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The effect of induced compliance on relative left frontal cortical activity: A test 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. An induced compliance experiment was 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 counterattitudinal action caused attitudes to be more consistent with the action. Also, high choice caused greater relative left frontal cortical activity than low choice. Copyright © 2006 John Wiley & Sons, Ltd.

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 presumed to cause organisms to do cognitive work in an attempt to reduce the dissonance. The original theory used the same word, 'dissonance,' to describe both the discrepancy between cognitions and the emotive state provoked by this discrepancy. To improve clarity about the processes, 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 'cognitive world' (i.e., attitudes, beliefs, or behaviors), we refer to the process as 'discrepancy reduction.' When the negative emotional-motivational state is successfully eliminated or reduced, we call this 'dissonance reduction.'

Several revisions have been proposed to explain the data generated by dissonance theory. Some revisions focused on the role of the self-concept or self-esteem as being important in dissonance

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processes. However, research has demonstrated problems with those explanations (Harmon-Jones, 2000). It is likely that self aspects may moderate dissonance processes but that they may not be necessary to cause dissonance (Harmon-Jones, 2000; Stone & Cooper, 2001). Other revisions have been proposed and empirically challenged, and much research has continued to support the original theory (Beauvois & Joule, 1996; Harmon-Jones, Brehm, Greenberg, Simon, & Nelson, 1996; Simon, Greenberg, & Brehm, 1995). However, the original theory never clearly specified why cognitive discrepancy caused the negative emotive state of dissonance and why individuals were motivated to reduce dissonance and discrepancy. To address these questions, the action-based model was proposed (Harmon-Jones, 1999). It builds on the earlier idea of an unequivocal behavioral orientation (Gerard, 1965) and integrates it with recent ideas about action orientation and implemental mindsets (Gollwitzer, 1990; Kuhl, 1984, 2000). In the end, the action-based model accepts the original theory of dissonance and hopes to extend it by positing why cognitive discrepancy causes the negative emotive state of dissonance and why individuals are motivated to reduce dissonance and discrepancy.

ACTION-BASED MODEL OF DISSONANCE

The action-based model of dissonance begins with the assumption that perceptions and cognitions can serve as action tendencies. Discrepancy between cognitions evokes dissonance because discrepancy has the potential to interfere with effective and unconflicted action. Discrepancy reduction, by bringing cognitions into consonance, serves the function of facilitating the execution of effective and unconflicted action (Gerard, 1965; Jones & Gerard, 1967). The action-based model accepts the ideas of Brehm and Cohen (1962) in that it posits that behavioral commitment provides the base around which dissonance reduction occurs. In other words, according to Brehm and Cohen (1962; see also Beauvois & Joule, 1996), most dissonance situations can be evaluated as decision situations. Once the individual decides on a course of action or makes a behavioral commitment, s/he enhances the value of the chosen course of action and reduces the value of the rejected course of action. Jones and Gerard (1967) went further to suggest that the individual attempts to 'maintain an unequivocal behavioral orientation toward his acts (p. 194).' The action-based model proposes that, after a decision (commitment) is made, the processing that occurs should assist with the execution of the decision. The tendency to move toward viewing the chosen course of action more positively or less negatively after a decision (i.e., attitude change) should help the individual to follow through and act on the decision in a more effective manner.

STATE ACTION-ORIENTATION AND SPREADING OF ALTERNATIVES

The post-decisional state is similar to the action-oriented state (Gollwitzer, 1990; Kuhl, 1984). When a person is in an action-oriented state, implementation of decisions is enhanced. Harmon-Jones and Harmon-Jones (2002) proposed that the action-oriented state that follows decision-making is equivalent to the state in which dissonance motivation operates and discrepancy reduction occurs. They found that experimentally manipulating the degree of action-orientation experienced following a decision affected the degree of discrepancy reduction (as measured by attitude change).

