Social Neuroscience

ISSN: 1747-0919 (Print) 1747-0927 (Online) Journal homepage: https://www.tandfonline.com/loi/psns20

Cognitive dissonance induction in everyday life: An fMRI study

Jan de Vries, Mark Byrne & Elizabeth Kehoe

To cite this article: Jan de Vries, Mark Byrne & Elizabeth Kehoe (2015) Cognitive dissonance induction in everyday life: An fMRI study, Social Neuroscience, 10:3, 268-281, DOI: 10.1080/17470919.2014.990990

To link to this article: https://doi.org/10.1080/17470919.2014.990990

Published online: 15 Dec 2014.

Submit your article to this journal

Article views: 996

View Crossmark data

Citing articles: 3 View citing articles

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=psns20

SOCIAL NEUROSCIENCE, 2015
Vol. 10, No. 3, 268–281, http://dx.doi.org/10.1080/17470919.2014.990990

Cognitive dissonance induction in everyday life: An fMRI study

Jan de Vries[1], **Mark Byrne**[2], **and Elizabeth Kehoe**[2]

[1]School of Nursing and Midwifery, Trinity College Dublin, Dublin, Ireland
[2]Trinity College Institute of Neuroscience, Trinity College Dublin, Dublin, Ireland

This functional magnetic resonance imaging (fMRI) study explored the neural substrates of cognitive dissonance during dissonance "induction." A novel task was developed based on the results of a separate item selection study (n = 125). Items were designed to generate dissonance by prompting participants to reflect on everyday personal experiences that were inconsistent with values they had expressed support for. One experimental condition (dissonance) and three control conditions (justification, consonance, and non-self-related inconsistency) were used for comparison. Items of all four types were presented to each participant (n = 14) in a randomized design. The fMRI analysis used a whole-brain approach focusing on the moments dissonance was induced. Results showed that in comparison with the control conditions the dissonance experience led to higher levels of activation in several brain regions. Specifically dissonance was associated with increased neural activation in key brain regions including the anterior cingulate cortex (ACC), anterior insula, inferior frontal gyrus, and precuneus. This supports current perspectives that emphasize the role of anterior cingulate and insula in dissonance processing. Less extensive activation in the prefrontal cortex than in some previous studies is consistent with this study's emphasis on dissonance induction, rather than reduction. This article also contains a short review and comparison with other fMRI studies of cognitive dissonance.

Keywords: Cognitive dissonance; fMRI; Insula; Anterior cingulate cortex; Dissonance induction; Cognitive conflict.

The study of cognitive dissonance (Festinger, 1957) has only recently moved into the neuroscience arena. While related issues such as cognitive conflict (Carter & Van Veen, 2007), conflict monitoring (Botvinick, 2007), error processing (Van Veen & Carter, 2006), moral reasoning (Young & Dungan, 2012), and decision-making (Sharot, De Martino, & Dolan, 2009) have been addressed for quite some time, sometimes with reference to cognitive dissonance, it is only in the last few years that studies with a direct focus on the neuroscience of cognitive dissonance have started to emerge. Initially EEG studies by Harmon-Jones and colleagues (Harmon-Jones, Gerdjikov, & Harmon-Jones, 2008; Harmon-Jones, Lueck, Fearn, & Harmon-Jones, 2006), and more recently functional magnetic resonance imaging (fMRI) studies (Izuma et al., 2010; Jarcho, Berkman, & Lieberman, 2011; Kitayama, Chua, Tompson, & Han, 2013; Qin et al., 2011; Van Veen, Krug, Schooler, & Carter, 2009) have begun to illuminate the way in which the brain processes cognitive dissonance. The study presented in this article is intended to continue this process.

Correspondence should be addressed to: Jan de Vries, School of Nursing and Midwifery, Trinity College Dublin, 24 D'Olier Street, Dublin 2, Ireland. E-mail: jan.devries@tcd.ie

Thanks to Sojo Joseph (fMRI technician), Deborah Keane (research assistant), Jeff Cooper (some excellent advice), Simon Dunne (task programmer), and Patricia Devine for allowing us to use the Cognitive Dissonance Measure (Elliot & Devine, 1994). The MRI data were accessed from the Lonsdale cluster maintained by the Trinity Centre for High Performance Computing. This cluster was funded through grants from Science Foundation Ireland.

