How culture gets embrained: Cultural differences in event-related potentials of social norm violations

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Humans are unique among all species in their ability to develop and enforce social norms, but there is wide variation in the strength of social norms across human societies. Despite this fundamental aspect of human nature, there has been surprisingly little research on how social norm violations are detected at the neurobiological level. Building on the emerging field of cultural neuroscience, we combine noninvasive electroencephalography (EEG) with a new social norm violation paradigm to examine the neural mechanisms underlying the detection of norm violations and how they vary across cultures. EEG recordings from Chinese and US participants (n = 50) showed consistent negative deflection of event-related potential around 400 ms (N400) over the central and parietal regions that served as a culture-general neural marker of detecting norm violations. The N400 at the frontal and temporal regions, however, was only observed among Chinese but not US participants, illustrating culture-specific neural substrates of the detection of norm violations. Further, the frontal N400 predicted a variety of behavioral and attitudinal measurements related to the strength of social norms that have been found at the national and state levels, including higher culture superiority and self-control but lower creativity. There were no cultural differences in the N400 induced by semantic violation, suggesting a unique cultural influence on social norm violation detection. In all, these findings provided the first evidence, to our knowledge, for the neurobiological foundations of social norm violation detection and its variation across cultures.

culture | social norms | N400 | electroencephalography | EEG

Humans are unique among all species in their ability to develop, maintain, and enforce social norms. It is therefore highly possible that humans have evolved complex neural mechanisms for detecting norm violations quickly to punish violators to enforce the social order. Moreover, although the enforcement of social norms is universal, there is wide variation in the strength of social norms across human groups. Some groups, particularly those that have experienced a high degree of ecological and historical threat, develop stronger norms and punishments of norm violators to coordinate social action (1, 2), and such human adaptations have an evolutionary basis for group survival (3).

Despite the fundamental aspect of human nature, there has been surprisingly little research on how social norm violations are detected at the neurobiological level. To be sure, there is a large amount of literature on how the human brain reacts to semantic violations (e.g., "I like my coffee with cream and dog") (4). Extant EEG research has revealed a notable negative-going deflection with peak around 400-ms poststimulus onset (the component called N400) when detecting unexpected linguistic stimuli across a variety of semantic tasks (5–8). Moreover, N400 effects are not confined to linguistic processing. Seminal research in social neuroscience has shown that the N400 component is observed in a variety of social tasks, including spontaneous trait inferences (9, 10), detection of stereotype incongruities (11), and processing of affective inconsistencies (12). Taken together, the N400 serves as a potent neural index of the detection of unexpected anomalous stimuli and affective and social incongruent information. Here we examine for the first time whether and how the N400 is engaged in social norm violation detection and whether it is distinct from the detection of semantic violations.

Although the existence of social norms is universal across all human cultures, there are large differences around the globe in adherence to social norms and the punishment of norm violators (1). Our second aim is to investigate whether the neural basis of social norm violation detection is sensitive to cultural variation. Human groups that have had high degrees of territorial threats necessitating national defense, low natural resources (e.g., food supply), and high degrees of natural disasters (e.g., floods, cyclones, and droughts) such as China, evolve to be tight, i.e., have strong norms and less tolerance for deviant behavior, to coordinate their social action. Human groups that generally have low threat such as the United States evolve to be loose, i.e., have weaker norms and higher tolerance for deviant behavior (1–3). Thus, individuals in tight compared with loose cultures tend to adhere to social norms and are more sensitive to others' violations. We test the hypothesis that the N400 is a neural marker of norm violation detection and its amplitude in response to social norm violations will be greater in tight (e.g., Chinese) compared with loose (e.g., American) cultures. Building on the findings of cultural (East Asian vs. Western) influences on the N400 in a variety of social incongruity tasks (9, 12–14), we expect that responses to social norm violations will differ between cultures, but responses to nonsocial incongruencies, such as purely semantic

Significance

Despite the fact that social norms are a fundamental aspect of human nature, there has been little research on how social norm violations are detected at the neurobiological level. Combining a new social norm violation paradigm with cross-cultural electroencephalography, we show consistent negative deflection of event-related potential around 400 ms (N400) over the central and parietal regions for both Americans and Chinese in detecting norm violations. However, the N400 at the frontal and temporal regions was evident only among Chinese, illustrating culture-specific neural substrates underlying detecting norm violations. Moreover, the frontal N400 was associated with greater cultural superiority and self-control, as well as lower creativity. The findings shed new light on the neurobiology of the detection of social norm violations.

