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The Effect of Commitment on Relative Left Frontal Cortical Activity: Tests of the Action-Based Model of Dissonance

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Abstract

The action-based model of dissonance and recent advances in neuroscience suggest that commitment to action should cause greater relative left frontal cortical activity. Two experiments were conducted in which electroencephalographic activity was recorded following commitment to action, operationalized with a perceived choice manipulation. Perceived high as compared to low choice to engage in the action, regardless of whether it was counterattitudinal or proattitudinal, caused greater relative left frontal cortical activity. Moreover, perceived high as compared to low choice caused attitudes to be more consistent with the action. These results broaden the theoretical reach of the action-based model by suggesting that similar neural and motivational processes are involved in attitudinal responses to counterattitudinal and proattitudinal commitments.

Keywords

cognitive dissonance, action-based model, commitment, asymmetrical frontal cortical activity

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The action-based model of dissonance was proposed to specify why cognitive discrepancy causes the negative emotive state of dissonance and why individuals are motivated to reduce dissonance and discrepancy (Harmon-Jones, 1999; Harmon-Jones, Amodio, & Harmon-Jones, 2009). According to the model, cognitive discrepancy evokes a negative emotive state because important cognitive discrepancies have the potential to interfere with effective action. The negative emotive state motivates the individual to resolve the discrepancy so that effective action can occur. The model proposes that this negative emotive state involves approach motivation following the arousal of dissonance via commitment to a chosen course of action. In support, research has revealed that neural activity indicative of increased approach motivation occurs following the arousal of dissonance via commitment to a chosen course of action (Harmon-Jones, Gerdjikov, & Harmon-Jones, 2008). Moreover, enhancement of approach motivation facilitates dissonance reduction (Harmon-Jones & Harmon-Jones, 2002; Harmon-Jones, Harmon-Jones, Fearn, Sigelman, & Johnson, 2008). The present research was designed to extend past work by (a) assessing whether this same pattern of approach–motivation–related neural activity would occur in a more "pure" dissonance situation, (b) assessing whether commitment to a chosen course of action even in a situation that did not arouse dissonance would cause the same pattern of neural activity, and (c) assessing how this latter type of commitment would influence attitude processes. The latter two aims are particularly important as they would suggest that the action-based model applies to a much broader set of concerns than those with which dissonance theory has been concerned.

Overview of Cognitive Dissonance Theory

The original theory of dissonance (Festinger, 1957) posited that inconsistency among important elements of knowledge (cognitions) creates dissonance, an unpleasant emotional-motivational state. This state was posited to cause organisms to do cognitive work in an attempt to reduce the dissonance. We use the terms *dissonance* or *dissonance arousal* to describe the emotive state and the term *cognitive discrepancy* to describe the inconsistency between cognitions. When dissonance is evoked, and organisms reduce it by changing their cognitions, we refer to the process as *discrepancy reduction*. When the negative emotional-motivational

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state is successfully eliminated or reduced, we call this *dissonance reduction*.

Much research has supported the original theory of dissonance (Harmon-Jones, Brehm, Greenberg, Simon, & Nelson, 1996; Harmon-Jones & Mills, 1999; Simon, Greenberg, & Brehm, 1995). The action-based model was proposed to more clearly specify why cognitive discrepancy causes the negative emotive state of dissonance and why individuals are motivated to reduce dissonance and discrepancy (Harmon-Jones, 1999).

Action-Based Model of Dissonance

The action-based model of dissonance begins with the assumption that perceptions and cognitions can serve as action tendencies (i.e., knowledge implies certain ways of behaving). Discrepancy between cognitions evokes dissonance because discrepancy has the potential to interfere with effective and unconflicted action. Discrepancy reduction brings cognitions into consonance and thus facilitates the execution of effective and unconflicted action (see also Gerard, 1965; Jones & Gerard, 1967).

The action-based model is consistent with the ideas of Brehm and Cohen (1962) in that it posits that behavioral commitment provides the base around which dissonance reduction occurs. Brehm and Cohen defined commitment by writing that "a person is committed when he has decided to do or not do a certain thing, when he has chosen one (or more) alternatives and thereby rejected one (or more) alternatives . . . it [commitment] generally provides a clear specification of psychological implication" (p. 7). Kiesler (1971) defined commitment similarly, by writing that "it is the pledging or binding of the individual to behavioral acts" (p. 30). Consistent with this definition, commitment is often operationalized by manipulating perceived choice (Brehm & Cohen, 1962; Kiesler, 1971). According to Brehm and Cohen (see also Beauvois & Joule, 1996, 1999), most dissonance situations can be evaluated as decision situations. Once the individual decides on a course of action or makes a behavioral commitment, he or she enhances the value of the chosen course of action and reduces the value of the rejected course of action.

The action-based model proposes that after a decision (commitment) is made, the processing that occurs should assist with the execution of the decision. Viewing the chosen course of action more positively (or less negatively) after a decision (i.e., attitude change) should help the individual follow through and act on the decision in a more effective manner.

State Action Orientation and Spreading of Alternatives

The action-based model proposes that the postdecisional state is similar to the action-oriented state (Gollwitzer, 1990; Heckhausen, 1986; Kuhl, 1984). When a person is in an action-oriented state or a mode of "getting things done," the person is more able to implement decisions. Consistent with these ideas, Harmon-Jones and Harmon-Jones (2002) found that experimentally manipulating the degree of action orientation experienced following a decision influenced the degree of discrepancy reduction. In one experiment, participants made either an easy decision or a difficult decision (i.e., which physical exercise to perform later in the session). Participants completed a mind-set questionnaire after the decision. The neutral mind-set questionnaire asked participants to list seven things they did in a typical day, whereas the action-oriented (or implemental) mind-set questionnaire asked participants to list seven things they could do to perform well on the exercise they had chosen. Participants then reevaluated the exercises. Participants in the difficult-decision, action-oriented condition demonstrated a greater increase in preference for the chosen over the rejected exercise (spreading of alternatives) than did participants in the other three conditions (difficult decision/neutral mind-set, easy decision/neutral mind-set, easy decision/action-oriented mind-set). A second experiment by Harmon-Jones and Harmon-Jones replicated these results using a different, more general manipulation of action orientation (Gollwitzer & Bayer, 1999). Additional research with individual differences in action orientation is consistent with these results (Beckmann & Kuhl, 1984).

Research using individual differences further supports the idea that dissonance reduction is an approach-related process, which we view as similar to an action orientation (Harmon-Jones, Schmeichel, Inzlicht, & Harmon-Jones, 2011). In this research, trait approach motivation, measured using Carver and White's (1994) Behavioral Inhibition Sensitivity/Behavioral Activation Sensitivity scale, related to postdecisional spreading of alternatives, and attitude change in an induced compliance paradigm.