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DISSONANCE AND NEURAL ACTIVITY

The previous experiments provided support for the action-based model of dissonance and cannot be easily interpreted by other revisions of dissonance theory (Harmon-Jones & Harmon-Jones, 2002). The action-based model suggests which neural circuits are involved in dissonance processes. When dissonance is aroused, it evokes increased sympathetic nervous activity as measured by increased skin conductance (Harmon-Jones et al., 1996). Neurally, we would expect dissonance to evoke activity in the anterior circulate cortex (ACC), a structure that has been found to be involved the detection of cognitive conflict. Research has suggested that activity in the ACC is involved in monitoring the occurrence of errors or the presence of response conflict (e.g., Carter et al., 1998; Gerhing, Goss, Coles, Meyer, & Donchin, 1993). Recent research has found increased ACC activity, as measured by the event-related potential known as the error-related negativity, when behavior conflicts with the self-concept (Amodio et al., 2004).

Once dissonance is aroused, discrepancy reduction can occur rapidly. Indeed, past research has revealed that behavioral commitment itself followed by immediate attitude assessment is sufficient to detect attitude change (Rabbie, Brehm, & Cohen, 1959). Discrepancy reduction, which theoretically occurs to assist in translating the intention into effective action, engages approach motivational processes, as the individual works to successfully implement the new commitment. This increase in approach motivation should activate the left frontal cortex. Past research suggests that the left frontal cortical region may be involved in approach motivational processes aimed at resolving inconsistency. The left dorsolateral prefrontal cortex is more active during preparation for color naming than during preparation for word naming in a Stroop task (MacDonald, Cohen, Stenger, & Carter, 2000). Moreover, more activity in this brain region was associated with less conflict (i.e., smaller reaction time interference effects). MacDonald et al. suggested that the left dorsolateral prefrontal cortex is involved 'in the implementation of control, by representing and actively maintaining the attentional demands of the task (p. 1837).'

Other findings have suggested that the left and right frontal cortical regions have different motivational functions, with the left frontal region being involved in approach motivational processes, and the right frontal region being involved in withdrawal motivational processes. The left prefrontal cortex has been described as a region that is important for intention, self-regulation, and planning—functions involved in approach motivation and action-oriented processing (Kuhl, 2000; Tomarken & Keener, 1998). These functions have often been described as properties of the will, a hypothetical construct important in guiding approach-related behavior. Persons with damage to this region are depressed, apathetic, experience less interest and pleasure, and have difficulty initiating actions (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; Sobotka, Davidson, & Senulis, 1992), independent of the valence of the approach motivation (Harmon-Jones, 2003). Although it was once posited that greater left than right frontal cortical activity is associated with greater positive affect, the past research that found positive affect to relate to relative left frontal activity confounded positive affect with approach motivation. Recent research on anger, an emotion that unconfounds this relationship because it is negative but often evokes approach-motivation, has revealed that greater relative left frontal activity is associated with approach motivation and not positive affect *per se* (Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003).

Because much of the research on left frontal cortical activity and approach motivation comes from EEG frequency domain analyses, particularly alpha power, and because the current research uses EEG alpha power, it is important to describe it. EEG alpha power is considered a measure of cortical activity,

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as much past research has found that alpha power is inversely related to cortical activity (Lindsley & Wicke, 1974). EEG alpha power over the frontal cortices is inversely related to activity over the same cortical regions measured using other methods, such as positron emission tomography (Cook, O'Hara, Uijtdehaage, Mandelkern, & Leuchter, 1998) and functional magnetic resonance imaging (Goldman, Stern, Engel, & Cohen, 2002). Recent source localization work has revealed that approach/withdrawal-related frontal EEG alpha asymmetry reflects dorsolateral prefrontal cortical activity (Pizzagalli, Sherwood, Henriques, & Davidson, 2005).