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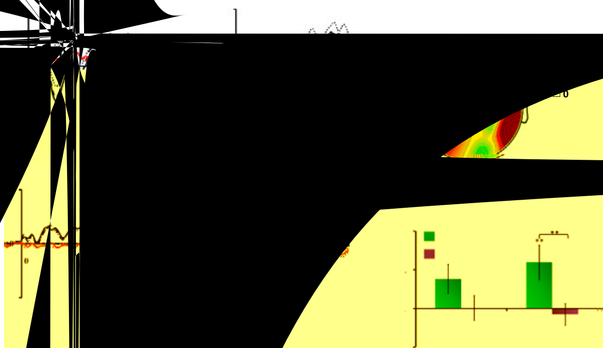
United States, China) $\times$ 3 (violation: strong, weak, and appropriate) ANOVAs of the N400 effect showed the strong and weak violation conditions elicited a greater N400 over the central and parietal regions relative to the appropriate condition [central: $F(2,96) = 7.87$, $P < 0.001$; parietal: $F(2,96) = 8.57$, $P < 0.001$]. Separate 2 (culture: United States, China) $\times$ 2 (violation: strong/weak, appropriate) ANOVAs further confirmed the greater N400 at the central and parietal regions was respectively observed in the strong [central: $F(1,48) = 17.01$, $P < 0.0002$; parietal: $F(1,48) = 16.21$, $P < 0.0002$; Fig. 2*B*] and weak violation conditions [central: $F(1,48) = 5.49$, $P < 0.05$; parietal: $F(1,48) = 9.31$, $P < 0.005$; Fig. 2*B*], relative to the appropriate condition. Post hoc analyses showed the significant central and parietal N400 effects (appropriate vs. strong) among both Chinese [central: $F(1,24) = 6.79$, $P < 0.02$; parietal: $F(1,24) = 6.69$, $P < 0.02$] and US subjects [central: $F(1,24) = 11.16$, $P < 0.005$; parietal: $F(1,24) = 15.55$, $P < 0.001$; Fig. 2*C*]. Similar but weaker N400 effect of the weak violation (vs. appropriate condition) was shown by separate post hoc analyses for each group [Chinese: $F(1,24) = 1.96$, $P = 0.17$; United States: $F(1,24) = 3.95$, $P = 0.06$ for central region; Chinese: $F(1,24) = 7.61$, $P < 0.02$; United States: $F(1,24) = 2.18$, $P = 0.15$ for parietal region]. No culture $\times$ violation interaction was found for the central and parietal regions [central: $F(2,96) = 0.01$, $P = 0.99$; parietal: $F(2,96) = 0.65$, $P = 0.52$], suggesting the generality of the N400 component at the central and parietal regions in the detection of social norm violations across cultures. Although N400 was stronger in the strong violation condition than in the weak violation condition, the difference between the two violation conditions was not statistically significant (*SI Results*).

Culture-specific N400 effects.



il[illegible]g t[illegible]mantic incorrect condition elicited larger N[illegible]r [illegible] regions for both US and Chinese subjects [illegible] F(1[illegible]82, P < 0.01; central: F(1,48) = 8.25, P < [illegible]por[illegible]8) = 7.06, P < 0.01; parietal: F(1,48) = 6.50, [illegible]; F[illegible] *B* and *C*] relative to the semantic correct [illegible]. T[illegible]as no culture effect [frontal: F(1,48) = 2.11, [illegible] ce[illegible]F(1,48) = 0.46, P = 0.50; parietal: F(1,48) = [illegible]0.7[illegible]poral: F(1,48) = 0.63, P = 0.43], nor a culture × [illegible] i[illegible]n [frontal: F(1,48) = 1.66, P = 0.20; central: F([illegible] 0.[illegible] = 0.44; parietal: F(1,48) = 0.04, P = 0.84; tempora[illegible]1,[illegible]11, P = 0.74], illustrating the effect of semantic violati[illegible]w[illegible]rved equally for Americans and Chinese.