Dissonance and Neural Activity

The previous experiments provided support for the action-based model of dissonance and cannot be interpreted by other revisions of dissonance theory (Harmon-Jones et al., 2009; Harmon-Jones & Harmon-Jones, 2002). The action-based model goes further to suggest neural circuits involved in dissonance processes. When dissonance is aroused, it evokes increased sympathetic nervous activity as measured by increased skin conductance (Croyle & Cooper, 1983; Elkin & Leippe, 1986; Harmon-Jones et al., 1996). Neurally, dissonance should evoke activity in the anterior circulate cortex, a structure that has been found to be involved in the detection of cognitive conflict. Research has suggested that activity in the anterior cingulate cortex is involved in detecting response conflict (e.g., Carter et al., 1998; Gehring, Goss, Coles, Meyer, & Donchin, 1993). Increased anterior cingulate cortex activity also occurs when behavior conflicts with the self-concept (Amodio, Devine, & Harmon-Jones, 2008; Amodio et al., 2004). These results suggest that higher level conflicts, the type with which dissonance research has been most concerned, also activate the anterior cingulate cortex. van Veen, Krug, Schooler, and Carter (2009) found that dissonance aroused in an induced compliance paradigm activated the dorsal anterior cingulate cortex.

Processes that occur to assist in translating the intention into effective action, such as discrepancy reduction, involve approach motivation, a basic impetus to move toward a stimulus, involved in conscious, goal-directed activities as well as low-level basic urges. This increase in approach motivation should activate the dorsolateral left frontal cortex, a region important for intention, self-regulation, and planning—functions involved in approach motivation and action-oriented processing (Knight & Grabowecky, 1995; Kuhl, 2000; Petrides & Milner, 1982). Persons with damage to this region are apathetic, experience less interest and pleasure, have difficulty initiating actions, and are more likely to be depressed (Robinson & Downhill, 1995). Research assessing electroencephalographic (EEG) activity has found that increased left frontal cortical activation relates to state and trait tendencies toward approach motivation (Harmon-Jones & Allen, 1997, 1998; Sobotka, Davidson, & Senulis, 1992), independent of the valence—positivity or negativity—of the approach motivation (Harmon-Jones, 2003; Harmon-Jones & Allen, 1998; Harmon-Jones, Gable, & Peterson, 2010; Harmon-Jones, Segelman, Bohlig, & Harmon-Jones, 2003; Haromn-Jones, Vaughn-Scott, Mohr, Sigelman, & Harmon-Jones, 2004). Moreover, increased left frontal activation relates to trait repression (Tomarken & Davidson, 1994). High trait repression has been linked to an increased likelihood of spontaneously reducing dissonance (Olson & Zanna, 1979) and may be linked to a tendency to engage in positive illusory thinking (Taylor & Brown, 1988), which may be associated with approach motivational tendencies (Gollwitzer & Kinney, 1989; Taylor & Gollwitzer, 1990). Thus, if commitment to a course of action engages approach-related action-oriented processing, then greater left than right frontal cortical activation should occur.

Effect of Commitment on Relative Left Frontal Cortical Activity

Support for the prediction that commitment to a chosen course of action increases relative left frontal cortical activity was reported in Harmon-Jones, Gerdjikov, et al. (2008). In this induced compliance experiment, participants were randomly assigned low versus high choice to write a counterattitudinal essay (increase tuition at their university). Immediately after starting to write, EEG activity was recorded. After essay completion, attitudes were assessed. Participants in the high-choice condition evidenced greater relative left frontal activation than individuals in the low-choice condition. Moreover, commitment to write the counterattitudinal essay (high choice) caused attitudes to be more consistent with the behavior, as compared to a low-commitment (low-choice) condition. Because this experiment was the first demonstration of the effect of decisional commitment on relative left frontal activity, we thought it was important to replicate.

Although the design of Harmon-Jones, Gerdjikov, et al. (2008) was similar to the vast majority of past induced compliance experiments in which participants engaged in counterattitudinal behavior that produced aversive consequences, one could question whether the behavioral commitment or the production of aversive consequences caused the greater relative left frontal cortical activation. One way to test this alternative explanation is to use a more "pure" induced compliance paradigm in which participants do not produce aversive consequences (Harmon-Jones, 2000; Harmon-Jones et al., 1996). Such an approach has been created and found to cause individuals given high choice (compared to low choice) to engage in counterattitudinal behavior to feel more negative affect, evidence greater skin conductance, and change their attitudes to be more consistent with their behavior (Harmon-Jones, 2000; Harmon-Jones et al., 1996).

In the present research, we also sought to test the generality of the effect by examining whether a commitment without actual writing behavior was sufficient to activate left frontal activity. Past dissonance research has found that attitude change (Beauvois & Joule, 1996; Rabbie, Brehm, & Cohen, 1959) and increased negative affect (Elliot & Devine, 1994) occur even when individuals have only made a commitment to engage in a counterattitudinal behavior but have not engaged in the behavior itself. In the past experiment, participants' brain activation was measured during their writing of the counterattitudinal essay. In the present Experiment 1, we measured brain activation immediately after commitment and before writing behavior to test the generality of the effect.

Another purpose of Experiment 1 was to test whether commitment to any kind of action would produce the relative left frontal cortical activation or whether a commitment to a counterattitudinal action is required. Addressing this issue will assist in determining whether relative left frontal cortical activation reflects dissonance arousal or processes involved in discrepancy reduction (and other commitment-bolstering activities). If it reflects dissonance arousal, we would expect only the high-choice/counterattitudinal condition to cause increased relative left frontal activation. This prediction is derived from past research that found that high-choice/proattitudinal conditions did not evoke increased arousal, whereas high-choice/counterattitudinal conditions did (e.g., Croyle & Cooper, 1983). On the other hand, if relative left frontal activation reflects commitment-bolstering processes, we would expect both high-choice conditions (counter- and proattitudinal) to cause increased relative left frontal activation.

The predicted increase in relative frontal cortical activity is posited to reflect the approach motivation engaged by commitment to action. Indeed, past research has suggested that commitment to proattitudinal action may cause approach-motivational effects similar to processes involved in discrepancy reduction. Janis and Mann (1977) suggested that "commitment can be said to result in increased motivation to adhere to a decision" (p. 298). In addition, behavioral commitment to a proattitudinal position causes individuals to show increased resistance to persuasion attempts that would change their original attitude (Kiesler, 1971). We suggest that the emotive-cognitive processes involved in resisting persuasion following proattitudinal commitment are similar to the emotive-cognitive processes involved in reducing a cognitive discrepancy following a dissonance manipulation and, as such, may cause enhanced resistance to persuasion. Based on Kiesler's (1971) research, we predict that proattitudinal commitments may not cause attitude change but they may increase attitude strength as measured in other ways (enhanced resistance to persuasion).

If commitment to a course of action increases relative left frontal activity, this would extend the scope of the action-based model beyond dissonance theory. This result would suggest that counterattitudinal and proattitudinal commitments exert some similar effects on motivational processes. It would also suggest that commitment alone is sufficient to evoke approach motivation, without the need for cognitive discrepancy.