No potential conflict of interest was reported by the authors.

This work was supported by the Trinity College Dublin Start Up Fund [grant number R01333].

© 2014 Taylor & Francis

Festinger (1957) first introduced the term cognitive dissonance to indicate the discomfort we feel whenever we consider psychologically inconsistent notions at the same time. This discomfort or dissonance motivates us to expend cognitive and behavioral effort to reduce it and restore cognitive consistency. A variety of other paradigms and models, such as Freud's conception of internal conflict between Id, Ego, and Superego (Freud, 1923), Rogers' (1951) incongruence concept, and Heider's (1958) balance theory, also made claims to explaining the impact of inner conflict, but only Festinger's conceptualization and research has led to a sustained empirical effort. Undoubtedly the extent of empirical research on cognitive dissonance and its theoretical advances (Cooper, 2007) makes it one of the most prominent contemporary models for understanding processing of inconsistent and conflicting cognitions. Cognitive dissonance (or dissonance, both terms are in use) has even been described as a core motivation in maintaining coherence in our thinking (Gawronski, 2012) and actions (Harmon-Jones & Harmon-Jones, 2002). Empirical studies have demonstrated significant and enduring support for the dissonance phenomenon (Cooper, 2007), even though researchers have disagreed on the exact contours and emphasis of the theory. The broad appeal of dissonance theory to neuroscience is that it provides a clear foundation for the development and testing of neural hypotheses, because it assumes a functional process of (a) perception of inconsistency, followed by (b) the induction of dissonance discomfort, accompanied by aversive emotions and sympathetic activation which serve as a drive to (c) motivate efforts to reduce the dissonance in a wide variety of ways. Furthermore, its empirical history inspires avenues for dissonance induction and reduction tasks that can be performed while brain activity is monitored.

Dissonance and fMRI

A search of several databases (Medline, PsychINFO, PsychArticles, and Academic Search Complete) using a variety of combinations of relevant keywords (cognitive dissonance, dissonance, neural, and fMRI) yielded only five fMRI studies that explicitly addressed cognitive dissonance. Each of these studies made use of scanner-compatible tasks that were modeled after paradigms used in the classic dissonance studies. Four of the studies (Izuma et al., 2010; Jarcho et al., 2011; Kitayama et al., 2013; Qin et al., 2011) employed a decision-induced attitude change paradigm (Brehm, 1956) in which forced choices between pre-rated foods, CDs, or paintings, led to more favorable attitudes to chosen items as compared to rejected items. The idea is that dissonance reduction motivated the attitude change. The rejection of an, until then, favored item-generated dissonance. A fifth study (Van Veen et al., 2009) was modeled after Festinger and Carlsmith's (1959) original induced compliance paradigm in which participants had to tell a confederate a lie (counter-attitudinal behavior) in a high or low reward condition. Van Veen et al. (2009) asked participants in the dissonance condition, while in the scanner, to lie about the unpleasantness of the scanning experience to put a waiting participant at ease. In contrast, participants in the control condition were asked to lie for extra money. In this paradigm, dissonance is generated by the inconsistency between the unpleasant experience in the scanner and the favorable attitude expressed, while the extent of the dissonance was reflected in the degree of attitude change towards liking the scanning experience, as measured afterwards.

While these studies are highly relevant, the present study is taking a different approach guided by a research paradigm based on the self-consistency revision of dissonance theory (Aronson, 1968). The emphasis in this revision is on the self-concept and suggests that dissonance is felt most strongly when aspects of the self are under threat, such as when actions, events, or perceptions lead us to feel bad, stupid, wrong, morally inferior, or otherwise in conflict with positive beliefs we hold about ourselves. This notion has led to a slew of empirical studies in which participants were confronted with past behaviors that were inconsistent with values they professed to support (Aronson, Fried, & Stone, 1991; Dickerson, Thibodeau, Aronson, & Miller, 1992; Fointiat, 2004; Fried, 1998; Harmon-Jones, Peterson, & Vaughn, 2003; Stone, Aronson, Crain, Winslow, & Fried, 1994; Takaku, 2001; Vinski & Tryon, 2009; Zanna & Cooper, 1974). As has been demonstrated in these studies, this confrontation generated significant degrees of dissonance (and behavioral change to reduce it).

