RUNNING HEAD: Response Conflict and Ingroup Bias

Ingroup Categorization and Response Conflict:

Interactive Effects of Target Race, Flanker Compatibility and Infrequency on N2 Amplitude

Cheryl L. Dickter

College of William and Mary

Bruce D. Bartholow

University of Missouri

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Contact information:
Cheryl L. Dickter, Ph.D.
Department of Psychology
College of William and Mary
PO Box 8795
Williamsburg, VA 23187-8795

Ph: 757-221-3722
Email: cldickter@wm.edu

Abstract

Three largely independent lines of research have investigated experimental manipulations that influence the amplitude of the N2 component of the event-related brain potential (ERP): one linking heightened N2 amplitude to response conflict, another showing that N2 is sensitive to stimulus infrequency, and the third showing larger N2 amplitude during categorization of racial ingroup relative to racial outgroup targets. The purpose of this research was to investigate potential interactions between these three features on the amplitude of the N2. ERPs were recorded while participants completed a modified flanker task using pictures of ingroup and outgroup faces. Results showed a 3-way interaction, indicating that the N2 was largest for ingroup targets on high-conflict trials but only when such trials were relatively infrequent. Implications of these findings for theories of both conflict monitoring and person perception are discussed.

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An important function of the information-processing system is to monitor ongoing interactions with the environment for potential conflicts (see Botvinick, Braver, Barch, Carter, & Cohen, 2001; Yeung, Botvinick, & Cohen, 2004). This conflict-monitoring function is essential for regulating many everyday behaviors, but is of particular importance for effective adaptation in complex interpersonal situations. Should I accept my host's gracious offer to eat the last piece of cake, or should I decline it and maintain my diet? Recent investigations into the role of conflict monitoring in expression of racial bias (e.g., Amodio et al., 2004; Payne, 2005) attest to the importance of this phenomenon for regulation of interpersonal processes.

Response conflict occurs whenever a person encounters information that activates multiple, opposing response options. This phenomenon often is studied in the lab using the Eriksen flanker task (e.g., Eriksen & Eriksen, 1974), in which a central target is flanked by peripheral stimuli that activate either the same response as the target (compatible trials) or an opposing response (incompatible trials; e.g., Coles, Gratton, Bashore, Eriksen, & Donchin, 1985; Gratton, Coles, & Donchin, 1992). In such tasks, response time is slowed and error rates are higher on incompatible relative to compatible trials. This "compatibility effect" (Gratton et al., 1992) is thought to occur because the flankers and target activate competing responses on incompatible trials, which increases the probability of incorrect responses and slows correct response output (e.g., Coles et al., 1985).

The neurocognitive mechanisms of response conflict have been investigated in numerous studies with event-related potentials (ERPs). In such studies the amplitude of the N2 or N200 component, a negative-going deflection peaking 200-400ms post-stimulus and typically maximal

at fronto-central scalp locations, is enhanced following incompatible relative to compatible arrays (e.g., Kopp, Rist, & Mattler, 1996; van Veen & Carter, 2002), leading to the conclusion that the N2 reflects the activity of a conflict monitoring mechanism (see Botvinick et al., 2001; Nieuwenhuis, Yeung, Van Den Wildenberg, & Ridderinkhof, 2003; van Veen & Carter, 2002).

However, the N2 is also sensitive to other manipulations not directly associated with competing response activations, such as the relative frequency of particular trial types. For example, Nieuwenhuis et al. (2003) varied the frequency of no-go trials in a response inhibition task and found that N2 amplitude was greater on low-frequency trials, regardless of whether they required response execution or suppression. Similarly, Bartholow et al. (2005) found that even compatible flanker arrays can elicit enhanced conflict – reflected in the correct-response negativity (CRN) – when they are relatively infrequent. Such findings suggest that conflict can occur whenever the response requirement for a given trial is inconsistent with a current response strategy, irrespective of whether stimuli activate opposing responses.