Thus, if commitment to a course of action engages approach-related action-oriented processing, then greater left than right frontal cortical activation should occur. To test this prediction, we conducted an experiment using the induced compliance paradigm. Participants were given low or high choice to write a persuasive essay arguing for a tuition increase at their university. We predicted that immediately after individuals committed to writing a counterattitudinal essay (i.e., in the high-choice but not the low-choice condition), they would evidence increased left frontal activity.

METHOD

Participants

Participants were 50 introductory psychology students. Only students responding with 'strongly agree' or 'mildly agree' to the statement 'Tuition should not be raised by 10% for the upcoming academic year' in a mass survey session were invited to the experiment. Participants were right-handed. Only right-handed participants were invited to participate in the experiment because research suggests that right- and left-handed persons may differ in hemispheric specialization of emotion (Heller & Levy, 1981).[1]

Procedure

The experimenter informed the participants that he was interested in the relationship between brainwave activity, personality traits, and attitudes. He explained that because people may become bored when working on too many questionnaires one after another, brainwave measurements would be performed between questionnaires. The experimenter also explained that the participant would complete another study for the Priorities Committee at the University.

After signing an informed consent form, the participant completed some filler personality questionnaires. Next, the experimenter allowed participants time to become familiarized with the recording equipment. After attaching all necessary sensors (which took about 40 min), the experimenter asked the participant to work on the study for the Priorities Committee. The participant heard and then read an introduction that explained that the Priorities Committee at the university sponsors research in the department of psychology, and that in exchange for these funds, the Priorities Committee occasionally asks the department to collect data for it. Participants were told that the committee was considering increasing tuition by 10% for the upcoming academic year and that they

[1]Eight participants refused to write the counterattitudinal essay (four in low and four in high choice). Nine more expressed suspicions about the purpose of the study (three in low choice and six in high choice). Another one in the high choice condition was both suspicious and refused to comply. These 18 individuals were excluded, leaving a total of 50 participants. Debriefing revealed that the suspicious individuals had participated in another induced compliance study being conducted in another laboratory in the same department at the university. An additional 10 participants' data were excluded from EEG analyses because of equipment malfunction (two), because of experimenter error (five), or because the EEG data could not be analyzed because it contained too much movement artifact (three).

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were interested in assessing students' opinions on this issue. It was explained that opinions would be collected by using the essay technique, which involved having individuals write essays containing strong and forceful arguments in support of one side of the issue. Finally, it was explained that the essays would be sent to the Priorities Committee who would consider students' opinions before making the decision about increasing tuition by 10% for the upcoming academic year.

Then the experimenter (who remained blind to condition) handed the participant an envelope containing the choice manipulation and a blank sheet on which to write. Participants in the *low-choice condition* read that the committee had finished collecting arguments against the tuition increase and was ready to gather arguments for the tuition increase. They also read that in order to finish the study and provide the committee with their data, individuals were being randomly assigned to write that tuition should be increased. Participants in the *high-choice condition* read similar instructions. However, instead of being told that they were randomly assigned to write the tuition-increase essay, they were told that writing arguments in favor of the tuition increase was their choice and completely voluntary. Both conditions were instructed to write a short statement saying that tuition should be increased by 10% for the upcoming academic year. They were instructed that after they had written the statement, they should place it in the enclosed envelope, seal the envelope, and put the envelope in the campus mail envelope. They were informed that the campus mail envelope would be mailed to the committee by the experimenter. In both conditions, the instructions ended with a statement reinforcing the choice manipulation and a place for the participant to sign indicating his/her agreement with the statement.

After writing the essay, participants were informed that the study for the Priorities Committee was over. They were then asked to complete more questionnaires as part of the study on the relationship between brainwave activity and personality (i.e., attitudes survey and a perceived choice manipulation check). Finally, the experimenter interviewed the participants to assess suspicion. Then he debriefed them and thanked them for their participation.

