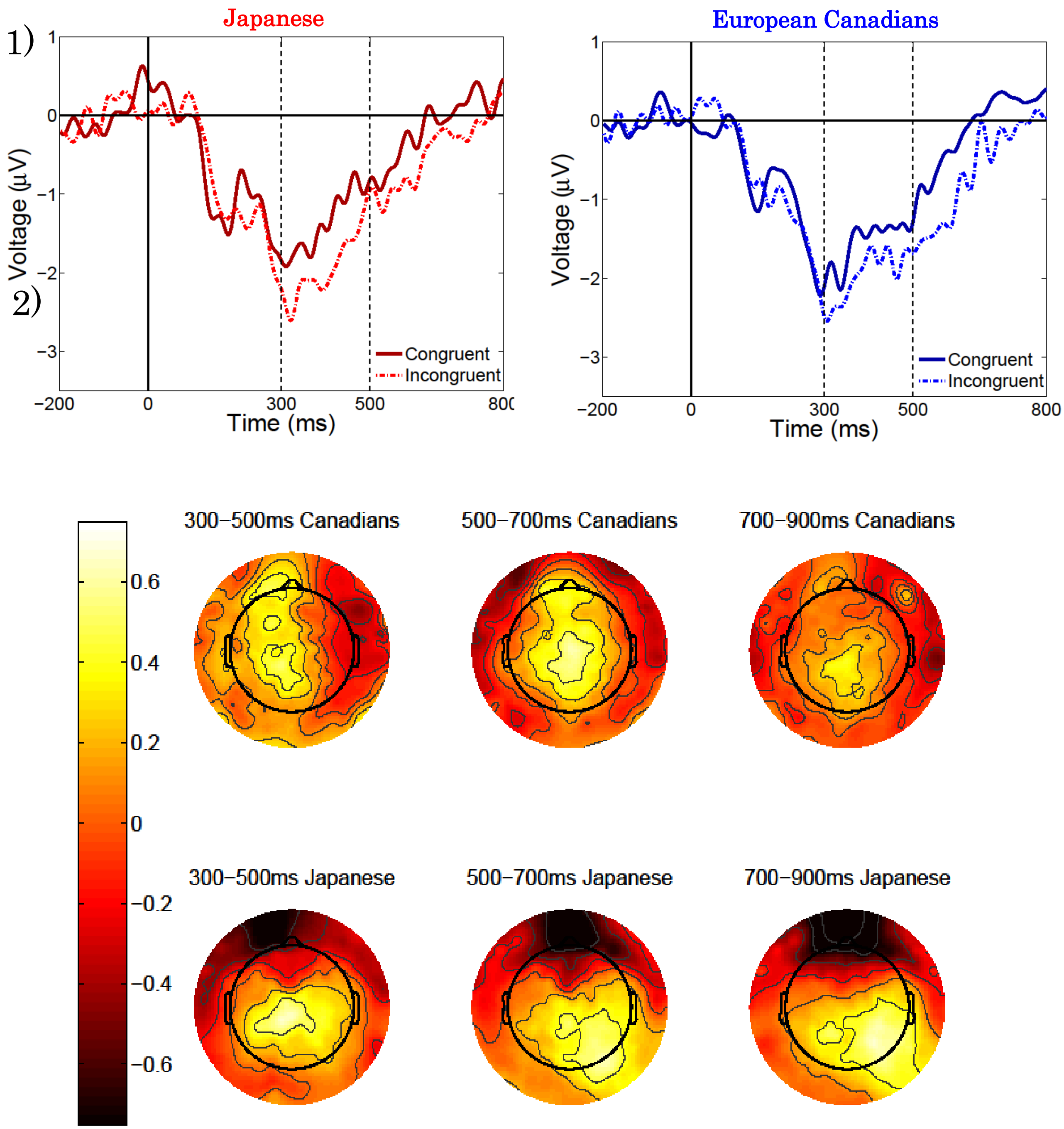
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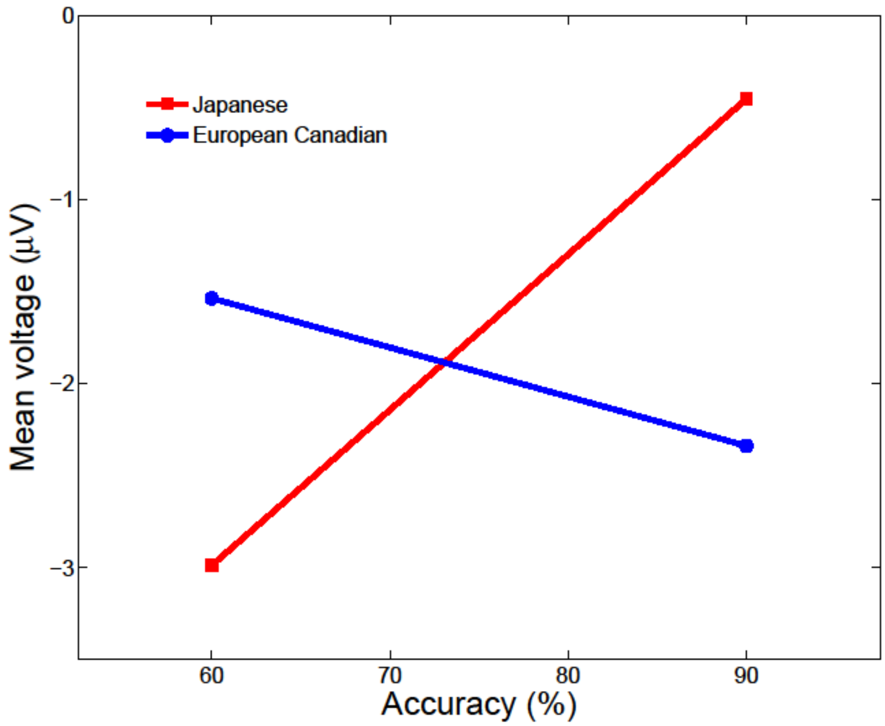
500–700ms Japanese
700–900ms Japanese


Japanese
European Canadian
Mean voltage (μV)
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Accuracy (%)