Experiment 1

Method

Under the guise of a memory study, students read a boring passage and then were given low or high choice to write a sentence saying that the passage was interesting. An additional condition gave participants high choice to write that the passage was boring. EEG was collected immediately after commitment and before writing began. Then, attitudes toward the passage were collected. We predicted that high choice, regardless of whether it was associated with counterattitudinal or proattitudinal behavior, would evoke greater relative left frontal activity than low choice.

Procedure

Thirty-six right-handed (score ≤17 on the Chapman & Chapman, 1987, handedness questionnaire) introductory psychology students participated in exchange for extra credit in their course. They reported no history of psychiatric disorder, neurologic disorder, or brain trauma. Only right-handed participants participated because research suggests that handedness influences hemispheric specialization of function (Heller & Levy, 1981).[1]

Participants were run individually. After greeting the participants, the experimenter explained that she was interested in factors that affect the recall of characteristics of stimuli and that at this point in her research she was seeing how writing sentences evaluating stimuli would affect recall of the details of the stimuli. She also indicated that the research was interested in the neural processes involved in memory and that brain waves would be recorded. She told participants that she would have them read a passage and would ask them to recall information from the passage. She informed participants that she was using a variety of passages, that she would not know which type of passage they would receive, and that they should not let her know which type of passage they did receive. After participants provided informed consent, they were prepared for the EEG. The experiment allowed participants time to become familiar with the recording equipment. No mention of electricity was made throughout the study. These precautions were taken to minimize tension due to physiological measurement (see Harmon-Jones et al., 1996, for a discussion).

After the experimenter attached all necessary sensors (which took about an hour), the experimenter gave participants a written introduction that reiterated her oral introduction. The introduction ended with instructions that assured participants of their anonymity.

The boring passage. All materials were placed in the participant's room before the beginning of the session so that the experimenter would not have to enter the participant's room after the session began. Communication between the experimenter and participant occurred via intercom. The materials were in numbered envelopes. After the participant read the introduction, the experimenter told the participant to open an envelope that contained a passage. Every participant received the same passage, which was a boring description of a tachistoscope taken from an equipment manual (see Harmon-Jones et al., 1996). Participants took approximately 10 min to read this passage.

Choice manipulation. Choice was manipulated as in past induced compliance research (Croyle & Cooper, 1983; Elkin & Leippe, 1986; Elliot & Devine, 1994; Scheier & Carver, 1980). Once the participant had read the passage, the experimenter told the participant to open the second envelope, which contained a set of instructions and a blank sheet of paper. The written instructions were used to induce the choice manipulation, to keep the experimenter unaware of the choice condition to which participants were assigned. The instructions for both low- and high-choice conditions began with a paragraph that reiterated the purpose of the study.

In the *low-choice/counterattitudinal condition*, instructions indicated that participants were randomly assigned to write that the passage they read was interesting. In the *high-choice/counterattitudinal condition*, instructions indicated that participants were to choose whether to write that the passage was interesting or uninteresting but that the experiment needed more individuals to write that the passage was interesting. In the *high-choice/proattitudinal condition*, instructions indicated that participants were to choose whether to write that the passage was interesting or uninteresting but that the experiment needed more individuals to write that the passage was uninteresting. Participants were asked to write only one sentence because past research has revealed short statements to cause greater dissonance than long statements (Beauvois & Joule, 1996). Participants were instructed to discard their statements in the trash once they had written them. For more details, see Harmon-Jones et al. (1996).

Immediately after participants indicated that they were finished reading the instructions and before they started writing, the experimenter told them to look straight ahead for 1 min while their brain waves were recorded. After the recording, participants wrote the statement.

Attitude questionnaire. Next, participants completed a questionnaire that assessed how interesting they found the passage. Prior to opening the envelope, participants were told that the envelope contained a questionnaire that assessed what they thought about the passage. The experimenter explained that this assessment was needed to see how it affected recall, and the experimenter told participants to return the questionnaire to the envelope when finished. Written instructions at the top of the questionnaire reiterated the experimenter's instructions and ended with the statement, "Please answer the following question by circling the number of the scale that best describes your feeling." Responses to the question "How interesting is the passage you read?" were made on a 7-point scale (1 = *not at all interesting,* 7 = *extremely interesting*).

Perceived choice questionnaire. After participants finished with the questionnaire and placed it in the envelope, the experimenter asked participants to complete another questionnaire. The questionnaire assessed how much choice the participant had over the position taken in the sentence that was written. Responses to this question were made on a 7-point scale (1 = *no choice at all*, 7 = *very much of a choice*). Once all participants completed this questionnaire, they were debriefed. In debriefing, no participants thought that the experimenter would retrieve from the trash the statements they had written.

EEG Recording and Processing

EEG was assessed for 1 min following the choice manipulation, as past research has revealed that the commitment alone (and not the complete essay writing) is sufficient to evoke dissonance (e.g., Beauvois & Joule, 1996; Rabbie et al., 1959). Electrodes mounted in a stretch-Lycra electrode cap (Electro-Cap, Eaton, OH) were placed on the participant's head. Electro-Gel (Eaton, OH) was used as the conducting medium. EEG was recorded from 27 (22 homologous and 5 midline) sites, specifically, the frontal, central, temporal, parietal, and occipital regions of the brain (and regions in between), using the 10% electrode system (Chatrian, Lettich, & Nelson, 1985). A ground electrode was mounted in the cap on the midline between the frontal pole and the frontal site. The reference electrode was placed on the left earlobe, and data were acquired from an electrode placed on the right earlobe, so that an off-line digitally derived, averaged ears' reference could be computed. Vertical eye movements (EOG) were recorded from the supra- and suborbit of the left eye to facilitate artifact scoring of the EEG. All electrode impedances were under 5,000 ohms, and homologous sites (e.g., F3 and F4) were within 1,000 ohms of each other.

EEG and EOG were amplified with Neuroscan Synamps (Herndon, VA), bandpass filtered (0.1 to 100 Hz; 60 Hz notch filter enabled), and digitized at 500 Hz. Before running each participant, to assess the technical integrity of the recording system, 400 microvolts 20 Hz sine-wave calibration signals were inspected.