The present study was modeled after these studies. While in the scanner, participants were presented with short descriptions of a value and asked whether they supported it. Subsequently, to induce dissonance, they were asked to reflect on an occasion in which they had behaved inconsistently with this value. For instance, participants were prompted to reflect on their memories of not giving money to a beggar after they had just been asked to support the importance of helping people in need. Or, they were prompted to think about an occasion when they lied after just having been asked whether they thought honesty was important.

We considered this approach of great interest for a variety of reasons. First, as Aronson (2003) suggests, the high intensity of self-related dissonance may make it a particularly promising way to identify the neural substrates of dissonance. Second, a task that would prompt participants to reflect on common dissonance-provoking events would allow us to study the neuroscience of "real-life" cognitive dissonance. The ecological validity of this approach makes it a particularly worthwhile avenue to pursue. Third, because this approach is considerably different from the ones used in other fMRI studies on dissonance, we are able to establish the extent to which a different operationalization of dissonance generates similar (or different) neural responses. More specifically, because our approach does not promote attitude change or other dissonance reduction efforts in the participants, it would allow us to disentangle the dissonance induction aspect from subsequent efforts to reduce it. As has been highlighted in the literature (Tryon & Misurell, 2008), dissonance induction and dissonance reduction are very different mental processes that may well be represented by different neural activation. It stands to reason that in the study of neural correlates of cognitive dissonance, we take this into account.

Neuroscience evidence

Specific evidence for the location of dissonance-related activation in the brain was first established by Harmon-Jones (Harmon-Jones, Harmon-Jones, & Amodio, 2012; Harmon-Jones et al., 2006, 2008) whose electroencephalogram (EEG) studies had led him to conclude that the anterior cingulate cortex (ACC) must be central to the dissonance induction aspect because of its conflict detection role, while the subsequent discrepancy reduction was associated with left-frontal cortical activity. In the five currently known fMRI studies of dissonance (at the time of submission of this publication), this distinction is not made. Overall, their findings concur with earlier fMRI findings on cognitive conflict (Carter & Van Veen, 2007; Van Veen et al., 2009) and more or less suggest that we should expect an interaction between ACC and insula. The conjoint activity of ACC and insula (Medford & Critchley, 2010) should not surprise us because it has been documented widely in a variety of contexts. Recent studies on unfairness (Güroğlu, van den Bos, van Dijk, Rombouts, & Crone, 2011), norm violations (Denke, Rotte, Heinze, & Schaefer, 2014), and embarrassment (Morita et al., 2014), arguably themes associated with dissonance, point in the same direction. Furthermore, the involvement of the prefrontal cortex (PFC) suggests a triangular neural involvement in the processing of dissonance (Ochsner & Gross, 2005, 2008). Aspects of this hypothesis were confirmed by four of the five recent neuroscience studies of dissonance (see Table 5). The evidence suggests that the cognitive conflict is detected in the dorsal anterior cingulate cortex (dACC), while for registering the discomfort the insula would be involved (Van Veen et al., 2009). In addition, Izuma et al. (2010) and Kitayama et al. (2013) found the expected activation of the PFC. The latter study also traced increased activation in the posterior cingulate cortex (PCC) and caudate putamen (CPU). Findings from one of the five studies were inconsistent with the rest. Jarcho et al. (2011) observed that dissonance-related attitude change was associated with activity in right inferior frontal gyrus (IFG), medial frontal-parietal regions, and ventral striatum as well as decreased activity in the anterior insula. These contrasting findings suggest that a hypothesis testing approach would need to be regarded with caution.

The study reported on here, while being mindful of the emerging hypothesis around ACC, insula, and PFC activity is essentially explorative in nature, using first and foremost a whole-brain perspective and keeping an open mind towards the involvement of other brain regions in the experience of cognitive dissonance.

