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

Yan Mu[a,1], Shinobu Kitayama[b], Shihui Han[c], and Michele J. Gelfand[a,1]

[a]Department of Psychology, University of Maryland, College Park, Maryland, 20742; [b]Department of Psychology, University of Michigan, Ann Arbor, Michigan, 48109; and [c]Department of Psychology and Peking University-International Data Group/McGovern Institute for Brain Research, Peking University, Beijing 100080, People's Republic of China

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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 co-

violations, will not, illustrating the unique cultural influence on detecting violations of social norms and not just the detection of any incongruity at the linguistic level.

In addition to examining cultural differences in the N400 in detecting social norms violations, this study further aims to examine whether such neurobiological differences are related to cultural differences in a wide variety of attitudes and behaviors. Compared with loose cultures, individuals in tight cultures have more self-control (1), prefer standard vs. creative solutions to

United States, China) ×

illustrating that the semantic incorrect condition elicited larger N400 over widespread regions for both US and Chinese subjects [frontal: $F(1,48) = 7.82$, $P < 0.01$; central: $F(1,48) = 8.25$, $P < 0.01$; temporal: $F(1,48) = 7.06$, $P < 0.01$; parietal: $F(1,48)$

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

muscle noise, and line noise) by independent component analysis (ICA), which