Independent work on social categorization has shown that N2 amplitude is enhanced when stimuli represent a social ingroup of the participants (e.g., a white face for white participants) relative to social outgroups (e.g., Dickter & Bartholow, 2007; Ito & Urland, 2003, 2005; Kubota & Ito, 2007; Willadsen-Jensen & Ito, 2006, 2008). This effect has been interpreted as a manifestation of biased attention to ingroup cues (see Ito & Urland, 2003). However, it remains unclear whether or how this "ingroup categorization" N2 is related to N2s elicited by conflict and stimulus infrequency. To date, no studies have directly investigated the extent to which response conflict, stimulus infrequency and ingroup categorization processes might interact to influence N2 amplitude. To the extent that features of the target stimuli elicit differential implicit attention or modulate the extent to which other early-stage processes are

engaged, as has been posited for ingroup relative to outgroup cues, such an interaction is indeed plausible. Most lab tasks investigating conflict involve stimuli that are devoid of motivational significance. For example, flanker arrays generally consist of strings of letters (e.g., HHSHH) or arrowheads (e.g., >><>>). In the current study, pictures of ingroup (white) and outgroup (black) men's faces served as targets and flankers, and the relative frequency of compatible (target and flankers of the same race) and incompatible arrays (target of one race, flankers of the other) was manipulated (cf., Bartholow & Dickter, 2008; Gratton et al., 1992). To the extent that ingroup targets elicit stronger engagement of the processes underlying the N2 than do outgroup targets, effects of compatibility and infrequency might be stronger for trials with ingroup than outgroup targets.

Three primary predictions were advanced for this study. First, the compatibility effect should increase as a function of the probability of compatible trials, as in previous research (e.g., Bartholow et al., 2005; Gratton et al., 1992). Second, N2 amplitude should be larger for ingroup (white) versus outgroup (black) targets (e.g., Dickter & Bartholow, 2007; Ito & Urland, 2003). Third, however, this effect is predicted to be qualified by a 3-way interaction, such that the N2 is largest for white incompatible trials, but only when compatible trials are highly probable. When incompatible trials are more probable, the N2 should be larger on compatible than incompatible trials, consistent with previous work showing enhanced conflict for stimuli that contradict a current response strategy (cf., Bartholow et al., 2005; Bartholow, Riordan, Saults, & Lust, in press; Nieuwenhuis et al., 2003).

<div align="center">Method</div>

Participants

Eighteen undergraduates (12 female; ages 18-25) with no history of neurological injury or disorder participated for course credit. All participants indicated their racial/ethnic group as white/non-Hispanic, had normal or corrected-to-normal vision, and were predominantly right-handed (Oldfield, 1971).

Stimuli and Experimental Design

Each trial consisted of a 200 ms fixation period followed by a 250 ms stimulus array consisting of three 7cm x 5cm color pictures (black and/or white men's faces wearing neutral expressions) shown side-by-side (separated by 2 cm) in the center of the monitor. Participants categorized the race of the central targets by pressing one of two keys (counterbalanced across participants) as quickly as possible. Trials were separated by a 1000 ms inter-trial interval. Four trial types were used, each presented 180 times (i.e., 720 total trials) across the 12 blocks of the task: black compatible (black target, black flankers), black incompatible (black target, white flankers), white compatible (white target, white flankers), and white incompatible (white target, black flankers). The probability of compatible and incompatible trials was manipulated across blocks (see Gratton et al., 1992), resulting in four blocks each of 80% compatible (expect-compatible; EC), 50% compatible (expect-neutral; EN) and 20% compatible trials (expect-incompatible; EI). Within each compatibility condition, half of the targets were White and half were Black, ensuring an equal number of right-hand and left-hand responses in each block. Block order was randomized for each participant.