METHODOLOGY

In preparation for the task design in this fMRI study, dissonance induction items needed to be constructed. The items were selected on the basis of the outcome of a separate Item Selection Survey (see details later). The fMRI study involved three types of data gathering: behavioral, fMRI, and debriefing data. Written, informed consent was obtained according to the Declaration of Helsinki. Ethical approval for the study was provided by the relevant ethics panel in the researchers' university.

Item selection survey (*n* = 125)

A total of 160 items were developed referring to common events people are likely to experience in life. Of these items 80 contained events that potentially generate dissonant responses (Have you ever watched images on television of dying children, but you did not give money to charities to help them?) and 80 were constructed to generate consonant responses (Have you ever offered your seat to an old person or pregnant woman in a waiting room or public transport?). The aim of the questions was to identify whether these events were commonly experienced. Some of the items were inspired by earlier empirical studies on dissonance (such as Dickerson et al., 1992; Fointiat, 2004). Mixed in with the evenly distributed dissonant and consonant items were 40 control items in which events were presented that participants would have been unlikely to have experienced (Have you ever fallen from a bridge in a river?). This was done to provide a contrast and to break the pattern of responding with a "yes" answer.

The item pool was divided into two versions, each containing 100 items (40 dissonance, 40 consonance, and 20 control items). Participants were randomly assigned to either one or the other version. Participants (n = 125) were students who were invited by email with an embedded link to the survey website (www.surveymonkey.com). The task took about 10–15 minutes to complete.

The results showed that the majority of participants reported to have experienced the presented dissonance- and consonance-provoking events. However, for inclusion in the fMRI study only the items that were experienced by over 80% of participants were considered. Nonetheless, many of the items selected were supported by close to 90% of participants. In total, 81 items met the criteria. Of these items, 72 were used. After the final selection, items were randomly assigned to the format of one of the four conditions (see Experimental and Control Conditions section).

FMRI study

Participants

To facilitate comparisons, a homogeneous sample was sought among undergraduate students (n = 14, mean age = 22 years, SD = 1.34, range: 20–25 years). Two of the participants' scans were compromised by excessive head movements and could not be included in the fMRI analysis. The following inclusion criteria were used: female, right-hand dominance, native English speaking, normal or corrected to normal vision. Exclusion criteria were: current use of psychoactive medication, history of psychiatric or neurological disorders. All participants were provided with written information on the procedure and provided informed written consent prior to scheduling and on arrival at the scanning session. Before the scanning procedure participants received a voucher for €30 in compensation for their time.

Procedure and stimuli

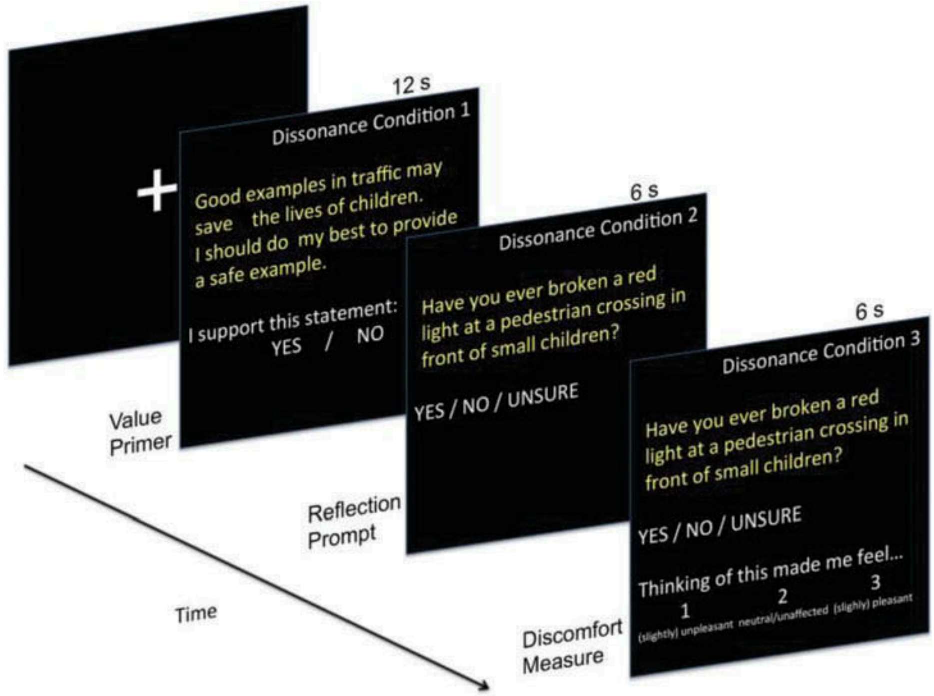
After a brief instruction session in a separate room with a mock scanner, participants were led into the scanner room to start the scanning session. The 72 trials were presented in groups of four containing a dissonance trial and three control conditions in random order. The session was divided in three runs of 24 trials each with a brief pause in between. Each trial contained the following sequence: value primer, memory prompt, and discomfort measure (see Figure 1).