To te[illegible]r the N400 effects induced by these two tasks are ind[illegible] with each other, we conducted correlation analysis be[illegible] the social norm N400 (strong vs. appropriate) and sema[illegible]400 effect (incorrect vs. correct) from the same electrode[illegible]e same time window (e.g., the semantic N400 of Cz at [illegible]0 ms and the social norm N400 of Cz at 200–600 ms). [illegible]gh the N400 elicited by semantic violation appears to have a[illegible]al overlap with the N400 elicited by social norm violations [illegible]emporally (e.g., peaks around 400 ms) and spatially (e.g., cen[illegible]nd parietal region), no significant correlations between t[illegible]wo N400 effects were found, illustrating that they were inde[illegible]ent of each other (all P > 0.05; Table S8).

Moreo[illegible]he semantic N400 was not significantly related to any of the[illegible]udinal and behavioral measurements (all P > 0.05; Table S9[illegible]erestingly, the semantic N400 increased as a function of hi[illegible] socioeconomic status (SES) (P < 0.05; Table S9), suggestin[illegible]t this ERP signal could reflect variations in executive f[illegible]on in language processing (21). This correlation is in stark c[illegible]ast with the frontal norm violation N400, which in fact decr[illegible] as a function of higher SES (P < 0.05; Table S6). The latt[illegible]rrelation is in line with the hypothesis that higher SES is [illegible]ated with less tight enforcement of social norms (22).

Discuss[illegible]

The de[illegible]ment and enforcement of social norms is a unique feature[illegible]man sociality that transcends time and groups. This study i[illegible]ur knowledge, the first study to illustrate the neurobiolo[illegible] social norm violation detection across cultures by combi[illegible] new experimental paradigm and cross-cultural EEG techn[illegible] Particularly, strong norm violations relative to the appropriate condition elicited stronger N400 at the ce[illegible] [illegible]gions. This effect was observed equally in both Chinese and Americans, suggesting that this component of detecting norm violation reflects psychological processes that are recruited equally in both cultures. Such processes may involve the detection of social incongruence and the processing of various anomalous social [illegible] be the case this culture-general ERP component signifies increased cognitive processes recruited to integrate the mismatched information engendered when perceiving other people engaging in inappropriate behavior in specific social situations.

An ability to detect norm violators is arguably particularly important in contexts of high threat where coordination among humans is critical for survival. Indeed, detecting and punishing norm violators in such contexts may have had an important evolutionary advantage (3), and thus, under such conditions, we expect that neural mechanisms of norm violation detection would be especially likely to be recruited. Along these lines, a novel finding from the current work concerns N400 at the frontal and temporal regions. This N400 component also responded to norm violation, but it was observed only for Chinese. Previous work has shown that the frontal N400 might be functionally distinct from the central-parietal N400 (25). In particular, the frontal N400 is implicated in the evaluation of the appropriateness of different human actions, such as the meaning of hand postures (26), appropriateness of tool use (27), and semantic anticipation of action sequences (28). Further the frontal N400 has been source-localized in regions encompassing a mentalizing neural network (i.e., inferior frontal cortex, superior frontal gyrus, superior temporal gyrus) (28, 29). One conjecture might be that, whereas both Americans and Chinese are equally likely to detect discrepancies between an observed behavior and the behavior normatively expected (as revealed in the centro-parietal N400), only Chinese go beyond the detected norm violation to infer the mental state of the person violating the norms. Recent cross-cultural research has shown that Chinese are much more tuned into others' perspective than Americans (30), which lends some support for this notion. We might even go as far as to argue that Chinese might consider different punishment options for the violator. Future functional MRI (fMRI) work focusing on areas that have been implicated in humans' punishment decisions [prefrontal regions such as the dorsal lateral prefrontal cortex (31) and ventral medial prefrontal cortex (32)] might shed some further light on this issue.

