



Interdependent self-construal predicts reduced sensitivity to norms under pathogen threat: An electrocortical investigation

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ARTICLE INFO

Keywords:

Threat
Social norms
Interdependence
Electroencephalography

ABSTRACT

Prior evidence suggests that external threat motivates people to monitor norm violations. However, the effect of threat may be attenuated for those high in interdependent self-construal (SC) because this SC affords a sense of protection against the threat. Here, we tested this possibility by priming or not priming young American adults with a pathogen threat. We then had participants read norm-violating or normal behaviors while assessing two electrocortical markers: N400 (indexing the detection of norm violations) and suppression of upper α -band power (indexing vigilance to the violations). In the threat priming condition, interdependent SC predicted decreased responsiveness to norm violations. In the control priming condition, however, interdependent SC predicted increased responsiveness. Our work suggests that interdependent SC may provide a sense of security under threat.

1. Introduction

How will people respond to external threats such as imminent wars, potential germ infection, and future earthquakes? Some people may be alarmed by the threat. These people may then become highly responsive to social norms, insofar as abiding by the norms is often crucial in coping with the external threat (Gelfand et al., 2011; Murray & Schaller, 2016). However, it is also conceivable that other people feel protected from such threats, reducing their level of alarm and their subsequent responsiveness to social norms. So far, little is known about individual differences predisposing these contrasting responses to external threats.

In the current work, we drew on recent evidence that a construal of the self as belonging to and embedded in significant social relations, called the interdependent self-construal (SC) (Markus & Kitayama, 1991), affords a sense of protection against external threats (Eisenberger et al., 2007; Wang et al., 2014). Based on the evidence that interdependent SC can buffer the sense of threat, we predicted that interdependent SC would moderate people's responsiveness to social norms under threat. While the available evidence suggests that people respond more strongly to norm violations under threat, the effect of threat may

be attenuated for those high in this SC, insofar as the sense of social connection associated with this SC buffers the sense of threat.

1.1. Interdependent SC and external threat

Interdependent SC refers to a view of the self as belonging to and being embedded in significant social relations (Markus & Kitayama, 1991). The dimension is distinguished from independent SC, which refers to a contrasting view of the self as separate from social relations (Markus & Kitayama, 1991). Compared to those low in SC, those high in this SC are more likely to define themselves in terms of their social position and role in their social relations. As a consequence, the need to belong to their primary groups (i.e., family, school, firms, and local communities) is more central to their identity.

Existing evidence suggests that interdependent SC comes with a sense of protection in the face of threat. Theoretically, close social relations are perceived as "warm" (Kelley, 1950; Williams & Bargh, 2008), consistent with a premise in attachment theory that close social relations can serve as a "secure base" (Bowlby, 1990). We may then expect that people high in interdependent SC will perceive social relations as

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warmer and thus more protective. Hence, interdependent SC may entail an analgesic effect. Consistent with this prediction, recent neuroimaging studies find that the presence of close others can mitigate neural responses to physical pain (Coan et al., 2006). Further, Eisenberger et al. (2007) showed that physiological responses to physical pain are not as strong among those who feel they have social support (Eisenberger et al., 2007). The reduced response to threat may be greater for those who are interdependent and thus closely attached to and supported by their relations. In support of this, a similar reduction of pain response was observed when people are induced to feel interdependent (Wang et al., 2014). Moreover, people high in interdependent SC are more resilient when they are socially excluded compared to people low in interdependent SC (Gardner et al., 2005; Over & Uskul, 2016; Ren et al., 2013; Uskul & Over, 2014, 2017).¹ Together, the growing body of evidence suggests that interdependence may be a potent buffer for the experience of threat.

1.2. Moderation of threat effects by interdependent SC

If interdependent SC buffers the experience of threat, it should attenuate the psychological effects of external threats. One of the most extensively studied effects of external threats relates to social norms (Murray & Schaller, 2016). For example, Gelfand et al. (2011) show that a higher historical level of external threats predicts tightness of norms across both many modern nations (Gelfand et al., 2011) and pre-industrial societies (Jackson et al., 2020). A similar effect may occur at the individual level. Murray and Schaller (2012) find that when exposed to cues of external threat, individuals judge normative transgressions to be less justifiable (Murray & Schaller, 2012). They also value conformity more strongly and agree with majority opinions more (Murray et al., 2011). Also consistent is a finding that people who are sensitized to germ threats hold more negative attitudes toward immigrants (who do not assimilate to local norms), compared to those who are not as sensitized to such threats (Karinen et al., 2019). Hence, when there is an imminent external threat, responsiveness to social norms should increase. However, interdependent SC is likely to buffer the sense of threat, and as a consequence, the heightened sensitivity to social norms under threat may be attenuated among those high in interdependent SC. Thus, the impact of the external threat would be most pronounced among those low in interdependent SC.