Experimental and control conditions

In the experimental condition dissonance was induced by asking participants to reflect on experiences in which they had behaved inconsistently with a value they had just professed to support. The experimental condition was compared with three control conditions in which no cognitive dissonance was expected to occur. In the "justification" control condition, dissonance was expected to be reduced or prevented by providing a prior justification before reflecting on inconsistent behavior. In the "consonance" control condition, participants were prompted to reflect on a consonant experience. And in the "non-self-related" condition, the participants were prompted to think of behavior of others inconsistent with the value presented. Only the dissonance condition was expected to generate the full dissonance discomfort experience.

MRI scanning protocol

Imaging data were acquired using a Philips Intera Achieva 3.0T MR system (Best, The Netherlands). Whole-brain BOLD (blood-oxygen-level dependent) signal changes were measured using a T2*-weighted echo-planar imaging sequence with repetition time (TR) = 2000 ms and echo time (TE) = 30 ms. In all, 482 volumes were acquired during each of the three experimental runs, with voxel dimensions of 3 × 3 × 3.5 mm and a 0.35-mm gap between the slices. Each volume of data covered the entire brain with 39 slices, and the slices were acquired in interleaved sequence from inferior to superior direction. A T1-weighted/inversion recovery (T1W/IR) sequence was used to collect a 3D high-resolution anatomical image with voxel dimensions equal to 0.9 × 0.9 × 0.9 mm for structural localization.



Control conditions	Slide 1	Slide 2/3
Justification	Honesty is a very important quality. However, it is not always wise.	Can you think of having been dishonest?
Consonance	It is important to save water to avoid water shortages.	Do you ever turn off taps to save water?
Not self-related	Overeating is an important health risk and should be avoided.	Do you know people who tend to overeat?

Figure 1. Timeline of the task with examples of the experimental and three control conditions.

Stimulus presentation was controlled using Matlab® software (www.mathworks.com).

FMRI data analysis

Pre-processing

The MRI data were analyzed using analysis of functional neuro-images (AFNI; Cox, 1996; http://afni.nimh.nih.gov/afni/) and FSL (FMRIB Software Library; http://www.fmrib.ox.ac.uk/fsl/). The first four dynamics were obtained to correct for T1 equilibration effects and were subsequently discarded. The data were motion corrected by realignment to the first volume of the first run, concatenated into a single run, global mean-adjusted by proportional scaling and smoothed with a 6 mm full-width-at-half-maximum Gaussian kernel.

First-level analysis

Statistical analyses were performed using a general linear model (GLM) approach in AFNI. Three regressors of interest were included to model the variance due to each trial in the task-one regressor each to model the BOLD signal at the onset times of the primer, memory, and rating prompts. As there were four trial types (dissonance, consonance, justification, and non-self related), there were 12 regressors of interest in total.

Several regressors of no interest were also included in the GLM to model the following sources of variance: (a) six head motion parameters, (b) eight regressors to model low frequency noise, and (c) three regressors to model the mean differences between the two experimental runs. All regressors were convolved with a standard gamma hemodynamic response function (HRF).

Transformation of results to standard MNI space

The first-level statistical results (regressor coefficients maps) were normalized to MNI space (Montreal Neurological Institute/International Consortium for Brain Mapping 152 standard atlas as provided in the FSL software package) using FSL's linear registration tool, FLIRT.