The EEG and EOG signals were visually scored on a computer monitor, and portions of the data that contained eye movements, muscle movements, or other sources of artifact were removed. Derived averaged-ears reference was used for further data reduction. All artifact-free epochs that were 2.048 s in duration were extracted through a Hamming window.[2] Contiguous epochs were overlapped by 75%, to minimize loss of data due to Hamming window extraction. A fast Fourier transform (FFT) was used to calculate the power spectra. Total power within the alpha (8-13 Hz) frequency range was obtained. Lateral frontal (F7, F8), midfrontal (F3, F4), and parietal (P3, P4) asymmetry indexes (natural log right minus natural log left alpha power) were computed. For comparison purposes, asymmetry indexes for the other sites (Fp1/2, Ft7/8, Fc3/4, T3/4, T5/6, C3/4, Cp3/4, P3/4, O1/2) were also computed. Because alpha power is inversely related to cortical activity (Cook, O'Hara, Uijtdehaage, Mandelkern, & Leuchter, 1998; Davidson, Chapman, Chapman, & Henriques, 1990), higher scores on the indexes indicate *greater relative left hemisphere activity*. This is the preferred index in research on asymmetric frontal cortical activity and motivation (Allen, Coan, & Nazarian, 2004). For the essay, all participants had greater than 10 artifact-free seconds (as recommended by Davidson, Ekman, Saron, Senulis, & Friesen, 1990).[3] Because past research has revealed slightly stronger effects for lateral frontal than midfrontal sites during approach motivational states (Harmon-Jones & Sigelman, 2001) and because conflict reduction has been found to involve the left dorsolateral frontal cortex (MacDonald, Cohen, Stenger, & Carter, 2000), our primary predictions concerned lateral frontal sites.

Results and Discussion

Attitude. To assess whether condition had an effect on attitude, we performed a one-way ANOVA. A significant main effect of condition resulted, $F(2, 33) = 8.03, p < .002$. It indicated that participants in the high-choice/counterattitudinal condition expressed more positive attitudes ($M = 2.58$, $SD = 1.24$) than did participants in the low-choice/counterattitudinal condition ($M = 1.58$, $SD = 1.00$) and high-choice/proattitudinal condition ($M = 1.08$, $SD = 0.29$), ps < .01. The fact that the latter two conditions did not differ is expected based on Kiesler's (1971) extensive research that showed that proattitudinal commitments do not cause attitude change in such situations.

Relative left frontal cortical activity. To test the hypothesis that high choice would produce increased relative left frontal cortical activity, we performed a one-way ANOVA on the lateral frontal asymmetry index. It was significant, $F(2, 31) = 3.78$, $p < .04$, and revealed that the two high-choice conditions differed from the low-choice/counterattitudinal condition, ps < .03 (see Figure 1).[4] These results support the hypothesis that commitment to a course of action would increase relative left frontal activity. They also reveal that the increase in left frontal activity is not due to dissonance arousal, as the effect did not occur only in the high-choice/counterattitudinal condition. Instead, the increase in left frontal activity is the result of commitment to a chosen course of action, regardless of whether the action is counterattitudinal or proattitudinal.

To examine whether these effects were specific to the frontal regions as predicted, we performed ANOVAs on all other asymmetry indexes. None were significant, ps > .10.

Statistical mediation. Statistical mediation is said to occur when (a) the independent variable (choice) significantly affects the mediator (relative left frontal activity), (b) the independent variable (choice) significantly affects the dependent variable (attitude) in the absence of the mediator, (c) the mediator has a significant unique effect on the dependent variable, and (d) the effect of the independent variable on the dependent variable shrinks upon the addition of the mediator to the model. The above requirements were tested for the counterattitudinal conditions only because significant attitude differences typically occur in these conditions. We excluded the proattitudinal condition from the mediation analyses because the attitude measure used in the present experiment did not capture the cognitive processes that typically occur following proattitudinal commitment (Kiesler, 1971, found that resistance to persuasion, rather than attitude change, typically occurred in the proattitudinal condition). In the two counterattitudinal conditions, the effect of choice on relative left frontal activity, $F(1, 21) = 6.40$, $p = .02$, and attitude, $F(1, 22) = 4.74$, $p = .04$, were significant. When relative left frontal activity was entered as a covariate in the choice on attitude ANOVA, the effect of choice on attitude was no longer significant, $F(1, 20) = 2.17$, $p = .16$ (similar results emerged using regression). Finally, a Sobel (1982) test was performed to assess whether full mediation occurred. The test was significant, $z = 2.01$, $p = .04$, suggesting that full statistical mediation occurred.

Manipulation check. Perceived choice differed as a function of condition, $F(2, 33) = 29.93$, $p < .001$. Participants in

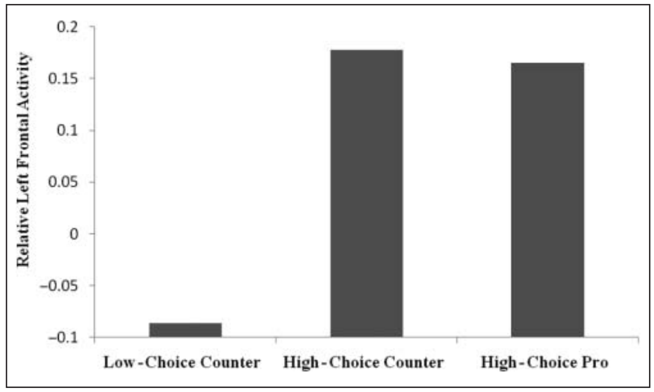


Figure 1. Relative left frontal cortical activity as a function of choice condition, Experiment 1

each high-choice condition perceived more choice than did participants in the low-choice condition ($M = 1.25$, $SD = 0.45$), ps < .03. Reflective of the idea that individuals feel more freedom to engage in proattitudinal rather than counterattitudinal acts, participants in the high-choice/proattitudinal condition perceived more choice ($M = 5.33$, $SD = 1.87$) than did participants in the high-choice/counterattitudinal condition ($M = 2.50$, $SD = 1.24$), $p < .01$.

Ancillary analyses. To assess whether the differences obtained between the choice conditions were the result of differences in the counterattitudinal sentences written, two independent judges unaware of condition rated on a 5-point scale how convincing they found the sentences (1 = *not at all*, 5 = *very*). The judges' ratings were significantly correlated, $r = .88$, $p < .001$, indicating high reliability. High- and low-choice conditions did not differ in how convincing the sentences were or in sentence length ($t < 1.0$), suggesting that the differences observed on attitude and relative left frontal activity were not due to differences in the strength or length of the counterattitudinal statements.

Experiment 2

Experiment 1 revealed that commitment to a chosen behavior, regardless of whether it is counterattitudinal or proattitudinal, causes greater relative left frontal cortical activation. These results support the prediction derived from the action-based model and extend this model beyond dissonance theory by suggesting that counterattitudinal and proattitudinal commitments exert some similar effects on motivational and attitudinal processes. The results also address a debate between Kiesler (1968) and Gerard (1968), who argued over whether commitment itself was motivating. Kiesler said no, and Gerard said yes. The current evidence favors Gerard.

To induce high choice in Experiment 1, participants were told they could choose what to write but then they were encouraged to write a certain statement (as has been done in most induced compliance research). This may have induced a sense of confusion or conflict, and the conditions differ on more dimensions than choice. Although the choice conditions differ, we are not aware of a mechanism by which confusion would cause the observed results.