What effect will interdependent SC have on responsiveness to norm violations when there are no external threats? The extant evidence suggests that in the absence of threat, interdependent SC may increase (rather than decrease) this responsiveness. For example, a recent study shows that when interdependence is primed, people become more responsive to norm violations of others (Salvador, Mu et al., 2020). This finding is consistent with an earlier review of cultural differences within the Asch-conformity paradigm, which shows that the conformity rate is significantly higher in countries that are higher in interdependent (vs. independent) SC (Bond & Smith, 1996). Moreover, when independent vs. interdependent SC is measured at the individual level, a similar trend is observed in an experimental paradigm designed to assess the effect of social influence on memory (Peterson & Paterson, 2012). Interdependent (vs. independent) individuals were more influenced by others. Altogether, interdependent SC is likely to predict an increased degree of norm abidance or norm sensitivity in the absence of any external threats. It is only when such threats are imminent that this SC may serve as a buffer to the threats, thereby decreasing the degree of norm abidance or

norm sensitivity.

1.3. Present study

In the current study, we tested whether the sensitivity to norm violations would be moderated by both an imminent threat and interdependent SC. For this purpose, we adopted a threat of pathogen contamination (Hill et al., 2015; Mortensen et al., 2010). Pathogen threat is typically invisible, yet potentially deadly, and has been one of the most impactful dangers across human history (Ackerman et al., 2018). Thus, it is suitable as a domain of interest in an initial inquiry into the effect of threat on responses to norm-violations. Participants were primed or not primed with a pathogen threat and then exposed to the norm-violations of another person while their electroencephalogram was monitored. Importantly, we directly tested mechanisms of the effect of threat on the responsiveness to norm violations by adopting electrocortical indicators of this responsiveness: N400 and suppression of upper α -band power.

N400 is a marked negative going deflection of electrocortical response, typically observed in centro-parietal regions of the brain approximately 400 ms post-stimulus (Kutas & Federmeier, 2011; Rabovsky et al., 2018). It indexes the detection of semantic expectation violations in the processing of sentences (Kutas & Hillyard, 1980), words (Hanslmayr et al., 2007; Na & Kitayama, 2011) and pictures (Goto et al., 2010, 2013). As may be expected, this component also responds to norm violations (Mu et al., 2015; Salvador, Mu et al., 2020). Another component that may be involved in the response to norm violations is the suppression of parietal upper α -band power. The α frequency band primarily reflects inhibitory neuron activity (Klimesch, 2012; Klimesch et al., 2007; Pfurtscheller et al., 1996). The α power assessed at parietal regions often increases when tasks require inwardly oriented attention, such as self-reflection and mind-wandering (Benedek et al., 2014). Conversely, the parietal α is typically decreased (or “suppressed”) when tasks require outwardly oriented attention, such as vigilance to an external stimulus. This decrease of spectral power as a function of the demands of external processing is quite pronounced for the upper half of the α band (10.5–13 Hz) (Klimesch et al., 2007; Ray & Cole, 1985). In contrast, the lower half of the α band (8–10.5 Hz, called lower α) is more diffused topographically and its functions are more general (Klimesch et al., 2007). Altogether, we anticipated that enhanced vigilance to others’ norm-violating (vs. normal) behaviors would entail systematic suppression of upper α -band power.

Our analysis suggests that interdependent SC would have a contrasting effect on the responsiveness to norms and norm violations assessed by both N400 and upper α -band power suppression, depending on the presence of an external threat. In the absence of such a threat, this SC will predict increased responsiveness. But in the presence of the threat, interdependence will predict decreased responsiveness. To assess interdependent SC, we used a well-validated measure of SC (a modified version of the Singelis SC scale, Park & Kitayama, 2014). Since prior work shows that effects of interdependent SC are sometimes mirrored by contrasting effects of independent SC (Goto et al., 2010; Kitayama et al., 2020; Na & Kitayama, 2011; Park & Kitayama, 2014), we also explored whether the predicted effect of interdependent SC might also be mirrored by independent SC and, if so, it might be more clearly observed by a difference score between the two (interdependent SC - independent SC).

2. Methods

2.1. Participants

The current study was conducted in the fall of 2017, well before the COVID-19 pandemic (the winter of 2020). Sixty-nine undergraduates at the University of Michigan participated in the study. All participants were right-handed. Moreover, they self-identified as European

¹ It is of note that Uskul and Over (2014) specified social exclusion by others whom the individual knows. This study therefore provides a particularly compelling demonstration that interdependence buffers a threat of social exclusion supposedly because there are others in the group who are still accepting the person even when some members of the group have excluded him or her.

American, Caucasian, or White. Participants received either course credit or \$15 compensation for their participation. Given the paucity of prior work using threat priming within an ERP paradigm, a priori power analysis was not possible. We thus drew on prior EEG studies comparing two groups, either within a norm violation paradigm (Mu et al., 2015) or with N400 as a key dependent variable within different paradigms (Goto et al., 2010, 2013; Na & Kitayama, 2011). These studies used up to 20 participants per cell. In the current work, we tried to increase the N at least by 50 % in each cell by testing as many participants as possible until the end of the term.

Of the 69 participants, 10 were excluded before analyses due to medication use (4), head injuries (2), not meeting ethnicity criteria (1) and excessively noisy ERP data (3) as determined by standard artifact rejection criteria (Luck, 2014). With these criteria, all participants included in the analysis (N = 59, 38 females, varying from 18 to 30 years of age, $M = 21.38$, $SD = 2.44$) had at least 50 % of usable trials in each Behavior type. More than 86 % of the Behavior type conditions had more than 90 % of trials included, with the average percent of inclusion of approximately 95 % of trials across the participants. The participants provided their written informed consent in accordance with the Declaration of Helsinki. The study protocol was approved by the Institutional Review Board of the University of Michigan.