Second-level analysis

Subject-specific contrasts were estimated using a fixed-effects model. For the group analysis these estimates were entered in a second-level analysis treating participants as a random effect. The average BOLD response across the brain during the reflection prompt in the dissonance condition ("dissonance induction") was compared to that in the other three, controls conditions with three paired *t*-tests. For these *t*-tests significant voxels initially passed a voxel-wise statistical threshold of $p \leq .01$, and a minimum cluster size of 960 mm^3 of contiguous statistically significant voxels was applied to correct for multiple comparisons across the brain. This cluster size was calculated using a Monte Carlo simulation (AlphaSim in AFNI) to obtain a family-wise error (FWE) corrected $p < .05$ statistical significance level. In order to control for Type-I errors upon performing three *t*-tests, a Bonferroni correction was applied to these results, using a voxel-level threshold of $p < .0033$ ($t > 3.11$). This was applied after the normal whole-brain FWE correction for multiple comparisons. The Statistical Parametric Mapping (SPM8, http://www.fil.ion.ucl.ac.uk/spm) anatomy toolbox (V1.8, Eickhoff et al., 2005) was used to localize activation clusters; however, where there were no probabilistic cytoarchitectonic labels available, a Brodmann area (BA) is given in the results table instead.

Temporal aspect of the analysis

Considering that the focus of the study was first and foremost on tracing dissonance induction, it was essential that the comparison of the fMRI data across the different conditions would take place at the moments of its likely occurrence. Therefore, the analysis has focused mainly on the reflection phase, when participants in the dissonance condition were most likely to first become aware of the discrepancy between the experience they had been asked to bring to mind and the value they had just before professed to support. It was important not to wait too long after this, because spontaneous justification efforts might have started a dissonance reduction process. Hence, the moments of acknowledgment of having experienced the event suggested for reflection was chosen as possibly the most optimal choice.

RESULTS

Behavioral results

Overall, the response to the questions confirms that the selection of values and events for the experimental design had been successful. In response to the value primer (Do you support this statement? YES/NO) participants responded with YES 88.3% of the times, which suggests that most of the values presented were supported by the vast majority of participants. In response to the reflection prompt, which asked participants whether they could recall an instance of the event suggested (YES/NO/UNSURE) participants responded with YES 88.5% of the times, which suggests that most of the events presented were experienced by the vast majority of participants.

The response to the discomfort measure (as shown in Table 1) shows that participants reported the dissonance, justification, and non-self-related conditions generally as unpleasant, while in contrast the consonance experience was experienced mostly as pleasant. It would seem that participants did not consciously discriminate in their affective response to the three inconsistency conditions.

FMRI results

Dissonance versus consonance

The comparison of the BOLD response during the reflection prompt in the dissonance versus consonance

TABLE 1
Response to discomfort measure (%) for the four conditions ($n = 14$)

Condition	*Unpleasant (%)*	*Pleasant (%)*	*Neutral (%)*
Dissonance	75.5	2.3	19.9
Consonance	75.3	3.2	18.1
Justification	9.1	69.9	17.6
Non-self-related	72.2	0.5	27.3

trials revealed greater activation to dissonance in a number of brain regions, particularly in parietal and frontal cortex and the cerebellum. The main clusters of increased dissonance-related activation were located in the precuneus, the inferior and superior parietal lobules, left dorsolateral PFC (BA 45), left and right ACC, left insular cortex (anterior insular cortex (AIC)), bilateral cerebellum (Crus I and II especially), visual cortex (BA 17, 18, and 37), and the left thalamus. These results are summarized in Table 2 and Figure 2.

Dissonance versus justification

There was increased activation in the dissonance versus justification conditions in frontal, parietal, and early visual cortex and in the cerebellum The main clusters of difference were located in the left precuneus, the right supramarginal gyrus, the precentral gyrus, and supplementary motor area (SMA) bilaterally, the left superior medial gyrus, the right calcarine gyrus, the left lingual gyrus, and bilateral lobule V of the cerebellum. These results are shown in Table 3 and Figure 3.