Although Experiment 1 provided support for the hypothesis, we thought it important to conceptually replicate the effect of proattitudinal commitment on approach-motivated neural activity, because of the novelty of the effect. Moreover, conducting a second experiment gave us an opportunity to test whether having high choice to engage in proattitudinal behavior would influence cognitive processes involved in enhancing the behavioral commitment. As Kiesler (1971) summarized, proattitudinal commitments rarely cause attitude change but instead cause resistance to attempts to change one's attitude. As Kiesler stated,

> If, however, the behavioral act is consistent with one's current views, the commitment should have no (necessary) immediate effect upon belief but should produce greater resistance to change if the belief (and by implication, the act) should come under subsequent attack. (p. 32)

In our view, proattitudinal commitments may strengthen attitudes on some measures but not others.

Experiment 2 also allowed us to test the generality of the effect observed in Experiment 1 by using a different attitude object, different attitudinal reaction, and different control condition. Instead of using attitudes about boring passages, Experiment 2 used attitudes toward a positive object, chocolate. Instead of measuring attitude following a proattitudinal statement, Experiment 2 measured resistance to persuasion. That is, following the proattitudinal commitment, participants were exposed to a persuasive essay and then their resistance to persuasion was measured with a self-reported attitude measurement.

In addition to measuring attitudes with self-reports, Experiment 2 provided a preliminary test of the effect of these manipulations on electrophysiological reactions to attitude relevant and irrelevant stimuli. Much research has indicated that stimuli rated high in valence cause large late positive brain potentials over central brain regions (Foti, Hajcak, & Dien, 2009; Hajcak, Dunning, & Foti, 2007). In the present experiment, we used attitudes toward chocolate because they are positive among large portions of individuals. Based on our conceptual ideas and past research, we expected that to the extent the commitment caused strong resistance to change to a persuasive communication, individuals' strong positive attitudes would be reflected in greater late positive potentials to attitude-relevant stimuli. In other words, individuals who show strong commitment effects, as measured by relative left frontal activation, should maintain strong positive attitudes toward chocolate and show larger late positive potentials to chocolate stimuli. In contrast, individuals who do not show strong commitment effects (in the high-choice condition) should not show larger later positive potentials to chocolate stimuli. These considerations lead to an interaction between the choice manipulation and relative left frontal activation following commitment that reveals the following: *Within the high-choice condition*, greater relative left frontal activation should correlate with greater late positive potentials to chocolate stimuli; this correlation should not occur in the low-choice condition. To control for individual differences in electrophysiological responses to pictorial stimuli, neutral stimuli were included.

Finally, instead of comparing the high-choice proattitudinal condition against a low-choice counterattitudinal condition, Experiment 2 compared the high-choice proattitudinal condition against a low-choice proattitudinal condition, further testing the generality of the effects observed in Experiment 1.

Method

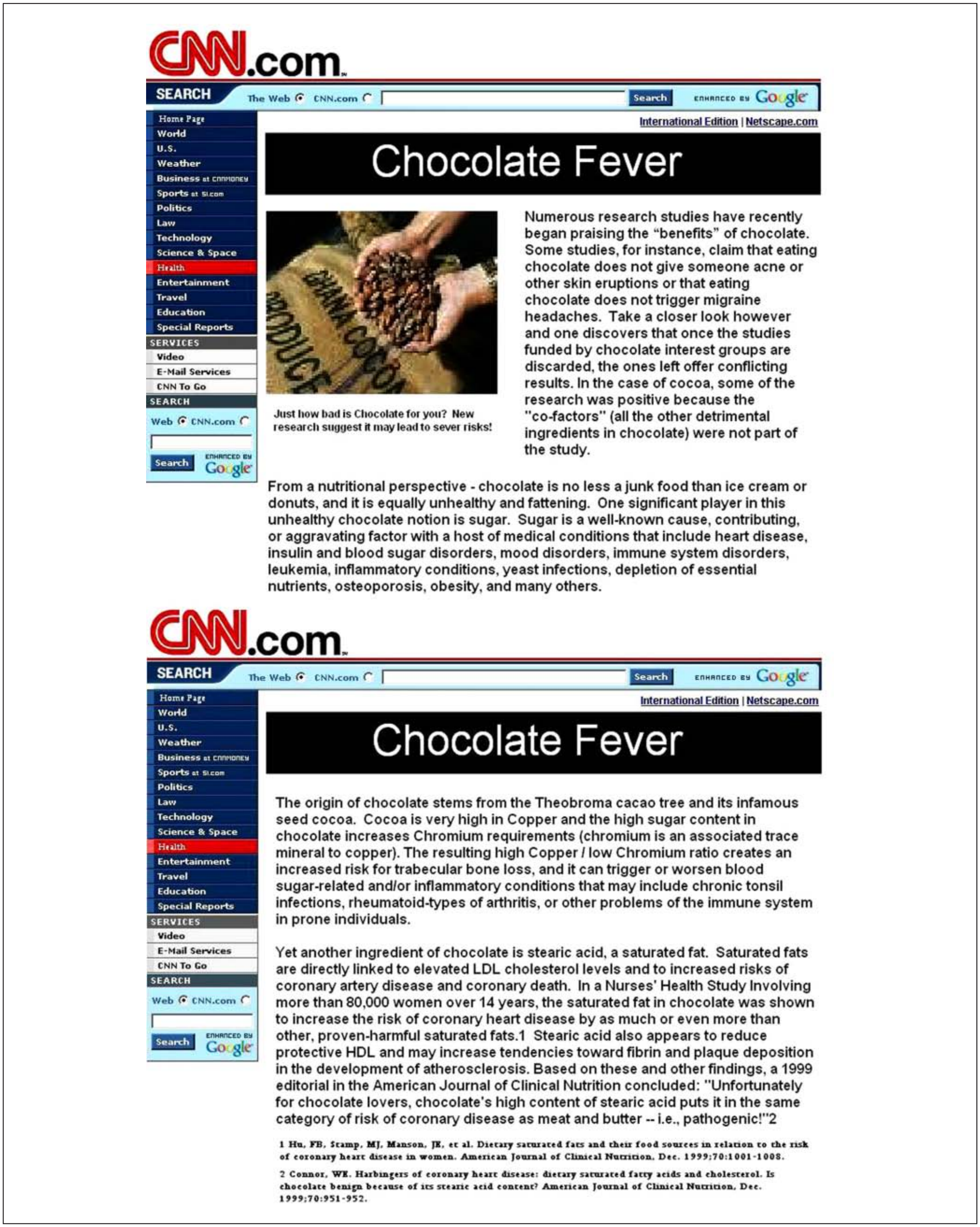
Under the guise of a study on cognition and emotion, university students were given low or high choice to write a sentence saying that they liked chocolate. Immediately after the choice manipulation and before writing, EEG was collected. Then, participants wrote the sentence and were exposed to a persuasive message indicating the harms of chocolate. Next, participants reported attitudes toward chocolate, and then they viewed pictures of chocolate and neutral stimuli while EEG was recorded. We predicted that as compared to low choice, high choice would evoke greater relative left frontal activity and more maintenance of positive attitudes toward chocolate.