2.2. Data availability

Materials, scripts for data-analysis, de-identified behavioral and EEG data of the present study are available at: https://osf.io/ga96k/?view_only=f2c3741cd2eb4ae0986af39b23b81f57.

2.3. Procedure

Upon arrival at the lab, participants filled out pre-screening questions on medication use, history of seizure disorders, head injury, ethnicity, and handedness. After the EEG was set up, participants were asked to evaluate a slideshow that was described as “educational materials for another study.” They were instructed to pay close attention to the slideshow and prepare themselves to answer several questions afterward. The participants were randomly assigned to either a threat or control priming condition. In the threat priming condition, the slideshow, entitled “The Growing Problem of Disease in America: A Sick Future Ahead,” illustrated the danger of germ contamination (Fig. S1-A). In the control priming condition, the slideshow, entitled “A Day at Home: Organizing your Desk,” illustrated how an office would look (Fig. S1-B). The current threat manipulation was successfully used in prior studies (Hill et al., 2015; Mortensen et al., 2010).

The slideshow rating task was followed by a norm violation judgment task, which consisted of a total 204 experimental trials (Fig. S2), preceded by 3 practice trials. Each trial started with a fixation point (“+”) (750 ms), followed by a word representing the situation (e.g., bike lane) (1000 ms). Following another fixation point (750 ms), a picture of the situation was shown. After 2000 ms, a word representing a behavior (e.g., cycling) was superimposed on the picture for 900 ms. The disappearance of the behavior was followed by a blank screen for 800 ms, after which a prompt to judge the behavior appeared. This period was inserted to minimize any motor artifacts. The participants judged how violating the behavior was for the situation by using a 4-point rating scale ranging from (1 = normal, 4 = very violating). After the response, the next trial started immediately with the presentation of a fixation point. The period between the presentation of the behavior and the disappearance of the behavior along with the picture constitutes the time window of interest for the electrocortical data.

In the norm violation judgment task, situation-behavior pairs and pictures were adopted from Salvador, Mu et al. (2020). There were 34 behaviors, each of which (e.g., cycling) was made normal (e.g., bike lane), weakly norm-violating (e.g., sidewalk), or strongly norm-violating (e.g., highway), depending on the situations it was

paired with, yielding 102 unique behavior-situation pairs. Two rounds of these 102 stimuli were used, resulting in 204 total trials. The order of the stimuli was randomized in each round for each participant.

After the norm violation judgment task, the participants filled out a packet of questionnaires. The packet included a modified version of the Singelis Self-Construct scale (Park & Kitayama, 2014), composed of a 10-item Independent SC subscale ($\alpha = 0.804$, “I do my own thing regardless of what others think”) and a 10-item Interdependent SC subscale ($\alpha = 0.664$, “I will sacrifice my self-interest for the benefit of the group I am in.”). Participants rated themselves on a 7-point rating scale (1 = strongly disagree, 7 = strongly agree). Our focus was on Interdependent SC. Interdependent SC was centered prior to running the reported models.² In addition, we performed a subsidiary analysis testing independent SC, as well as the difference between the two SCs (interdependence - independence).

2.4. EEG recording and processing

EEG was recorded from 32 scalp channels using a BioSemi Active-Two System. Four bipolar EOG electrodes were used to monitor eye movements and an electrode was placed on both of the left and right mastoids. During the set-up of electrodes, impedances were verified to be within +/- 20K Ω . The data were digitized at 512 Hz, then offline resampled at 256 Hz and referenced to the average of the two mastoids. Within MATLAB, the EEGLAB plugin and ERPLAB extension were used for data analysis. An offline bandpass filter with a lowpass of 30 Hz and a high pass of 0.1 Hz was applied. Then the data were segmented 200 ms pre-stimulus baseline and 900 ms post-response (1100 ms in total). Ocular artifacts were corrected based on a commonly used algorithm (Gratton et al., 1983). Trials were then rejected if they exceeded +/- 150 μ V as determined with a 400 ms moving window using a 100 ms stepwise peak-to-peak threshold, if they fluctuated more than 30 μ V between two sampling points, or if they had little to no activity (less than +/- 0.5 μ V) over the course of the trial (Luck, 2014).

2.5. Measurement of N400

The EEG was time-locked to the presentation of each stimulus behavior and baseline corrected to 200 ms prior to the critical stimulus. A visual inspection of the post-behavior EEG identified a clear negative-going deflection approximately 440 ms after the onset of the behavior in the central sites. We selected Cz for further analyses. This is the same site used in prior work with the same paradigm (Salvador, Mu et al., 2020). Moreover, the spatiotemporal location corresponds closely to prior work on N400 (Kutas & Federmeier, 2011; Na & Kitayama, 2011). First, the average peak latency across all conditions was visually determined (440 ms). The mean amplitude was extracted using a time window +/- 50 ms around the average peak latency (390–490 ms). As in prior work, the mean amplitude for all trials for each participant was then used as a dependent variable in further analyses.