Electrophysiological Recording

The electroencephalogram (EEG) was recorded from 9 standard scalp locations (F3, Fz, F4, C3, Cz, C4, P3, Pz, P4) using tin electrodes in an electrode cap (Electrocap International, Eaton, OH). Vertical and horizontal electrooculogram (EOG) was recorded with bipolar

electrodes above and below the left eye and 2 cm from the outer canthus of each eye. Blinks were corrected off-line using a regression-based procedure (Semlitsch, Anderer, Schuster, & Presslich, 1986). Impedance was kept below 8 kΩ. EEG was sampled at 250 Hz using Neuroscan Synamps amplifiers and filtered on-line using a .01 to 40 Hz bandpass. Grand average waveforms were further filtered offline at 12 Hz (lowpass). Inspection of each participants' grand average waveforms showed that the N2 occurred between 220-350ms post-stimulus ($M =$ 280ms). Thus, the N2 was scored as the average (mean) negative voltage within this epoch.

Procedure

Participants were told that the study measured control of attention and facial recognition. After electrodes were placed and tested the experimenter explained the task, and told participants to respond as quickly as possible without sacrificing accuracy. Participants were not given information about how expectancy or compatibility would change between or within blocks. Participants then completed a short practice block of 40 trials (10 of each type) followed by the 12 experimental blocks. The experimenter then removed the electrodes and escorted the participant to a private restroom to clean up. Finally, participants were fully debriefed, thanked, and dismissed.

<div align="center">Results</div>

Behavioral data from 1 participant were discarded because she misunderstood task instructions, leaving the sample for behavioral analyses at 17. Two additional participants' ERP data were discarded due to recording problems, leaving the sample for ERP analyses at 15. Greenhouse-Geisser adjusted *p*-values are reported for all analyses involving multiple numerator degrees of freedom.

Response time data from correct response trials were subjected to a 2 (Target race; black, white) x 2 (Compatibility; compatible, incompatible) x 3 (Expectancy; EC, EN, EI) repeated measures analysis of variance (ANOVA), which showed a significant Compatibility effect, $F(1, 16) = 36.6$, $p < .001$, $\eta^2_p = .70$, and the predicted Compatibility x Expectancy interaction, $F(2, 32) = 23.1$, $p < .001$, $\varepsilon = .94$, $\eta^2_p = .59$ (see Figure 1A). Planned contrasts showed that the compatibility effect was significant in the EC ($M = 30.9$ ms; $t[16] = 8.31$, $p < .001$, $d = 2.01$) and EN conditions ($M = 15.2$ ms; $t[16] = 4.37$, $p < .01$, $d = 1.06$), but not in the EI condition, ($M = 3.5$ ms; $t[16] = 0.96$, $p = .35$, $d = 0.24$). No other effects were significant.

Error rate analyses were based on the arcsine of the square root of errors in each condition. For ease of interpretation, the untransformed data are presented in Figure 1B. A 2 (Target race) x 2 (Compatibility) x 3 (Expectancy) repeated measures ANOVA showed a significant Compatibility effect, $F(1, 16) = 17.65$, $p < .001$, $\eta^2_p = .52$, and the predicted Expectancy x Compatibility interaction, $F(2, 32) = 4.05$, $p < .05$, $\varepsilon = .99$, $\eta^2_p = .20$. Planned contrasts showed that the compatibility effect was significant in the EC ($M = .034$, $t[16] = 3.60$, $p < .01$, $d = 1.80$) and EN conditions ($M = .018$, $t[16] = 3.27$, $p < .01$, $d = 1.64$), but not in the EI condition ($M = .002$; $t[16] = 0.64$, $p > .50$, $d = 0.32$). No other effects were significant.

Figure 2 presents grand average waveforms measured at midline locations as a function of the conditions of the experiment. Initial analyses showed that the N2 was larger at frontal ($M = -2.33$ μV) than at central ($M = -0.92$ μV) or parietal ($M = 1.58$ μV) scalp locations, $F(2, 28) = 24.9$, $p < .001$, $\varepsilon = .66$. Thus, main analyses used data from frontal locations only in a 2 (Target race) x 2 (Compatibility) x 3 (Expectancy) x 3 (Electrode; F3, Fz, F4) repeated measures ANOVA. This analysis showed the predicted main effect of Target race, $F(1, 14) = 20.24$, $p < .001$, $\eta^2_p = .59$. The N2 was larger for white (ingroup) targets ($M = -3.19$ μV) than for black