Participants. Forty right-handed introductory psychology students (18 female) participated in exchange for course credit. Only participants who responded *yes* to the question, "Do you like chocolate?" during a prescreening session were invited to participate. Four participants were excluded because of participant noncompliance with procedures. One additional participant was excluded from EEG analysis because of equipment failure during recording.

Procedures. After signing a consent form, participants were told that the study was interested in cognition, emotion, and perception. After the EEG attachment, the experimenter entered an adjacent room and gave directions via the computer screen and an intercom.

Participants were told that the next part of the study examined how writing different statements expressing different opinions would affect perceptions of pictures. They were then given low choice or high choice to type a sentence saying they liked chocolate, using instructions similar to those used in Experiment 1 and in Harmon-Jones et al. (1996).

Following the choice manipulation instructions, but before the typing of the sentence, EEG was assessed for 1 min. Once EEG was assessed, participants typed the actual statement and then were presented with the persuasive article. It was an essay purportedly from CNN.com that described health risks of chocolate (see Figure 2). The essay was from



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Chocolate Fever

Just how bad is Chocolate for you? New research suggest it may lead to sever risks!

Numerous research studies have recently began praising the "benefits" of chocolate. Some studies, for instance, claim that eating chocolate does not give someone acne or other skin eruptions or that eating chocolate does not trigger migraine headaches. Take a closer look however and one discovers that once the studies funded by chocolate interest groups are discarded, the ones left offer conflicting results. In the case of cocoa, some of the research was positive because the "co-factors" (all the other detrimental ingredients in chocolate) were not part of the study.

From a nutritional perspective - chocolate is no less a junk food than ice cream or donuts, and it is equally unhealthy and fattening. One significant player in this unhealthy chocolate notion is sugar. Sugar is a well-known cause, contributing, or aggravating factor with a host of medical conditions that include heart disease, insulin and blood sugar disorders, mood disorders, immune system disorders, leukemia, inflammatory conditions, yeast infections, depletion of essential nutrients, osteoporosis, obesity, and many others.

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Chocolate Fever

The origin of chocolate stems from the Theobroma cacao tree and its infamous seed cocoa. Cocoa is very high in Copper and the high sugar content in chocolate increases Chromium requirements (chromium is an associated trace mineral to copper). The resulting high Copper / low Chromium ratio creates an increased risk for trabecular bone loss, and it can trigger or worsen blood sugar-related and/or inflammatory conditions that may include chronic tonsil infections, rheumatoid-types of arthritis, or other problems of the immune system in prone individuals.

Yet another ingredient of chocolate is stearic acid, a saturated fat. Saturated fats are directly linked to elevated LDL cholesterol levels and to increased risks of coronary artery disease and coronary death. In a Nurses' Health Study Involving more than 80,000 women over 14 years, the saturated fat in chocolate was shown to increase the risk of coronary heart disease by as much or even more than other, proven-harmful saturated fats.1 Stearic acid also appears to reduce protective HDL and may increase tendencies toward fibrin and plaque deposition in the development of atherosclerosis. Based on these and other findings, a 1999 editorial in the American Journal of Clinical Nutrition concluded: "Unfortunately for chocolate lovers, chocolate's high content of stearic acid puts it in the same category of risk of coronary disease as meat and butter -- i.e., pathogenic!"2

1 Hu, FB, Stamp, MJ, Manson, JE, et al. Dietary saturated fats and their food sources in relation to the risk of coronary heart disease in women. American Journal of Clinical Nutrition, Dec. 1999;70:1001-1008.

2 Connor, WE. Harbingers of coronary heart disease: dietary saturated fatty acids and cholesterol. Is chocolate benign because of its stearic acid content? American Journal of Clinical Nutrition, Dec. 1999;70:951-952.

Figure 2. Persuasive message used in Experiment 2

various online health articles concerning chocolate, and it was designed to persuade participants to change their attitudes about chocolate. After reading the article, participants rated the statements "I really enjoy chocolate" and "I really enjoy rocks" on 9-point scales (1 = *strongly disagree*, 9 = *strongly agree*). The statement about chocolate was designed to measure explicit attitudes toward chocolate, and the statement about rocks was designed to measure attitudes toward a neutral object, rocks, that would be included in the picture viewing session (described below). Next, participants responded to a manipulation check question that asked: "How much choice do you feel you had over which position you took in the sentence you wrote" (1 = *no choice at all*, 9 = *very much of a choice*).

Following the completion of the questionnaire, participants viewed 20 neutral (rocks) and 20 chocolate pictures presented in a random order. Rocks were used as the neutral stimuli because they were easily matched to chocolate stimuli on size, shape, and color. Each picture was presented for 5,200 ms and was preceded by a 3,000-ms presentation of a fixation cross. Intertrial intervals varied between 4,500 ms and 6,500 ms. EEG was continuously recorded during picture viewing. Upon completion of the picture segment, EEG sensors were removed and participants were debriefed.

EEG recording and processing. EEG was recorded in a manner similar to that used in Experiment 1 with the following exceptions. An additional 32 sensors were used to record EEG, thus providing greater coverage of the brain. Because of the greater coverage, data were re-referenced to whole head average. Also because of the inclusion of more sensors, we were able to include more sites in our assessment of lateral frontal activity; we used an average of sites F8/F7, F6/F5, and AF4/3.

To examine the late positive potential component of ERP, we used artifact-corrected and whole-head-referenced data (see above). Then, we low-pass filtered at 35 Hz and epoched from –100 ms to 1,200 ms for each picture. Aggregated waveforms for each picture type (neutral and chocolate) were created, and baseline was corrected using the prestimulus activity. Based on previous research, we extracted mean activity from 400 to 1,000 ms at central midline site (CZ) where late positive potential is maximal for affective pictures (Hajcak et al., 2007).

Results and Discussion

Attitudes. We first examined the effect of proattitudinal commitment on self-reported liking of chocolate. Participants in the high-choice condition maintained a more positive attitude toward chocolate ($M = 7.94$, $SD = 1.39$) than did participants in the low-choice condition ($M = 6.89$, $SD = 2.08$), $t(34) = 1.79$, $p = .08$ (marginal). We found no effect of condition on the liking of rocks, $p = .32$, suggesting that the manipulation did not cause a general effect on attitude but rather caused a specific effect on attitude toward chocolate.

Relative left frontal cortical activity. For relative left frontal activity immediately following commitment, participants in the high-choice condition evidenced greater activity than did participants in the low-choice condition, $t(32) = 2.10$, $p = .04$. These results replicate Experiment 1's results and extend them with the inclusion of a low-choice proattitudinal condition. To examine whether these effects were specific to the frontal regions as predicted, we performed ANOVAs on all other asymmetry indexes. None were significant, ps > .07.