2.6. Measurement of upper α -Band suppression

To measure the upper α -band power, several steps were taken. To perform a time-frequency analysis (TFA) utilizing a moving window

² In addition, the packet included perceived vulnerability to disease (Duncan et al., 2009), fear of negative evaluation (Leary, 1983), need to belong (Baumeister & Leary, 1995), neuroticism (Kitayama et al., 2018), PANAS (Watson et al., 1988), and other measures from creativity and cultural superiority (Mu et al., 2015), and the 14-item Tightness/looseness belief scale (Gelfand et al., 2011). Some of them were included for other purposes. The remaining scales were included for exploratory purposes and are not discussed in the current paper. Regardless, the current findings held even when these variables were statistically controlled.

approach, it is necessary to use a data segment larger than the time-period of interest. Here, we elected to mirror the original data epochs (Cohen, 2014) in order to maximize the amount data for analysis. That is, the original data epoch was duplicated, reversed along the x-axis (time), and attached to both ends of the original epoch. In addition to retaining more data for analysis, the mirroring allowed us to avoid edge artifacts in the TFA (Cohen, 2014), while also reducing the influence of DC (or “direct current”) drifts (baseline variation of low-frequency drifts) in the data. This has the added benefit of minimizing the issues that can occur in regression-based eye corrections (Croft & Barry, 1998). This process was repeated in order to create an EEG data segment from -4043 to 4742 ms. Next, we ran a TFA using complex Morlet wavelets (Cohen, 2014). The wavelets were 3 cycles wide at 0.5 Hz and gradually shrunk to 36 cycles wide at 30 Hz. We extracted 473 log-spaced frequencies between .5 and 30 Hz utilizing zero-padding to a factor of 8 and estimated 400 timepoints between -700 and 1400 ms.

For each trial, the baseline was defined as the 200 ms window prior to the onset of the stimulus. To calculate the event-related spectral perturbation (ERSP), we took the average of the upper alpha (10.5–13 Hz) frequency range from 400 ms and 900 ms post-stimulus onset, where the suppression was evident. Consistent with prior work (Klimesch et al., 2007), this effect was most pronounced at the midline parietal sites, thus we selected Pz for further analyses during the 400–900 ms time window of interest.

2.7. Analytic plan

We analysed data from the set of 102 stimuli, which were repeated twice, resulting in two rounds of the same stimulus set. To guard against the possibility that the repetition of identical norm violations could invite habituation (Zajonc, 1968), we first ran each round separately. When the results for the second round were no different from those of the first round, the two rounds were combined. Further, prior evidence with neural measures shows that the two degrees of norm violation (strong vs. weak) do not differ from each other (Mu et al., 2015; Salvador, Mu et al., 2020). To ensure that this applies to the current work (which includes both N400 and upper alpha suppression), preliminary analysis was performed to compare the two conditions. Our main set of analyses used interdependent SC scores. In addition, however, we also tested both independent SC and the difference between the two (interdependence - independence).

3. Results

3.1. N400

Fig. 1-A shows waveforms at Cz in both threat and control priming conditions. The time window for the N400 is highlighted in grey. Our prediction implies that the effect of norm violation on the N400 would be moderated by both Prime and Interdependent SC. We first performed a preliminary analysis focusing on the strong vs. weak norm-violating behaviors. This variable showed no main effects nor interactions with other variables, $ps > .133$. We thus collapsed the two norm-violation conditions. Further, another preliminary analysis examining each of the two rounds showed nearly identical patterns. We thus performed a $2 \times 2 \times 2$ mixed ANOVA (Behavior type x Prime x Interdependent SC) on the magnitude of the N400 that were combined across the two rounds.

This analysis showed the main effect of Behavior type, $F(1, 55) = 9.93, p = .003, \eta_p^2 = .153$, showing that the N400 is significantly greater for norm-violating behaviors than for normal behaviors. Moreover, the 3-way interaction involving Behavior type, Prime, and SC proved

significant, $F(1, 55) = 10.74, p = .002, \eta_p^2 = .163$.³ This interaction is illustrated in Fig. 1-B. To more closely examine the nature of this interaction, separate 2×2 mixed ANOVAs (Behavior type x Interdependent SC) were performed on each of the two priming conditions.

First, in the threat priming condition, the main effect of Behavior type was marginally significant, $F(1, 29) = 3.18, p = .085, \eta_p^2 = .099$, showing that the N400 was somewhat greater in magnitude for norm-violating behaviors than for normal behaviors. The effect of interdependent SC, apparent in Fig. 1-B (the left panel), did not achieve statistical significance, $F(1, 29) = .195, p = .662, \eta_p^2 = .007$. However, the interaction between Behavior type and Interdependent SC was statistically significant, $F(1, 29) = 5.86, p = .025, \eta_p^2 = .161$. For those 1SD below the mean for Interdependent SC, the N400 was significantly higher for norm-violating behaviors than for normal behaviors, $F(1, 29) = 9.75, p = .004, \eta_p^2 = .252$. However, this effect disappeared, with the N400 being no greater for norm-violating behaviors than for normal behaviors, for those 1SD above the mean in Interdependent SC, $F(1, 29) = .303, p = .586, \eta_p^2 = .010$.

