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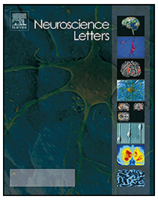

Individual differences in epistemic motivation and brain conflict monitoring activity

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HIGHLIGHTS

- Need for closure (NFC) can be linked to neurocognitive processes of conflict monitoring.
- Low (vs. high) NFC is linked with enhanced N2 effect of stimulus–response congruency and bigger amplitude of ERN component.
- High NFC may act as a bulwark against anxiety-producing uncertainty.

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ABSTRACT

It is well documented that motivation toward closure (NFC), defined as a desire for a quick and unambiguous answer to a question and an aversion to uncertainty, is linked to more structured, rigid, and persistent cognitive styles. However, the neurocognitive correlates of NFC have never been tested. Thus, using event-related potentials, we examined the hypothesis that NFC is associated with the neurocognitive process for detecting discrepancies between response tendencies and higher level intentions. We found that greater NFC is associated with lower conflict-related anterior cingulate activity, suggesting lower sensitivity to cues for altering a habitual response pattern and lower sensitivity to committing errors. This study provides evidence that high NFC acts as a bulwark against anxiety-producing uncertainty and minimizes the experience of error.

1. Introduction

According to Kruglanski's [1] lay epistemic theory, the needs to avoid and attain cognitive closure are fairly fundamental epistemic motives that underlie how people approach and process social information. Individual differences related to the need for cognitive closure (NFC) reflect dispositional variability in preference for order, predictability, tolerance of ambiguity, and closed-mindedness. People who score low on the NFC scale are open to prolonging uncertainty, engage in more deliberative decision-making and flexibility of thought, and exhibit a higher tolerance for ambiguity and nonconformity. They use piecemeal or individuation processes; this preference is manifested in vigilant behavior that is based on a systematic and effortful search for relevant information, its evaluation, and its unbiased assimilation [2,3]. In contrast, people who score high on the NFC scale generally use category-based, nonsystematic and heuristic information processing styles; they prefer predictability and quick decision-making, and they exhibit rigidity of thought and a greater preference for conformity [4]. The motivational tendencies to avoid or attain closure affect the ways in which people interpret and respond to information in their social environments, and can even influence their tendency to anchor (and perpetuate) the status quo (i.e., cognitive conservatism) or question and criticize it [4].

Although the cognitive and social consequences of NFC are well established, the neurocognitive processes that contribute to this motivation remain unknown. Therefore, this article proposes an exploration of the possible neurocognitive correlates of NFC.

1.1. *Neurocognitive correlates of NFC*

Several behavioral studies have revealed that high (vs. low) NFC reduces uncertainty and conflict because it prefers answers that successfully accommodate experience, represents a narrow goal pursuit that turns attention away from discrepancy, or rigid

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predictions that assimilate inconsistent observations [4–7]. This cognitive responsiveness might be triggered by low detection of errors in performance [8] or by less efficient continuous monitoring of the demand placed upon a person's limited cognitive resources by a task [9]. Thus we propose that these psychological differences between high and low NFC individuals may map onto the widely studied neurocognitive self-regulatory process of conflict monitoring.

Conflict monitoring is defined as a general mechanism for detecting when one's habitual response is mismatched with the response required by the current situation [10]. Specifically, detecting conflict during response selection (i.e., the simultaneous activation of incompatible actions) may provide an early warning of conditions in which errors are likely and, hence, increased attention is required. This response conflict is typically associated with enhanced anterior cingulate cortex (ACC) activity, indexed by event-related potentials (ERPs), error-related negativity (ERN), and the N2 component [9,11]. ERN is a medial–frontal potential that peaks within 100 ms of error commission in simple decision tasks [12,13]. Its amplitude depends critically on the processing of target stimulus information (which underlies the ability to produce error-correcting responses). N2 is a component that typically peaks approximately 250 ms following a correct response in congruent and incongruent trials; its effect is quantified as the difference in peak conflict between congruent and incongruent trials with correct responses [14].

We proposed that differences in high (vs. low) NFC participants' responsiveness to complex and potentially conflicting information relate to the sensitivity of this general mechanism for monitoring response conflict. Specifically, we expected that greater NFC would predict lower conflict-related activity. High (vs. low) NFC individuals tend to reduce uncertainty and conflict because they prefer answers that successfully accommodate experience; as such, we expected that this tendency would exhibit less neuronal sensitivity to errors (decreased ERN) and less intense processing of irrelevant stimuli (decreased N2 effect). To test this assumption, we recorded the electroencephalographic activity of the brain (EEGs) while participants completed a color-naming Stroop task [15].