Late positive potentials. For late positive potentials at CZ, a 2 (choice) × 2 (chocolate vs. neutral picture) ANOVA revealed a main effect of picture type, $F(1, 32) = 4.12$, $p = .05$, but no significant interaction ($p > .50$). The main effect indicated that late positive potentials were larger to chocolate pictures ($M = .82$, $SD = 1.47$) than to neutral pictures ($M = .06$, $SD = 1.66$). (See Figure 3.) This result is consistent with past research and suggests that the late positive potential indexed positivity toward chocolate pictures.

Statistical mediation. The first two steps for mediation have been established in the above analyses. The third and fourth steps require the mediator to have a significant unique effect on the dependent variable, and the effect of the independent variable on the dependent variable to shrink upon the addition of the mediator to the model. In essence, the third step requires a significant correlation between the mediator (relative left frontal activity) and the dependent variable (attitude) within the critical (high-choice) condition. However, support for this step is extremely difficult to achieve because the predicted effect on the dependent variable is no attitude movement. In fact, 10 of the 18 participants in the high-choice condition scored the highest possible score on the self-reported attitude measure, leaving little variance to correlate with the mediator. Consequently, the test of the third step was not significant.

Another way to assess the predicted process, however, is to examine whether the proposed mediator influences the late positive potential to chocolate pictures, a variable with more variance than self-reported attitude. That is, individuals who show the greatest relative left frontal activation following commitment should be the individuals most likely to maintain their attitude as measured by the late positive potential. However, conventional mediational support for dependent variable cannot be achieved because the choice manipulation did not significantly influence it. Nonetheless, we thought examination of this hypothesis would provide some tentative support for the late positive potential.

To assess whether the choice manipulation interacted with relative left frontal activity immediately after commitment to predict greater late positive potential activity to chocolate pictures, we conducted a regression analysis in which the choice manipulation (effect coded) and relative left frontal activation predicted late positive potentials to

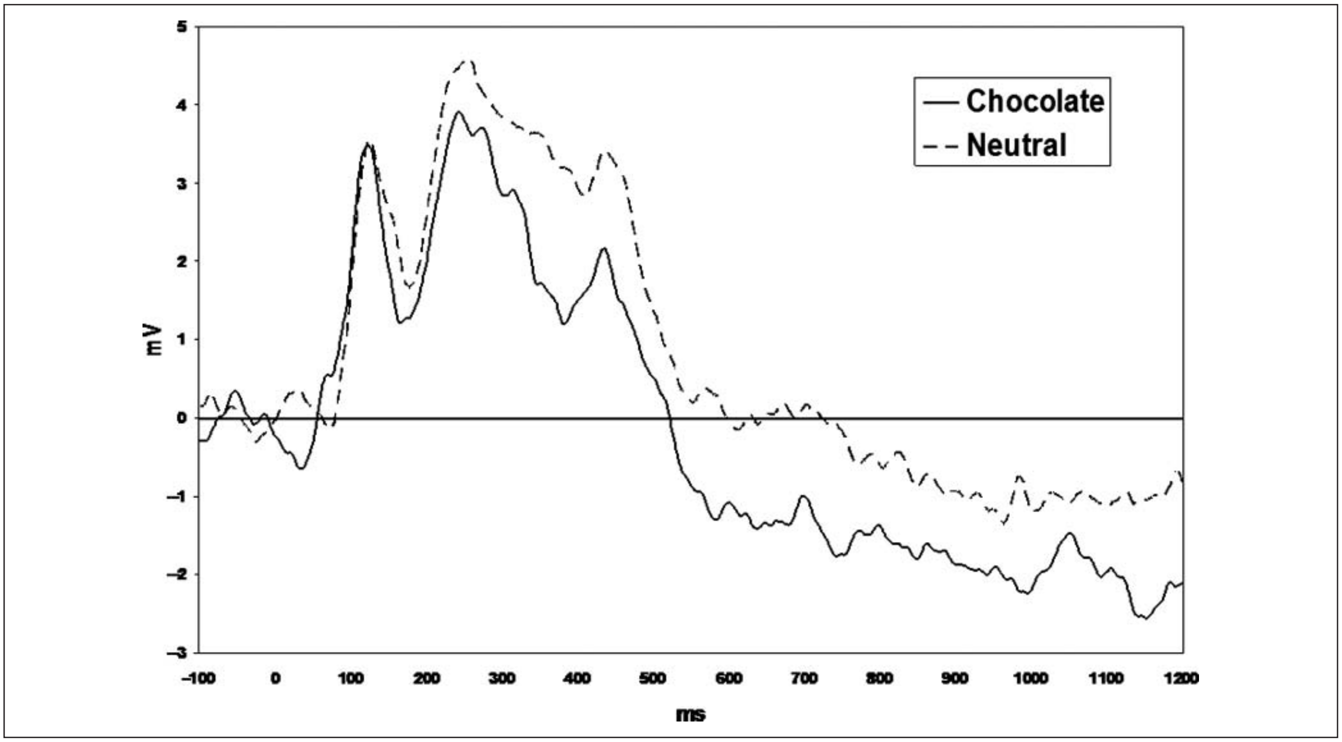

Figure 3. Average event-related potentials to chocolate versus neutral pictures in Experiment 2

chocolate pictures (subtracting late positive potentials to neutral pictures, to control for individual differences in responses). The regression revealed a significant interaction, $F(1, 30) = 7.45$, $p < .01$, $\beta = .57$. Follow-up correlations revealed that within the high-choice condition, greater relative left frontal activation immediately after commitment predicted greater late positive potentials to chocolate stimuli, $r = .53$, $p = .04$. However, with the low-choice condition, relative left frontal activation did not significantly predict late positive potentials to chocolate stimuli, $r = -.41$, $p = .09$. These correlational results are consistent with the prediction that high-choice individuals who showed the most evidence of being committed to the proattitudinal statement (as revealed by relative left frontal activation) maintained their positive attitudes toward the chocolate stimuli (as revealed by relatively large LPPs to chocolate stimuli).

Ancillary analyses. To determine whether the differences obtained between the choice conditions were the result of differences in the sentences written, two independent judges who were unaware of the experimental condition rated on a 5-point scale how convincing they found the sentences (1 = *not at all*, 5 = *very*). The judges' ratings were significantly correlated, $r = .50$, $p < .01$. High- and low-choice conditions did not differ in how convincing the sentences were or in sentence length ($t < 1.0$), suggesting that the differences observed were not due to differences in the strength or length of the sentences.

General Discussion

Results from two experiments revealed that commitment to behavior evoked greater relative left frontal cortical activity. These effects occurred even when the commitment was proattitudinal. These results are consistent with predictions derived from the action-based model of dissonance and recent neurocognitive models of cognitive control. Moreover, they extend previous results and broaden the theoretical reach of the action-based model.