Self-Report Measures

The attitudes survey asked questions about the possible tuition increase, abortion, and the legalization of marijuana. On 9-point scales, participants were asked to rate the statement 'Tuition should be increased by 10% at the University of Wisconsin' on four items (1 = *not at all favorable*−9 = *very favorable*; 1 = *not at all wise*−9 = *very wise*; 1 = *not at all bad*−9 = *very bad*; 1 = *not at all unfair*−9 = *very unfair*). Analogous questions about marijuana and abortion were included. On the next page, participants reported their perceived choice, 'How much choice do you feel you had over which side of the issue to write?' (1 = *no choice at all* to 7 = *very much of a choice*).

EEG Recording and Analyses

EEG was assessed for 1 min following the beginning of the writing of the counterattitudinal essay, as past research has revealed that the commitment alone (and not the complete essay writing) is sufficient to evoke dissonance (Beauvois & Joule, 1996; Rabbie et al., 1959). We captured the same amount of EEG for all participants, as they all wrote for at least 1 min. Participants were given instructions *via* intercom by the experimenter, who was in an adjacent room. Six electrodes mounted in a stretch-lycra electrode cap (Electro-Cap, Eaton, OH) were placed on the participant's head using known anatomical landmarks. EEG was recorded from lateral frontal (F7/F8), mid-frontal (F3/F4), and parietal (P3/P4) regions. A ground electrode was mounted in the cap on the mid-line between the frontal pole (Fpz) and the frontal site (Fz). The reference electrode was placed on the left ear (A1), and data were also

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acquired from an electrode placed on the right ear (A2), so that an off-line digitally derived, averaged ears' reference could be computed. Vertical eye movements (EOG) were recorded from the supra- and sub-orbit of the left eye to facilitate artifact scoring of the EEG. All electrode impedances were under 5000 ohms, and homologous sites were within 1000 ohms of each other. EEG and EOG were amplified with a Contact Precision Instruments EEG8 amplifier unit (Cambridge, MA), bandpass filtered (0.1–100 Hz; 60 Hz notch filter enabled), and digitized at 200 Hz.

The EEG and EOG signals were visually scored on a computer monitor and portions of the data that contained artifacts were removed. Derived averaged-ears reference was used for data reduction. All artifact-free epochs that were 2.56 seconds in duration were extracted through a Hamming window. Contiguous epochs were overlapped by 75%. A fast Fourier transform (FFT) was used to calculate the power spectra. These power values were averaged. Total power within the alpha (8–13 Hz) frequency range was obtained.[2] Asymmetry indexes [log right minus log left alpha power] were computed for lateral frontal (F7/F8), mid-frontal (F3/F4), and parietal sites (P3/P4). Because alpha power is inversely related to cortical activity (Cook et al., 1998), higher scores on the indexes indicate *greater relative left hemisphere activity*.[3] Because past research has revealed slightly stronger effects for lateral frontal than mid-frontal sites during approach motivational states and because conflict reduction has been found to be implemented by the dorsolateral left frontal cortex (MacDonald et al., 2000), our primary predictions concerned lateral frontal sites.

RESULTS

Attitude Change

The attitude scale included four items. To analyze these data, we performed a MANOVA, with Choice as a between-participants variable and Attitude Items as dependent variables. A significant effect of Choice resulted, *Wilks lambda* $= .76$, $F(4, 45) = 3.63$, $p < .02$. It indicated that high-choice participants expressed attitudes more consistent with their behavior than low-choice participants. Means are displayed in Table 1. No significant differences emerged for attitudes toward marijuana legalization or abortion (p'$s > .30$). That high-choice produced attitudes more consistent with the behavior replicates past research and sets the stage for evaluating whether the high-choice manipulation also produced increased relative left frontal cortical activity.

Asymmetrical Cortical Activity

To test the hypothesis that high choice would produce increased relative left frontal cortical activity, we performed an ANOVA with choice as the independent variable, and lateral frontal asymmetry as the

[2]ACC activity was not monitored in the present experiments because the experimental design would not allow it. Multiple trials of the same psychological event, as well as within-subject comparison events, are needed to detect ACC activity (see Amodio et al., 2004).