Second, in the control priming condition, the main effect of Behavior type was statistically significant, $F(1, 26) = 7.37, p = .012, \eta_p^2 = .221$. The N400 magnitude was greater for norm-violating behaviors than for normal behaviors. The effect of Interdependent SC, apparent in Fig. 1-B (right panel), did not reach statistical significance, $F(1, 26) = 1.64, p = .211, \eta_p^2 = .059$. Importantly, the Behavior type x Interdependent SC interaction was significant, $F(1, 26) = 5.20, p = .031, \eta_p^2 = .167$. For those 1SD above the mean for Interdependent SC, the N400 was significantly greater for norm-violating behaviors than for normal behaviors, $F(1, 26) = 13.75, p = .001, \eta_p^2 = .346$. This effect disappeared for those 1SD below the mean in Interdependent SC, $F(1, 26) = .219, p = .644, \eta_p^2 = .008$. For these individuals, the N400 was no greater for norm-violating behaviors than for normal behaviors.

3.2. Upper alpha suppression

The results of the time-frequency analysis over both rounds across all conditions are plotted in Fig. 2-A. The focal upper α -band is marked by a red box in the time-frequency chart. A decrease of upper α -band power (indicated by blue shading) is evident, starting around 400 ms after the onset of the target behavior and continuing throughout the time period of interest. As in the prior analysis we first focused on the two norm violation conditions. This analysis showed that the degree of norm violation had no main effects nor interactions with other variables, $ps > .120$. Hence, these two conditions were averaged and we performed a $2 \times 2 \times 2$ mixed ANOVA (Behavior type x Prime x Interdependent SC) on upper α suppression. For the first round of stimulus presentation, upper α suppression was greater for norm-violating than normal behaviors as shown by a main effect of Behavior type, $F(1,55) = 9.25, p = .004, \eta_p^2 = .144$. Moreover, the 3-way interaction involving Behavior type, Prime, and SC proved significant, $F(1, 55) = 6.11, p = .017, \eta_p^2 = .100$. When we examined the second round of stimulus presentation, the main effect of Behavior type was weaker, but remained significant, $F(1, 55) = 4.51, p = .038, \eta_p^2 = .076$. Importantly, however, the 3-way interaction involving Behavior type, Prime, and SC was not, $F(1, 55) = .148, p = .702, \eta_p^2 = .003$. We return to this in the discussion.

The 3-way interaction for the first round is illustrated in Fig. 2-B. To more closely examine the nature of this interaction, a separate 2×2 ANOVA (Behavior type x Interdependent SC) was performed on each of the two priming conditions. First, in the threat priming condition (left panel), the main effect of Behavior type was significant, $F(1, 29) = 7.98, p = .008, \eta_p^2 = .216$. There was greater upper α suppression for norm-violating behaviors than for normal behaviors. The effect of

³ When Round (1st vs. 2nd) was included as an additional independent variable, the interaction between Round, Behavior type, Prime and SC was not significant, $F(1, 55) = 0.18, p = .893, \eta_p^2 = .000$.

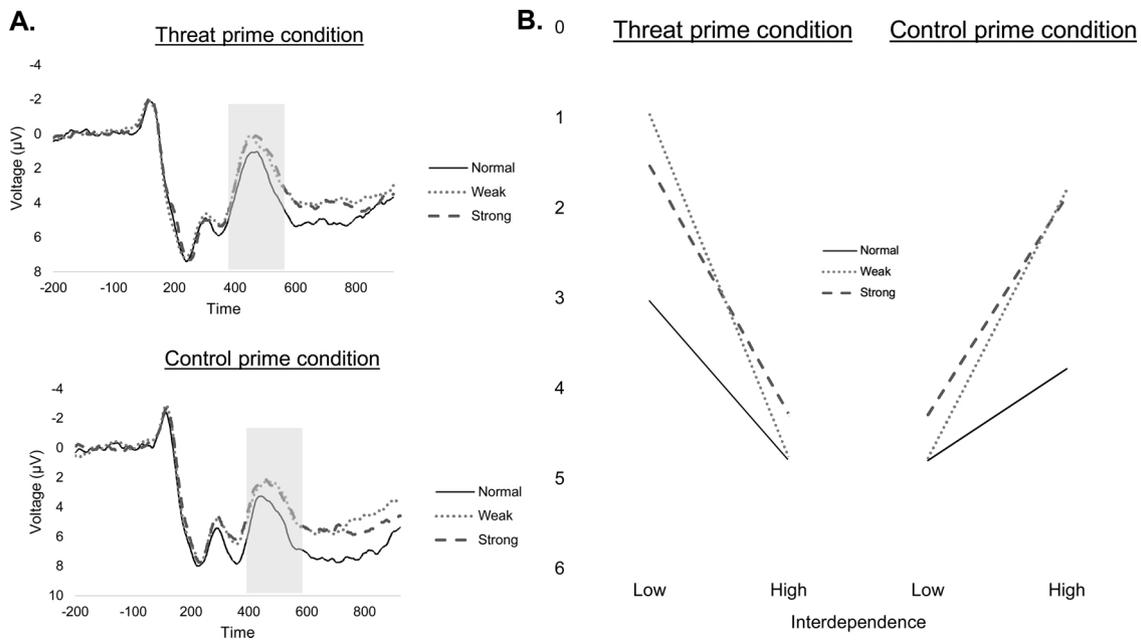


Fig. 1. A. Wave forms at Cz in the threat prime and control prime conditions. B. N400 mean amplitude for norm-violating and normal behaviors in the two prime conditions at +1 and -1 SD of interdependent self-construal.