It is of note that the magnitude of the frontal N400 was related to a variety of attitudes and behaviors associated with the strength of social norms, including greater cultural superiority and self-control but also lower creativity. It is possible that the tightness of culture (which is likely fostered by various historical threats) (1, 2) sensitizes the members of tight cultures to norm violations (as revealed in the strong frontal N400), which might in turn influence certain abilities and functions including creativity and, more generally, inclination toward intellectual and social openness. Thus, our findings extend former work conducted at the national and state ldh t15), which illustrate trade-offs of tightness and looseness, namely of greater order, stability, and cohesion in tight groups but greater creativity and openness in loose groups. Our findings add to this multild research agenda by providing evidence for the neural systems underlying norm detection and behavior.

We note that ERP is particularly well suited to examining the time-lock nature of responses to social norm violations but has inherent limitations with respect to spatial resolution. Thus, future research should localize the relevant brain regions involving in detecting social norms by using fMRI techniques. Research should also extend the current work to examine potential genetic pathways of neural responses to social norm violations. Detection of norm violation may require close social attunement and if so, it may be linked to polymorphic variants of oxytocin genes (33). Or, alternatively, norm violation detection may require error processing involving discrepancies between normative expectations and observed behaviors. If so, one might anticipate possible involvement of polymorphic variations in dopamine-system genes (34). Future work along these lines may even reveal how the adaptive task of norm violation might have played a significant role in selecting certain genetic variants in different historical or evolutionary contexts.

Another issue that deserves concerted research attention in future work relates to a potential relationship between social norm violation and moral violations (35–38). We would expect that they may have some neural overlap because they both involve recruiting prior knowledge about a behavior. However, social norm violation detection, which involves the detection of discrepancies between normative expected and observed behaviors, is likely to be distinct from moral violation judgments, which involve matching observed behaviors with moral values such as harm and justice. Last, but not least, the current results should be extended to other populations. Consistent with previous findings that tightness-looseness varies within the United States (2), it would be interesting to examine whether N400 responses are stronger in tight states (i.e., Kansas) compared with loose states (i.e., California). Future research should also examine situational factors that affect N400 responses to norm violations. We would predict, for example, that after a temporary territorial threat (e.g., 9/11 in the United States), the evolved brain mechanisms for social norm detection would be enhanced to help strengthen the cohesion of groups in the face of threats. In all, the cultural neuroscience of social norm detection can help us to address numerous basic and applied research questions about our unique human nature.

Materials and Methods

Participants. Twenty-nine subjects in Beijing and 29 subjects in the United States were recruited through the Internet for participation in this study. Four Chinese participants and one US participant were ruled out because of excessive artifacts in their EEG signal, which contaminated more than 50% of trials. Only individuals who were born in their native countries were included, excluding three students from India in the United States. This left a final sample size of 25 Chinese subjects (11 females; mean age, 23.2 y; range, 20–28 y; all Asian) and 25 US subjects (13 females; mean age, 21.4 y; range, 18–49 y; 5 African American, 3 Asian, 12 European American, and 5 Hispanic). There were no age differences between two groups [$t(48) = 0.19$, $P > 0.05$]. All participants had normal or corrected-to-normal vision. All participants, except three, were right-handed. All individuals gave their written informed consent before starting experiment and participated for monetary compensation.

Stimuli and Procedure. We developed a new social norm violation task in which subjects were asked to judge whether certain behaviors were appropriate or not in different situations (Fig. 1A). Thirty-four behaviors (e.g., dancing) were presented in three kinds of situations: appropriate (e.g., tango lesson), weakly inappropriate (e.g., subway platform), and strongly inappropriate (e.g., art museum). Participants were asked to judge the level of appropriateness for all behavior × situation combinations. Each run first showed an instruction screen that was followed by 33 trials. As Fig. 1A illustrates, each trial began with 500–1,500 ms of fixation. Thereafter, the first sentence depicting a situation (e.g., Amanda is at the art museum) was presented for 1500 ms, followed by a fixation of 100 ms. Then the second sentence (e.g., She is dancing) depicted a specific behavior, which was separated into two successive 400-ms screens with a 100-ms fixation. After an 800-ms fixation, a response screen was shown during which participants were asked to judge whether the behavior was appropriate from 1 (very inappropriate) to 4 (very appropriate) by using an index and middle finger on the left and right hand on a keyboard. Ten behaviors were randomly chosen for each participant to present twice. As a result, there were 44 behaviors × 3 situations in total. The 132 trials were randomly assigned into four runs, with each run lasting about 3.5 min. All of the stimuli used in the social norm violation task were piloted extensively by independent US and Chinese samples and the piloting results can be obtained from the authors.