Dissonance versus non-self-related

There was greater activation in response to dissonance versus non-self-related reflection prompts in a number of brain areas, particularly in the frontal and parietal lobes. The main clusters were located in the left inferior and superior parietal lobules, the left middle occipital gyrus, BA 6 and 45 bilaterally in the PFC, the left insula and insula/IFG, the left middle cingulate cortex, bilateral cerebellum, and early visual cortex (BA 17 and 18). Table 4 and Figure 4 show a summary of these results.

Debriefing results

The response to the Dissonance Measure (Elliot & Devine, 1994) suggests that overall participants did not feel residual discomfort after having been prompted to remember dissonance-provoking events. Participants were asked to indicate their response to a list of 24 emotions of which three constituted the dissonance measure: uneasy, uncomfortable, and bothered (scale from 1 (does not apply at all) to 7 (applies very much)). The mean response to these three items (averaged) showed very low levels of dissonance emotions (m = 1.57, SD = 0.85). Furthermore, the scanner experience (10-point scales) did not give cause for concern as participants mostly thought of it as more interesting than boring

TABLE 2

Results of a *t*-test showing greater activation for dissonance versus consonance conditions during the reflection prompt

Brain area	*# Voxels*	*t-Value*	*MNI coordinates*	*Anatomical label*
Parietal lobe				
Left precuneus	228	5.94	−12, −62, 46	SPL (7A): 20%
Left inferior parietal lobule	166	5.35	−44, −42, 50	Area 2: 30%
Left superior parietal lobule	150	10.37	−34, −56, 64	SPL (7A): 60%
Temporal/parietal lobe				
Right superior temporal gyrus	149	7.73	66, −42, 20	IPC (PF): 80%
Temporal/frontal lobe				
Left temporal pole	68	5.40	−46, 6, −14	BA 38
Frontal lobe				
Left middle frontal gyrus	149	9.41	−34, 26, 22	BA 45
Left precentral gyrus	116	6.25	−32, −12, 68	Area 6: 10%
Right middle frontal gyrus	62	5.79	32, 60, 20	BA 46
Left inferior frontal gyrus	38	7.54	−40, 30, −4	BA 45
Right ACC	28	4.20	12, 34, 12	BA 33
Left ACC	22	5.28	−8, 28, 26	BA 24
Left insula lobe	17	5.12	−36, 12, 14	Insula
Cerebellum				
Right cerebellum	130	4.93	12, −52, −14	Lobule V: 63%
Left cerebellum	101	6.23	−18, −48, −32	—
Right cerebellum	92	9.00	38, −72, −32	Crus I: 98%
Occipital lobe				
Left cuneus	89	6.21	−8, −74, 20	Area 17: 30%
Right calcarine gyrus	86	4.63	20, −64, 14	Area 18: 30%
Right inferior occipital gyrus	15	4.42	34, −82, −16	V4: 60%
Left fusiform gyrus	11	4.12	−28, −54, −16	BA 37
Subcortical				
Left thalamus	44	4.60	−14, −6, 14	Temporal: 20%

Notes: For each statistically significant cluster, the *t*-value and MNI coordinates of the peak value are given. For the sake of brevity only the main clusters of difference in each brain area are listed. MNI coordinates are: *LPI* where left, posterior, and inferior directions are negative. Clusters are significant at $p < 0.0033$, Bonferroni corrected.