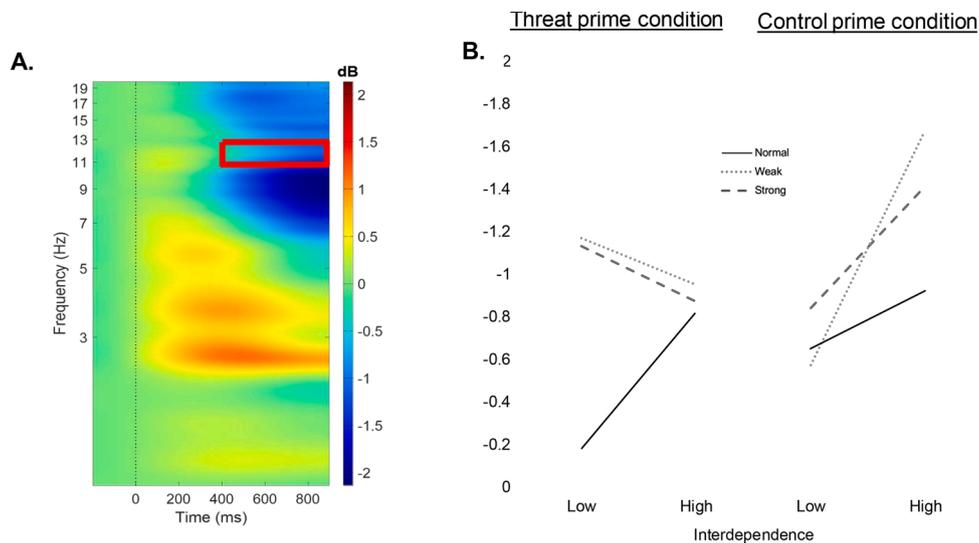


Fig. 2. A. Time Frequency plot at Pz for the upper-alpha (10.5–13 Hz) range over all conditions, with a 200 ms pre-stimulus baseline. The time window of interest is marked with red. B. The upper alpha suppression for norm-violating and normal behaviors in the threat and control prime conditions at +1 and -1 SD of interdependent self-construal. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article).

Interdependent SC was statistically negligible, $F(1, 29) = .357, p = .56, \eta_p^2 = .012$. However, the interaction between Behavior type and Interdependent SC was statistically significant, $F(1, 29) = 4.32, p = .047, \eta_p^2 = .130$. For those 1SD below the mean for Interdependent SC, upper α suppression was significantly higher for norm-violating behaviors than for normal behaviors, $F(1, 29) = 13.18, p = .001, \eta_p^2 = .312$. This effect disappeared for those 1SD above the mean in Interdependent SC, $F(1, 29) = .096, p = .759, \eta_p^2 = .003$. Upper α suppression was no greater for norm-violating behaviors than for normal behaviors.

Second, in the control priming condition, the main effect of Behavior type was not significant, $F(1, 26) = 2.29, p = .142, \eta_p^2 = .081$. The effect of Interdependent SC in Fig. 2-B (right panel) did not achieve statistical significance, $F(1, 26) = 1.27, p = .270, \eta_p^2 = .047$. Neither did the Behavior type x Interdependent SC interaction, $F(1, 26) = 2.01, p =$

$.169, \eta_p^2 = .072$.

3.3. Perceived severity of norm-violations

A preliminary analysis performed on the strong vs. weak norm-violating behaviors, showed a significant main effect of the extent of norm violation, $F(2, 54) = 663.73, p < .001, \eta_p^2 = .925$. Thus, in this analysis, we did not collapse the two norm violation conditions. In an ANOVA performed on the perceived severity of norm violation for each of the two rounds separately, only the main effect of Behavior type was significant, $F(2, 53) = 750.49, p < .001, \eta_p^2 = .934$ and $F(2, 53) = 623.44, p < .001, \eta_p^2 = .920$ for the first and second rounds, respectively. Across the two rounds, the normal, weakly violating and strongly violating behaviors were all rated as significantly different from each other ($M_s =$

1.09, 2.10 and 2.90), $ps < .001$. The remaining effects did not reach statistical significance, $ps > .089$.

3.4. Effects of independent SC

Subsequently, we performed the same analyses after replacing interdependent SC with independent SC. We also tested the difference between interdependent and independent SC (interdependence - independence). Unlike some prior work suggesting that the effect of interdependent SC is mirrored in the effect of independent SC, we found no effect of independent SC.