The semantic violation task (Fig. S1A) was based on an established paradigm in which participants were randomly presented with a number of semantically correct or incorrect sentences and asked to judge whether they were right or wrong. There were 40 subject-verb-object segmented sentences for the correct condition (e.g., "Sophia returned bicycle and key" for the United States; "张静/归还了/自行车/和/钥匙" for Chinese), and another 40 for the semantic violation condition (e.g., "Sophia answered bicycle and key" for the United States; "张静/回答了/自行车/和/钥匙" for Chinese). The verb of the correct sentence (e.g., returned) was replaced with a semantically incongruent one (e.g., answered), inducing a semantic violation in relation to both object noun phrases. The paradigm and material has been used in previous semantic studies and has been shown to elicit N400 component (17). To make it comparable with the social norm violation task, we used the same duration for the presentation of crucial stimuli and a similar number of trials for each condition. Each run first showed an instruction screen which was followed by 40 trials. Each trial began with a varied fixation of 600–1,000 ms. Then the sentence was segmented into several words or short phrases that appeared for 400 ms, with an additional 100-ms blank. After presenting the whole sentence, an 800-ms blank was shown, followed by a response screen during which muscle noise, and line noise) by independent component analysis (ICA), which has been proved to effectively detect and remove contamination from a wide variety of artifacts (43, 44). The corrected data were epoched into a 1,200-ms time window with a 200-ms prestimulus baseline in the social norm violation and semantic task. The epochs with peak-to-peak amplitudes not exceeding $\pm 60\ \mu V$ were kept for further analyses, resulting in the retention of at least 90% of trials across participants (92% appropriate condition, 90% strong violation, 92% weak violation). The artifact-free epoched EEG for each participant was averaged for each condition, resulting in ERPs which used for further statistical analyses. In the semantic task, the artifact-free correct trials in which participants responded correctly were used for further analysis.

Repeated-measures ANOVAs were conducted with two factors: culture (two levels: China, United States) and violation (three levels in the social norm violation task, strong, weak and appropriate; two levels in the semantic task, incorrect and correct) for each electrode from the frontal/central/parietal/temporal regions (F1, F3, F5, F7, Fz, F2, F4, F6, F8, FC1, FC3, FC5, FCz, FC2, FC4, and FC6 for frontal; C1, C3, Cz, C2, C4, CP1, CP3, CPz, CP2, and CP4 for central; P1, P3, Pz, P2, P4, PO3, PO7, POz, PO4, PO8, O1, Oz, and O2 for parietal, and T7, T8, TP7, TP8, FT7, and FT8 for temporal) at every 50-ms time bin from 0 to 1,000 ms after stimuli onset. The electrodes (F1, F2, Fz, FC1, FC2, FCz, C1, C2, Cz, CP1, CP2, CPz, P1, P2, Pz, POz, O1, O2, and Oz) were chosen to represent the midline part of different regions, whereas the rest representative electrodes listed above were chosen to represent the lateral parts of different regions. The mean amplitude of each electrode site at the given time window was the dependent measure. To correct for inhomogeneity of variances, the Greenhouse-Geisser was performed. The time windows for ERP components were first chosen by visual inspection of the waveforms from the grand average of all subjects. To calculate the N400 effect in social norm violation task, we subtracted neural response to the strong and weak conditions from those from the appropriate condition for each brain region at the 200- to 600-ms time window, which has been viewed as a conventional time interval for the N400 component in previous studies (4, 18–20). To check the consistency of the N400 component in this time window, we also performed ANOVAs on adjacent 50-ms time bins (i.e., 200–250, 250–300, 300–350, 350–400, 400–450, 450–500, 500–550, and 550–600 ms) at each of the regions mentioned above. These tests showed consistent and reliable N400 effects at any three consecutive time bins. Representative electrodes were chosen for post hoc analysis. Similarly, the N400 effect in the semantic task was calculated by subtracting neural responses to the semantic incorrect from the semantic correct conditions. When comparing the neural activity between the semantic and social norm tasks, we extracted the same time window of 200–600 ms in these two tasks. In addition, to keep correlation analysis comparable and consistent between tasks, we used the same representative electrodes between tasks (e.g., N400 at the Cz in the semantic task with N400 at the Cz in the social norm violation).