[3]Additional analyses of separate left and right lateral frontal sites revealed a significant condition by hemisphere interaction, which indicated that whereas participants in the low-choice condition evidenced symmetry between left and right lateral frontal sites (no difference between left and right, p'$s > 0.20$), participants in the high-choice conditions evidenced greater activity in the left than right lateral frontal cortex, $p < 0.04$. 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.

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Table 1. Attitudes as a function of attitude item and choice condition

Choice condition	Wise	Bad	Unfair	Favorable
Low choice	3.42 (2.28)	6.88 (1.98)	6.79 (2.02)	3.21 (1.89)
High choice	4.08 (1.90)	5.50 (1.96)	5.23 (2.03)	3.38 (1.88)

Note: The values represent mean attitudes for each of the attitude items. Standard deviations are in parentheses.

dependent variable. A main effect of choice emerged, $F(1, 38) = 4.86$, $p = .03$, which indicated that high-choice participants evidenced greater relative left frontal cortical activity ($M = 0.359$, $SD = 0.348$) than low-choice participants ($M = 0.157$, $SD = 0.204$).[3] These results support the hypothesis derived from the action-based model that commitment to a course of action would increase relative left frontal activity.

To examine whether these effects were specific to the lateral frontal regions as predicted, we performed ANOVAs on mid-frontal and parietal asymmetry. Neither effect was significant, p's $> .18$. Also, statistical mediation analyses revealed that relative left lateral frontal activity did not mediate the effect of choice on attitude.

Manipulation Check

Perceived choice differed marginally as a function of experimental condition $F(1, 48) = 3.73$, $p = .059$, with participants in the high-choice condition reporting more choice to engage in the essay writing ($M = 2.39$, $SD = 1.72$) than participants in the low choice condition ($M = 1.54$, $SD = 1.32$).

Ancillary Analyses

To assess whether the differences obtained in relative left frontal activity and attitude between the choice conditions were the result of differences in the counterattitudinal essays written, two independent judges who were unaware of the experimental condition rated how convincing and complex they found the essays (on a 5-point scale, where 1 = *not at all* and 5 = *very*). The judges' ratings were significantly correlated, r's $> .81$, p's $< .001$, indicating high reliability. Judges' ratings were averaged for each measure. High- and low-choice conditions did not differ in how convincing or complex the essays were or in essay length (t's < 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. This lack of difference in essay content between conditions is consistent with past dissonance research (Elliot & Devine, 1994).

DISCUSSION

Results revealed that the most commonly used manipulation of dissonance—choice to engage in counterattitudinal behavior—affected relative left frontal cortical activity, with high choice producing greater relative left frontal activity. This research supports the hypothesis that discrepancy reduction causes an increase in activity in the left frontal cortical region, a brain region involved in approach motivation. The idea that commitment would evoke an approach motivational state was predicated on

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the action-based model of cognitive dissonance. The action-based model predicts that when individuals are committed to an action, they are motivated to follow through with their commitment and will evidence increased approach motivational tendencies to assist them in behaving in an effective and unconflicted manner with regard to the commitment. Attitude change is motivated by this approach state. The results provide support for this prediction by demonstrating that individuals given a choice to engage in counterattitudinal behavior evidenced greater relative left frontal activity than individuals not given a choice to engage in the same behavior. Other research is consistent with this conclusion. When neurofeedback training has been used to reduce relative left frontal activation, attitude change in the free choice paradigm is decreased (Harmon-Jones, Fearn, Johnson, Sigelman, & Harmon-Jones, 2006).