As for N400, when independent SC was used instead of interdependent SC, the 3-way interaction involving Behavior type, Prime, and SC was not significant, $F(1, 55) = 1.77, p = .189, \eta_p^2 = .031$. When the difference between the two SCs was used the Behavior type, Prime, and SC interaction was significant, $F(1, 55) = 7.14, p = .010, \eta_p^2 = .115$. On upper α suppression, when independent SC was used instead of interdependent SC, the 3-way interaction involving Behavior type, Prime, and SC was not significant, $F(1, 55) = 1.054, p = .309, \eta_p^2 = .019$. When the difference between the two SCs was used the Behavior type, Prime, and SC interaction was significant, $F(1, 55) = 4.14, p = .047, \eta_p^2 = .070$. Lastly, on the perceived severity measure, we found no effect of independent SC as in the analysis with interdependent SC reported above.

3.5. Relationship among the three indicators of the response to norm violations

As the last step of our analysis, we examined the correlations among the three indices of the response to norm violations: norm-violation N400, upper α suppression for norm-violating (vs. normal) behaviors, and perceived norm-violation for norm-violating (vs. normal) behaviors. As shown in Table 1, the correlations were all quite small and statistically non-significant.

4. Discussion

The present work shows that people respond to norm violations very differently depending on both pathogen threat priming and interdependent SC. In the threat priming condition, the effect of norm violation was observed only for those low in interdependent SC. For these individuals, both N400 and upper α suppression were stronger for norm-violating behaviors than normal behaviors. But for those high in interdependent SC, these effects disappeared. This pattern supports the hypothesis that interdependent SC has an analgesic effect when there is an imminent threat. In contrast, in the control prime condition, the effect of norm violation was observed only for those high in interdependent SC. For these individuals, N400 was stronger for norm-violating behaviors than for normal behaviors. This is consistent with the idea that under ordinary circumstances, people high in interdependent SC are more sensitive to social norms. Notably, the heightened response to norm violations for those high in interdependent SC in the control condition was observed for N400 (an index of the detection of norm violations), but not the upper α suppression measure (an index of vigilant attention to norm violations). Perhaps, under ordinary circumstances, even when people are sensitized to norm violations due to their interdependent SC, there is no strong need to monitor norm violations and thus to be vigilant.

Table 1

Correlations between (1) the norm violation N400, (2) upper α suppression for norm-violating (vs. normal) behaviors, and (3) perceived norm-violation for norm-violating (vs. normal) behaviors.

	N400	Upper α suppression
Upper α suppression	0.176	1
Perceived severity of violation	0.026	-0.105

It is noteworthy that the effect we observed for interdependent SC was unique to this SC. Unlike some available studies that show the effect of interdependent SC is mirrored by independent SC (Goto et al., 2010; Kitayama et al., 2020; Na & Kitayama, 2011; Park & Kitayama, 2014), we found no effect of independent SC. It might be the case that some functions of interdependent SC, such as promoting social harmony, can be achieved through reduced propensities toward independence. In such situations, the effect of interdependent SC would be mirrored by a contrasting effect of independent SC. However, the function of interdependent SC that is relevant to the present work was to yield a sense of security or protection when a threat was imminent. It might not be possible to achieve this effect by reducing the level of independence. Future work must elaborate on this line of analysis and determine the precise conditions in which the two SCs have mirroring or unique effects.

4.1. Mechanisms underlying N400 and upper α -Suppression

In the current procedure, the same set of 102 stimuli were presented twice in separate rounds. The predicted interaction between Prime and Interdependent SC was robust across the two rounds for N400 (which indexes the detection of norm violations). However, it was robust only for the first round for upper α -suppression (which indicates vigilance for them). While unpredicted, this discrepancy may reveal distinct mechanisms underlying the detection (N400) and the vigilance (upper α -suppression) to norm violations.

To detect a norm violation, one must retrieve a relevant norm, keep the norm active in working memory, and compare the target behavior against the norm (Kahneman & Miller, 1986). If the target behavior does not match the norm, then N400 will ensue. The finding that the N400 effect is strong in both the first and the second rounds suggests that the norm accessibility is fairly stable across the two rounds. If the accessibility is made high (or low), it remains high (or low) throughout. When a violation is detected, people may allocate attention to it (as indicated by the upper α -suppression). This attention is a precautionary measure taken against any danger the behaviors could be posing, which may be only salient when there is cause for alarm, such as in the threat condition. At first glance, the disappearance of the vigilance response in the second round might seem puzzling as the N400 measure shows that the effect of the present priming manipulation persisted over the two rounds. Upon closer scrutiny, however, this effect might reveal a hitherto unappreciated mechanism that could be of substantial significance for adaptation and survival.

Imagine that you have encountered a novel stimulus, say a person who is acting "strangely." This encounter may be alarming. Then, imagine that nothing adverse has happened afterward. You may classify the behavior as "safe." The "safety-tag" attached to the person may enable you to approach the same person more proactively, or perhaps in a less guarded fashion when you see him or her next time. A "safety-tag" mechanism like this could be responsible for the mere exposure effect, wherein repeated exposure to novel stimuli results in increased liking (Zajonc, 1968). In the present context, when a norm-violating behavior is presented for the first time under threat, it generates an alarm response (indicated by the upper α suppression) for those low in interdependent SC. However, by design, in the present procedure, nothing adverse occurs upon the presentation of the behavior. As a consequence, the behavior may be tagged as safe. When the behavior is presented for the second time, it will still generate N400 since the mismatch between the behavior and the relevant norm remains. However, the "safety tag" attached to it may override any precautionary alarm responses, including the upper α suppression. This potential mechanism must be tested more closely in future work.