Unlike past research that has revealed that commitment to counterattitudinal behavior and not proattitudinal behavior evokes increased sympathetic nervous system arousal (skin conductance), the current research revealed that commitment to both counterattitudinal and proattitudinal behavior evoked greater relative left frontal activity. These results suggest that the increased sympathetic nervous system arousal and relative left frontal activity are dissociated in "commitment" paradigms and they reflect different processes. We suggest that sympathetic nervous system activation reflects dissonance arousal, whereas increased left frontal cortical activity reflects approach-motivational processes directed toward the commitment. Following a commitment, the individual is prepared to act effectively with regard to the commitment. The commitment itself, even to a proattitudinal behavior, is enough to evoke an action-oriented approach state.

The current research suggests that commitment to behavior may have similar approach-motivational properties regardless of whether the behavior is inconsistent or consistent with attitudes. The results suggest there is more similarity between counterattitudinal and proattitudinal paradigms than was thought by dissonance researchers. Along these lines, the results integrate dissonance theory with other theories of motivation (Gollwitzer, 1990; Kuhl, 1984, 2000) and cognitive conflict reduction (MacDonald et al., 2000).

These results also suggest that the relative left frontal activity caused by commitment to behavior is part of the neural circuitry involved in bolstering commitments. Consistent with this conclusion, a neurofeedback-training-induced reduction in relative left frontal activation decreased attitude change in the free choice paradigm (Harmon-Jones, Harmon-Jones, Fearn, Sigelman, & Johnson, 2008).

On Statistical Mediation

Experiment 1 revealed that relative left frontal cortical activation statistically mediated the effect of choice on attitude within the counterattitudinal conditions. Such an effect is in line with the idea that relative left frontal activation may be involved in attitude change. These results are consistent with research showing that a manipulated decrease in relative left frontal activity caused a reduction in the amount of attitudinal spreading of decision alternatives that typically occurs following a difficult decision (Harmon-Jones, Harmon-Jones, et al., 2008).

Experiment 2 did not provide conventional evidence of statistical mediation. This is likely because most participants in the high-choice condition resisted persuasion and maintained their extremely positive attitudes toward chocolate, as predicted. Thus, there was little variability in attitudes in the high-choice condition, making it difficult for commitment-related relative left frontal cortical activation to correlate with attitude. The correlational evidence with the late positive potential, however, suggested something akin to mediation. That is, within the high-choice condition, greater relative left frontal cortical activation was associated with greater late positive potentials to chocolate versus neutral stimuli. This suggests that individuals who responded to the choice manipulation with greater approach motivation (or commitment) also showed more appetitive responses toward the chocolate stimuli.

The evidence for relative left frontal cortical activity as a mediator between choice and attitude processes is mixed. We have observed evidence of mediation in two previous experiments (Harmon-Jones, Harmon-Jones, et al., 2008) and failed to observe it in another (Harmon-Jones, Gerdjikov, et al., 2008). Of the present research, Experiment 1, but not Experiment 2, provides evidence of statistical mediation. These findings are similar to the larger dissonance literature, which has not found consistent evidence of statistical mediation for arousal and negative affect (Croyle & Cooper, 1983; Elkin & Leippe, 1986; Elliott & Devine, 1994; Harmon-Jones, 2000). Several explanations can be offered for the mixed evidence on statistical mediation: (a) the measures are insensitive; (b) the mediational chain is counterintuitive, participants are not conscious of the processes, and these things impede their ability to report evidence consistent with mediation; and (c) the measures of the mediator and the dependent variable are from different domains, and it may be difficult to find evidence of mediation from such diverse domains.

On Relative Left Frontal Activity and Motivational Processes

EEG, like many human neuroscience tools, has limitations (Harmon-Jones & Beer, 2009). Its primary limitation is its spatial resolution, its ability to detect precise sources of the electrical brain activation. One may thus question the source of the EEG signals. Similar relations of asymmetric dorsolateral frontal cortical activation with motivational processes have been found with other methodologies, such as lesions (Robinson & Downhill, 1995), functional magnetic resonance imaging (Berkman & Lieberman, 2010), repetitive transcranial magnetic stimulation (van Honk & Schutter, 2006), transcranial direct current stimulation (Hortensius, Schutter, & Harmon-Jones, 2010), and positron emission technology (Thut et al., 1997). These methodologies converge in suggesting that asymmetric frontal cortical activity plays an important role in motivational direction.

In the literature on asymmetric frontal cortical activity, some researchers have suggested that the left frontal cortical region is involved in positive affect, whereas the right frontal cortical region is involved in negative affect (Davidson, Ekman, et al., 1990). Could this interpretation explain the current results? We think not. In particular, Experiment 1 and Harmon-Jones, Gerdjikov, et al. (2008) found that high choice to engage in counterattitudinal behavior caused greater relative left frontal activity, and this same choice manipulation has been found to induce feelings of *negative affect* (Elliot & Devine, 1994; Harmon-Jones, 2000).

Conclusion

The present research integrates a neuroscience perspective with a recent version of one of social psychology's oldest theories concerned with the regulation of cognitive inconsistencies. By integrating the action-based model of cognitive dissonance with the known functions of the frontal cortex, the present research suggests that the dissonance aroused by commitment to a chosen course of action evokes an approach motivational state, and this finding thus supports a prediction derived from the action-based model of dissonance. The finding that relative left frontal activity is also evoked by proattitudinal commitment extends the reach of the action-based model and suggests similar motivational processes underlie reactions to both counterattitudinal and proattitudinal commitments.

Authors' Note

This article is dedicated to the memories of Jack Brehm and Jud Mills.

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Notes

1. Eight participants refused to write the counterattitudinal essay (4 in low choice and 4 in high choice). Nine more expressed suspicions about the purpose of the study (3 in low choice and 6 in high choice). Another 1 in the high-choice condition was both suspicious and refused to comply. These 18 individuals were excluded, leaving a total of 50 participants for analyses of self-report data. Debriefing revealed that the suspicious individuals had participated in another induced compliance study in another laboratory. An additional 10 participants' data were excluded from electroencephalographic (EEG) analyses because of equipment malfunction (2), because of experimenter error (5), or because the EEG data could not be analyzed because it contained too much movement artifact (3).
2. Because of changes in the data collection computer, EEG data for the last 10 participants were sampled at 500 HZ, and thus the epoch length was altered to 1.024 s for the fast Fourier transform.
3. Anterior cingulate cortex activity was not monitored because the present experimental design would not allow it. Multiple trials of the same psychological event, as well as comparison events, are needed to detect anterior cingulate cortex activity with EEG methods (see Amodio et al., 2004).
4. In both experiments, additional analyses of separate left and right lateral frontal sites revealed significant Condition × Hemisphere interactions, ps < .03. They indicated that whereas participants in the low-choice condition evidenced symmetry between left and right lateral frontal sites (no difference between left and right, ps > .20), participants in the high-choice condition evidenced greater activity in the left than right lateral frontal cortex, ps < .04. Because the EEG frontal asymmetry literature has found and emphasized that it is the relative difference between hemispheres that is most important for motivational direction (Harmon-Jones, 2003), we focus on the asymmetry index in the article.

   Degrees of freedom differ from the attitude results because of loss of EEG data due to technical problems.

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