Would an increase in relative left frontal cortical activity be expected in other types of dissonance situations? We would expect such effects when dissonance is aroused by a strong commitment to behavior, which is what typically occurs in the induced compliance and free choice paradigms (e.g., Beauvois & Joule, 1996; Brehm & Cohen, 1962). In such situations, individuals are predicted to be motivated to follow through with their behavioral commitment and change their attitudes to be consistent with their behavior (Stone, Wiegand, Cooper, & Aronson, 1997). However, in some induced compliance situations, individuals may reduce dissonance by means other than attitude change, perhaps because their commitment is not sufficiently strong or because their original attitude is very important (Simon et al., 1995).

In other dissonance paradigms, relative left frontal activation may occur to the extent that dissonance is likely to be reduced *via* approach motivational processes. When individuals are exposed to counterattitudinal information, dissonance affect is aroused and may be reduced by engaging in approach-related actions, such as by signing petitions to stop a counterattitudinal policy from taking place (Harmon-Jones et al., 2003). However, other belief disconfirmation situations may evoke avoidance motivation and we would expect to see an increase in relative right frontal cortical activation in such situations. That is, when smokers are exposed to counterattitudinal information, they may reduce dissonance by selectively avoiding the information (Brock & Balloun, 1967).

On Mediation

The experiment failed to provide evidence of statistical mediation. This null effect may have been produced for a number of reasons, such as variability in the extremity and importance of the original attitude or the weakness of the choice manipulation. In other research, we have found that a manipulation of relative left frontal activity *via* neurofeedback training affects attitude change in the free-choice paradigm (Harmon-Jones et al., 2006). That is, a 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. The neurofeedback results provide stronger evidence of mediation because the presumed mediator—relative left frontal cortical activity—was manipulated rather than merely measured and correlated with the other variables (Sigall & Mills, 1998).

On Relative Left Frontal Activity and Motivational Processes

We have suggested that the observed increase of left frontal cortical activity reflects approach-related action orientation. This interpretation is consistent with much previous research (Pizzagalli, Shackman, & Davidson, 2003). Moreover, we have recently found that an implemental, action-oriented mindset not only increases attitude change in favor of the decision (spreading of alternatives), replicating past work (Harmon-Jones & Harmon-Jones, 2002), but that it also increases relative left frontal cortical activity, which relates to the degree of attitude change (Harmon-Jones et al., 2006).

Activity in this cortical region is also associated with the execution of control or inhibition (MacDonald et al., 2000). Thus, perhaps the increased left frontal cortical activity partially reflects the inhibition of the explicit attitude that participants had the outset of the experiment or the inhibition of implicit attitudes (Gawronski & Strack, 2004).

It is also possible that an approach-related action orientation at this cortical level reflects both the strengthening of the approach action tendencies and the inhibition of action tendencies that would interfere with the execution of the action. Past research showing that approach-oriented anger is associated with greater relative left frontal cortical activity is consistent with this possibility, as approach-oriented anger often involves the suppression of fear and anxiety (van Honk & Schutter, in press), emotions that would interfere with angry behavior. Future research will need to explore the possibility that approach-motivated action orientations that involve the left frontal cortex cause selective strengthening of approach action tendencies as well as inhibition of conflicting action tendencies.

It is also important to note that left frontal activity is not only associated with approach motivational processes. Other studies have found that left frontal activity is associated with language, semantic memory retrieval, and episodic memory encoding (Cabeza & Nyberg, 2000). However, it does not seem plausible that these cognitive processes provide alternative explanations for why commitment to behavior increases left frontal activity and why the same commitment causes greater attitude change in support of the behavior. Thus, it seems reasonable to conclude that the manipulation of behavioral commitment, rather than some other cognitive variable, caused the effects.

CONCLUSION

The present research begins to integrate the neuroscience perspective with a recent version of one of social psychology's oldest theories concerned with the regulation of cognitive inconsistencies and negative emotion. By integrating the action-based model 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. The finding that relative left frontal activity is evoked by commitment also extends the understanding of the motivational and emotional functions of the frontal cortices, as it is consistent with a growing body of research that suggests that asymmetrical frontal cortical activity taps motivational direction rather than affective valence.

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