4.2. Why did self-report show no effects of either threat or interdependent SC?

Given the consistency of our findings for the two disparate neural measures of the response to norm violations under threat, it is noteworthy that the self-report measure of the severity of norm violation showed no comparable evidence. To understand the theoretical significance of the dissociation between the neural measures and the self-report measure, we must recognize some uniqueness of the psychological reactions to threat.

The threat network of the brain is likely to involve the amygdala (AMG), the anterior insula (aINS), and the anterior cingulate cortex (ACC), among others. The pathogen threat manipulation may activate this network (Kitayama & Tompson, 2015). Evidence shows that monitoring of errors and conflicts (including norm violations) implicate the ACC (Carter & van Veen, 2007; Swick & Turken, 2002). Further, vigilance is a function of perceptual processing that is modulated strongly by the AMG activity. Accordingly, when the threat is primed, both ACC and AMG are activated (along with aINS). The increased activity of ACC and AMG would enhance the ability to both detect norm violations (N400) and to become vigilant to the violation (upper α suppression). However, neither ACC nor AMG is directly related to the cognitive appraisal of norm violations. Hence, there is an ample reason why there is a substantial dissociation between neural responses and self-report. Indeed, cognitive dissonance as a state of self-threat is barely accessible to self-report (Nisbett & Wilson, 1977), even though it comes with a distinct pattern of activation of its neural mechanisms involving aINS and ACC (Kitayama & Tompson, 2015). Given these findings, it might now be more meaningful to ask when the two might coincide and if they do, why.

4.3. Limitations and conclusion

Some limitations of the current work must be acknowledged. First, our work leaves open the question of whether the current evidence would generalize across a wider array of threats (e.g., natural disasters, such as earthquakes and tsunamis, and social adversities such as wars and joblessness). It is possible that threat in general leads to tightening of norms, as implied by some existing analyses (Gelfand et al., 2011). Moreover, interdependence may defray the impact of all such threats. At the same time, the threat of pathogen contamination may be unique in numerous ways (Ackerman et al., 2018; Sng et al., 2018). Indeed, other threats such as warfare and resource scarcity may also be unique in theoretically meaningful ways. Future work must address whether the current results would extend to other types of threats.

Second, in the current work, we did not specify whether the norm violator was an ingroup vs. outgroup member. Prior work shows that external threats, such as pathogen threats, typically entail ingroup favoritism, outgroup derogation, or both (Ji et al., 2019). It is not clear whether the responses to norm violations studied here might be linked directly to either ingroup favoritism or outgroup derogation. Nevertheless, it might prove useful to explore the effect of group membership within the current paradigm.

Third, whereas EEG offers high temporal resolution, it lacks spatial resolution (Luck, 2014). Future work may utilize functional magnetic resonance imaging to better understand the neural substrates involved in different facets of norm tightening, including vigilance, monitoring, and punishment (Buckholz & Marois, 2012). Fourth, our work drew only on a U.S. college student sample. It is of theoretical interest to test whether our findings would generalize to other cultures, in which the sense of community is thought to be chronically higher and culturally more elaborated (Markus & Kitayama, 1991). It is possible that in these societies, complacency responses might be likely even for those low in interdependent SC as the high levels of interdependence of society at large may be sufficient to provide an analgesic effect on an impending threat. Lastly, our EEG measure of sustained attention is based on

extensive prior work (Klimesch, 2012). However, in future work, these findings must be supplemented with eye tracking and other behavioral indicators of vigilance.

These limitations notwithstanding, our work shows that interdependent SC may have important consequences on the perception and coping with external threats. As such, it may offer unique implications for the coronavirus (COVID-19) pandemic in 2020. Major outbreaks of the virus are being reported in social gatherings of a large number of people. Moreover, evidence shows that societies that normatively encourage social openness exhibit faster spread of the disease during the pandemic (Salvador, Berg, et al., 2020). The sense of community or interdependence, plausibly enhanced in these groups, might have fostered complacency, as the threat of infection became increasingly evident. Individuals may have become looser in norm enforcement, thereby substantially increasing the chances of pathogen infection. This public health implication of the current theorizing may deserve a careful assessment in the future.

Author contributions

CES, JMA, MJG & SK developed the study concept and contributed to the study design. Data collection was performed by CES and the data analysis and interpretation was done by CES and BTK under the supervision of SK. CES and SK drafted the manuscript, and JMA, BTK & MJG provided critical revisions. All authors approved the final version of the manuscript for submission.

Declaration of Competing Interest

The authors report no declarations of interest.

Acknowledgements

This work was funded in part by US Air Force Grant FA9550-14-1-0020, the US Army Research Laboratory as well as National Institute of Health grant number T32NS047987 (BTK). We would like to thank research assistants for assistance with data collection. We would also like to thank members of the Culture & Cognition Lab who provided feedback in earlier versions of the manuscript.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.biopsycho.2020.107970>.

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