2. Method

2.1. Participants

Prior to the experiment, 455 students (242 female, *M* = 20.75, *SD* = 1.98; one participant did not provide gender information and two other participants did not provide their age) filled out the NFC Scale [16,17] (Cronbach's $\alpha = .75$). The NFC scores (*M* = 3.55, *SD* = .62) were roughly normally distributed (skewedness = −0.26; kurtosis = −0.29). The NFC scores were used to create two groups with higher (>70 percentile) and lower (<30 percentile) psychometric NFC scores on the NFC scale; thus, only 60 participants were invited to the experiment (35 female, aged 18–27, *M* = 20.8; *SD* = 1.9). All participants had normal hearing and normal (or corrected to normal) vision. They all reported freedom from neurological and psychiatric disorders and an absence of drug abuse and medication. Students signed an informed consent and received 12€ (50 PLN) for their participation. Data from 15 subjects were excluded from the analysis because of equipment malfunction, problems with recording, excessive eye blinks or muscle artifacts; consequently, 45 subjects remained in the sample (25 female).

2.2. Measures/procedure

The experiment was carried out in a dimly lit, sound-attenuated, and electrically shielded cabin. The procedure included completing the NFC scale to check the temporal stability of the instrument (the correlation between first and second was high, *r* = .89) and performing a computerized version of the color-naming Stroop task [15]. The experimental trials were presented in a fixed random order. After eight practice trials, participants were given 288 experimental trials. In each trial, a stimulus word was presented for 200 ms; the maximum time for response was restricted to 2200 ms. Two-thirds of the stimuli were congruent, and the remaining third were incongruent. A computer screen was placed approximately 70 cm away from the participants.

2.3. EEG recording

EEG was recorded using a BioSemi Active-Two system with 64 active electrodes placed on the scalp using an Electro-Cap. Two additional electrodes were used for offline linked mastoid reference. Ocular activity was monitored by four electrodes, placed above and below the right eye and in the external canthi of both eyes. EEG and EOG recordings were sampled at 256 Hz and filtered (band pass 0.01–45 Hz, 24 dB/oct). The stimulus-locked EEG was separated into epochs of 650 ms duration, containing 150 ms pre-stimulus activity, and baseline corrected. The response-locked EEG was separated into 450 ms epochs including 250 ms pre-response activity. Trials containing blinks and eye movements were corrected [18].

The N2 component was defined as the mean voltage within 240–340 ms after stimulus onset in correctly responded trials. The ERN component was calculated by subtracting the average ERP recorded in correctly responded trials from that measured in incorrect trials, and was defined as the mean voltage within −65–50 ms relative to response time. The analyses were performed separately for mean amplitudes of the N2 and ERN and were restricted to frontal–central electrodes FCz and Cz. The amplitudes of N2 component were tested with repeated-measures ANOVA, examining the effects of within-subjects factors of stimulus type (congruent vs. incongruent), as well as the between-subjects factor of NFC scores (low vs. high). The amplitudes of ERN components were analyzed using repeated-measures ANOVA testing the effects of between-subjects factor of NFC (low vs. high).

3. Results

3.1. Behavioral results

Subjects were slower on incongruent (*M* = 551.6 ms; *SD* = 147.5) than on congruent (*M* = 709.1 ms; *SD* = 200.9) trials of the Stroop task. This difference was reflected in a highly significant main effect of stimulus type [*F*(1,43) = 141.58, *p* < .0001]. A similar pattern of differences was obtained for both groups differentiated by their NFC scores (congruent trials: *M* = 540.4 ms; *SD* = 134.7 and *M* = 565.6 ms; *SD* = 164.5; incongruent trials: *M* = 702.2 ms, *SD* = 172.6 and *M* = 717.8 ms; *SD* = 235.9 for low and high NFC subjects, respectively). This result was confirmed by non-significant stimulus by NFC interaction [*F*(1,43) = .13, *p* = .719]. Subjects in both groups responded equally fast [*F*(1,43) = .16, *p* = .695].

The mean error rate was higher for incongruent trials (*M* = 24.2; *SD* = 23.0) than for congruent trials (*M* = 10.4; *SD* = 12.5). This difference led to a highly significant main effect of stimulus congruency [*F*(1,43) = 25.16; *p* < .0001]. Correspondingly, the effect of stimulus congruency was comparable in both groups (congruent trials: *M* = 7.49; *SD* = 7.6 and *M* = 14.09; *SD* = 16.3; incongruent trials: *M* = 19.26; *SD* = 13.7 and *M* = 30.31; *SD* = 30.3 for low and high NFC subjects, respectively). This finding was confirmed by non-significant stimulus due to NFC interaction [*F*(1,43) = 0.64, *p* = .429]. We simultaneously noticed that low NFC subjects outperformed