(outgroup) targets ($M = $ -1.46 µV), as in previous research (e.g., Dickter & Bartholow, 2007; Ito & Urland, 2003). This main effect was qualified by the predicted Target race x Compatibility x Expectancy interaction, $F(2, 28) = 5.28$, $p < .02$, $\varepsilon = .90$, $\eta^2_p = .27$ (see Figure 3). This interaction was decomposed, first, by testing the 2-way Compatibility x Expectancy interaction separately for white target and black target trials. The ANOVA on black target trials showed no significant effects ($Fs < 0.80$, $ps > .40$). In contrast, the ANOVA on white target trials showed a significant Compatibility x Expectancy interaction, $F(2, 28) = 5.99$, $p < .02$ (see Figure 3). Follow-up contrast analyses of the means associated with this interaction showed that the linear Expectancy effect for incompatible trials was significant, $t(14) = $ -2.53, $p < .05$, $d = $ -0.55, indicating that N2 amplitude for incompatible trials decreased along with decreasing probability of compatible trials ($Ms = $ -4.06, -3.09, & -2.55 µV for EC, EN, & EI, respectively). The linear Expectancy effect for compatible trials also was significant, $t(14) = 2.46$, $p < .05$, $d = 0.48$, indicating that N2 amplitude increased significantly as the probability of compatible trials decreased ($Ms = $ -2.36, -3.42, & -3.67 µV for EC, EN, & EI, respectively). Also, the compatibility effect was significant in the EC condition ($M = 1.7$ µV), $t(14) = 3.79$, $p < .01$, was marginally nonsignificant in the EI condition ($M = 1.1$ µV), $t(14) = 1.86$, $p < .07$, and was not significant in the EN condition ($t < 1$). For black targets, the linear Expectancy effects for both compatible ($Ms = $ -1.35, -1.51, & -1.30 µV for EC, EN, & EI, respectively) and incompatible trials ($Ms = $ -1.10, -1.68, & -1.84 µV for EC, EN, & EI, respectively) were nonsignificant ($ts < 1.13$, $ps > .50$), and the compatibility effects were nonsignificant in all expectancy conditions ($ts < 1$). The only other significant effect in the main analysis was a main effect of Electrode, $F(2, 28) = 5.04$, $p < .02$, $\varepsilon = .85$. The N2 was larger at the midline Fz location ($M = $ -2.87) than at the lateral F3 ($M = $ -2.15) and F4 ($M = $ -1.96) locations.

Discussion

Numerous previous studies have established that response conflict (see Botvinick et al., 2001), stimulus or response infrequency (e.g., Nieuwenhuis et al., 2003), and ingroup categorization (e.g., Dickter & Bartholow, 2007; Ito & Urland, 2003) all independently increase the amplitude of the N2 component. The importance of the current work lies in showing that these factors can interact to jointly influence N2 amplitude. Specifically, although the N2 in general was larger to ingroup than outgroup targets, the ingroup N2 was sensitive to both conflict and the probability of conflict. This pattern suggests that the biased processing of ingroup relative to outgroup cues (see Dickter & Bartholow, 2007; Ito & Urland, 2003, 2005) during the stage of processing represented by the N2 is moderated by conflict and frequency information. Moreover, the fact that the N2 was not largest to arrays containing the most ingroup cues (i.e., white compatible) indicates that preferential processing of ingroup information does not simply trump the other processes that affect the N2 response. The current results also extend previous work (e.g., Bartholow et al., 2005; Nieuwenhuis et al., 2003) indicating that task parameters can influence medial-frontal negativity in the ERP independently of whether stimuli elicit conflicting responses.