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1. Gelfand MJ, et al. (2011) Differences between tight and loose cultures: A 33-nation study. Science 332(6033):1100–1104.
2. Harrington JR, Gelfand MJ (2014) Tightness-looseness across the 50 united states. Proc Natl Acad Sci USA 111(22):7990–7995.
3. Roos P, Gelfand MJ, Nau D, Lun J (2015) Societal threat and cultural variation in the strength of social norms: An evolutionary basis. Organ Behav Hum Decis Process 129: 14–23.
4. Kutas M, Federmeier KD (2011) Thirty years and counting: Finding meaning in the N400 component of the event-related brain potential (ERP). Annu Rev Psychol 62: 621–647.
5. Kutas M, Hillyard SA (1980) Reading senseless sentences: Brain potentials reflect semantic incongruity. Science 207(4427):203–205.
6. Röder B, Rösler F, Neville HJ (2000) Event-related potentials during auditory language processing in congenitally blind and sighted people. Neuropsychologia 38(11):1482–1502.
7. Hagoort P, Hald L, Bastiaansen M, Petersson KM (2004) Integration of word meaning and world knowledge in language comprehension. Science 304(5669):438–441.
8. Ceballos NA, Houston RJ, Smith ND, Bauer LO, Taylor RE (2005) N400 as an index of semantic expectancies: differential effects of alcohol and cocaine dependence. Prog Neuropsychopharmacol Biol Psychiatry 29(6):936–943.
9. Na J, Kitayama S (2011) Spontaneous trait inference is culture-specific: Behavioral and neural evidence. Psychol Sci 22(8):1025–1032.
10. Varnum MEW, Na J, Murata A, Kitayama S (2012) Social class differences in N400 indicate differences in spontaneous trait inference. J Exp Psychol Gen 141(3):518–526.
11. White KR, Crites SL, Jr, Taylor JH, Corral G (2009) Wait, what? Assessing stereotype incongruities using the N400 ERP component. Soc Cogn Affect Neurosci 4(2):191–198.
12. Goto SG, Yee A, Lowenberg K, Lewis RS (2013) Cultural differences in sensitivity to social context: Detecting affective incongruity using the N400. Soc Neurosci 8(1): 63–74.
13. Goto SG, Ando Y, Huang C, Yee A, Lewis RS (2010) Cultural differences in the visual processing of meaning: Detecting incongruities between background and foreground objects using the N400. Soc Cogn Affect Neurosci 5(2-3):242–253.
14. Ishii K, Kobayashi Y, Kitayama S (2010) Interdependence modulates the brain response to word-voice incongruity. Soc Cogn Affect Neurosci 5(2-3):307–317.
15. Chua RYJ, Roth Y, Lemoine J-F (December 8, 2014) The Impact of Culture on Creativity How Cultural Tightness and Cultural Distance Affect Global Innovation Crowdsourcing Work. Adm Sci Q, 10.1177/0001839214563595.
16. Guilford JP (1967) The Nature of Human Intelligence (McGraw-Hill, New York).
17. Zhang Y, Zhang J (2008) Brain responses to agreement violations of Chinese grammatical aspect. Neuroreport 19(10):1039–1043.
18. Kutas M, Hillyard SA (1980) Event-related brain potentials to semantically inappropriate and surprisingly large words. Biol Psychol 11(2):99–116.
19. DeLong KA, Urbach TP, Kutas M (2005) Probabilistic word pre-activation during language comprehension inferred from electrical brain activity. Nat Neurosci 8(8): 1117–1121.
20. Weckerly J, Kutas M (1999) An electrophysiological analysis of animacy effects in the processing of object relative sentences. Psychophysiology 36(5):559–570.
21. Hackman DA, Farah MJ, Meaney MJ (2010) Socioeconomic status and the brain: Mechanistic insights from human and animal research. Nat Rev Neurosci 11(9): 651–659.
22. Piff PK, Stancato DM, Côté S, Mendoza-Denton R, Keltner D (2012) Higher social class predicts increased unethical behavior. Proc Natl Acad Sci USA 109(11):4086–4091.