Perhaps most striking about the current findings is the fact that compatibility and trial type infrequency – factors known to have large effects on the N2 – had no effect when the central targets were black faces. One possible explanation for this finding is that outgroup target faces may capture perceivers' attention early in processing, resulting in less attention being directed to the flanker faces. Recent evidence from a number of sources suggests that white perceivers attend more to black male faces than to white male faces early in processing, as demonstrated by larger P2 amplitude (e.g., Dickter & Bartholow, 2007; Ito & Urland, 2003,

2005) larger amygdala activation to black faces than white faces (e.g., Cunningham et al., 2004), and quicker RTs in a dot-probe task (Trawalter, Todd, Baird, & Richeson, 2008). Thus, at this early processing stage, white perceivers may not be as affected by manipulations to flanker stimuli when the central targets are black faces relative to white faces. However, flanker information might draw attention later in processing, as seen in the current RT results. As mentioned previously, nearly all extant studies of flanker compatibility effects – as well as studies investigating how conflict and infrequency affect the N2 – have used stimuli largely devoid of motivational significance or salience to respondents. The current findings demonstrate that the properties of the stimuli themselves can influence very basic aspects of information processing. Future research should investigate whether similar patterns will emerge with participants representing different ingroups (cf., Dickter & Bartholow, 2007).

The pattern shown in Figure 3 (right panel) is highly similar to that seen in two other, recent investigations (Bartholow et al., 2005; Bartholow et al., in press). Specifically, using a sequential priming task, Bartholow et al. (in press) found that the N2 was larger for prime-incongruent targets when prime-congruent targets were highly probable, but that the N2 was larger for prime-congruent targets when prime-incongruent targets were more probable. Bartholow et al. (2005) found a conceptually similar pattern in the CRN using a flanker task. Together with the current results, these findings suggest that participants use probability information to develop response strategies (see Gratton et al., 1992), and that "conflict" can arise when the current strategy is suboptimal for responding on a given trial.

It perhaps should not be surprising that the current behavioral findings are highly similar to those seen in other flanker tasks using more generic stimulus arrays (e.g., Bartholow et al., 2005; Gratton et al., 1992), given that cognitive control processes involved in social perception

appear to be similar to those used in behavioral regulation more generally (see Amodio et al., 2004; Payne, 2005). However, the fact that behavioral responses were not influenced by target race as was the N2 weakens the possibility that some common factor underlies all three effects. Still, although the Compatibility x Expectancy x Target race interaction was not significant in the behavioral data, examination of the extent to which compatibility effects were moderated by expectancy as a function of target race shows that effects were larger for white target trials in both RT (ds = 1.52 and 1.06 for white targets and black targets, respectively) and error rates (ds = 0.48 and 0.08, respectively), suggesting some differential sensitivity to target race at the behavioral level.

In conclusion, although the current results should be considered preliminary until further investigations can test their generalizability in other participant groups (and with other tasks), this study provides initial evidence that response conflict, stimulus infrequency and ingroup categorization processes can jointly affect the amplitude of the N2 component. This study represents an attempt to bridge heretofore independent areas of inquiry that have been instrumental in mapping the psychological functions subserved by medial frontal negativities in the ERP. Future researchers should use these findings as a foundation for further investigation of potential connections between basic neurocognitive functions and processes associated with social perception.

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Figure Captions

Figure 1. Reaction times (panel A) and error rates (panel B) as a function of expectancy and compatibility conditions. EC = expect compatible (80% compatible trial blocks); EN = expect neutral (50% compatible trial blocks); EI = expect incompatible (20% compatible trial blocks). Vertical bars represent standard errors.

Figure 2. Stimulus-locked ERP waveforms recorded at target onset as a function of expectancy and compatibility conditions for white targets (top panel) and black targets (bottom panel). EC = expect compatible (80% compatible trial blocks); EN = expect neutral (50% compatible trial blocks); EI = expect incompatible (20% compatible trial blocks). Vertical arrows on the timeline indicate stimulus array onset.

Figure 3. Mean N2 amplitude collapsed across the 3 frontal electrode locations (F3, Fz, F4) as a function of target race, expectancy and compatibility conditions. EC = expect compatible (80% compatible trial blocks); EN = expect neutral (50% compatible trial blocks); EI = expect incompatible (20% compatible trial blocks). Vertical bars represent standard errors.