23. Fong MC, et al. (2014) Switching between Mii and Wii: The effects of cultural priming on the social affective N400. Cult Brain 2(1):52–71.
24. Masuda T, Russell MJ, Chen YY, Hioki K, Caplan JB (2014) N400 incongruity effect in an episodic memory task reveals different strategies for handling irrelevant contextual information for Japanese than European Canadians. Cogn Neurosci 5(1):17–25.
25. Bridger EK, Bader R, Kriukova O, Unger K, Mecklinger A (2012) The FN400 is functionally distinct from the N400. Neuroimage 63(3):1334–1342.
26. Gunter TC, Bach P (2004) Communicating hands: ERPs elicited by meaningful symbolic hand postures. Neurosci Lett 372(1-2):52–56.
27. Bach P, Gunter TC, Knoblich G, Prinz W, Friederici AD (2009) N400-like negativities in action perception reflect the activation of two components of an action representation. Soc Neurosci 4(3):212–232.
28. Reid VM, Striano T (2008) N400 involvement in the processing of action sequences. Neurosci Lett 433(2):93–97.
29. Proverbio AM, Riva F, Zani A (2010) When neurons do not mirror the agent's intentions: sex differences in neural coding of goal-directed actions. Neuropsychologia 48(5):1454–1463.
30. Wu S, Keysar B (2007) The effect of culture on perspective taking. Psychol Sci 18(7): 600–606.
31. Strobel A, et al. (2011) Beyond revenge: Neural and genetic bases of altruistic punishment. Neuroimage 54(1):671–680.
32. de Quervain DJ-F, et al. (2004) The neural basis of altruistic punishment. Science 305(5688):1254–1258.
33. Gordon I, et al. (2013) Oxytocin enhances brain function in children with autism. Proc Natl Acad Sci USA 110(52):20953–20958.
34. Marco-Pallarés J, et al. (2009) Genetic variability in the dopamine system (dopamine receptor D4, catechol-O-methyltransferase) modulates neurophysiological responses to gains and losses. Biol Psychiatry 66(2):154–161.
35. Greene JD, Sommerville RB, Nystrom LE, Darley JM, Cohen JD (2001) An fMRI investigation of emotional engagement in moral judgment. Science 80(293):2105–2108.
36. Greene J, Haidt J (2002) How (and where) does moral judgment work? Trends Cogn Sci 6(12):517–523.
37. Moll J, Zahn R, de Oliveira-Souza R, Krueger F, Grafman J (2005) Opinion: The neural basis of human moral cognition. Nat Rev Neurosci 6(10):799–809.
38. Young L, Koenigs M (2007) Investigating emotion in moral cognition: A review of evidence from functional neuroimaging and neuropsychology. Br Med Bull 84:69–79.
39. Group WVS (1994) World Values Survey, 1981-1984 and 1990-1993 (Inter-university Consortium for Political and Social Research, Ann Arbor, MI).
40. Albright M, Kohut A (2002) What the World Thinks in 2002: How Global Publics View: Their Lives, Their Countries, the World, America (Diane Publishing Company, Collingdale, PA).
41. Goldberg LR (1999) International Personality Item Pool: A scientific collaboratory for the development of advanced measures of personality and other individual differences. Available at ipip.ori.org/ipip/. Accessed August 14, 2002.
42. Adler NE, Epel ES, Castellazzo G, Ickovics JR (2000) Relationship of subjective and objective social status with psychological and physiological functioning: Preliminary data in healthy white women. Health Psychol 19(6):586–592.
43. Jung T-P, et al. (2000) Removing electroencephalographic artifacts by blind source separation. Psychophysiology 37(2):163–178.
44. Delorme A, Makeig S (2004) EEGLAB:Aan open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. J Neurosci Methods 134(1):9–21.
45. Hayes AF (2013) Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach (Guilford Press, New York).