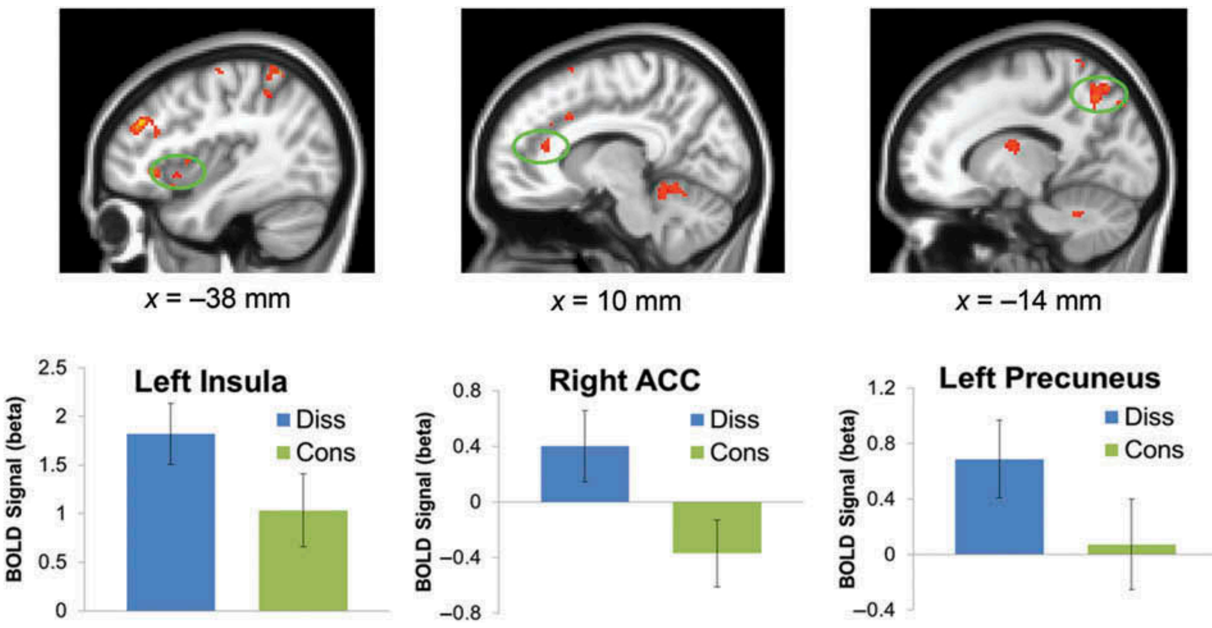


Figure 2. Greater activation for the dissonance versus consonance conditions during the reflection prompt. The bar charts depict beta values from the peak voxel of difference in the highlighted clusters.

TABLE 3
Results of a *t*-test showing greater activation for dissonance versus justification conditions during the reflection prompt (see Table 2 notes)

Brain area	*# Voxels*	*t-Value*	*MNI coordinates*	*Anatomical label*
Parietal/occipital lobe				
Left precuneus	405	8.69	−8, −60, 14	Area 18: 30%
Frontal lobe				
Right precentral gyrus	390	10.14	28, −10, 54	Area 6: 20%
Left SMA	299	5.47	−4, −16, 50	Area 6: 90%
Left precentral gyrus	71	5.26	−36, −10, 58	Area 6: 40%
Right SMA	34	4.77	2, 6, 66	Area 6: 50%
Right superior medial gyrus	28	4.49	4, 56, 20	BA 9
Left superior medial gyrus	17	4.41	0, 58, 10	BA 9
Parietal/frontal lobe				
Right postcentral gyrus	195	8.15	32, −40, 64	Area 1: 60%
Right precentral gyrus	121	8.17	46, −14, 44	Area 4a: 70%
Left postcentral gyrus	138	5.90	−40, −32, 58	Area 3 b: 60%
Parietal lobe				
Left postcentral gyrus	23	5.14	−24, −42, 52	Area 2: 50%
Right supramarginal gyrus	11	4.66	32, −40, 42	Area 2: 50%
Occipital lobe				
Right calcarine gyrus	153	7.54	20, −62, 18	Area 18: 10%
Left lingual gyrus	11	4.74	−14, −34, −6	Hipp (SUB): 80%
Cerebellum				
Right cerebellum	87	6.49	16, −44, −18	Lobule V: 84%
Left cerebellum	73	7.97	−16, −44, −14	Lobule V: 57%
Subcortical				
Left caudate nucleus	32	4.21	−4, 6, −6	—

(m = 6.86, SD = 2.66), more pleasant than unpleasant (m = 6.36, SD = 2.17), and reported to have been mostly calm rather than nervous (m = 2.57, SD = 2.31). Participants had not found it very difficult to focus (m = 2.64, SD = 1.90) nor did they find the console difficult to operate (m = 1.29, SD = 0.61). We can therefore be confident that the performance on the task had not been impeded by the participant's experience in the scanner.

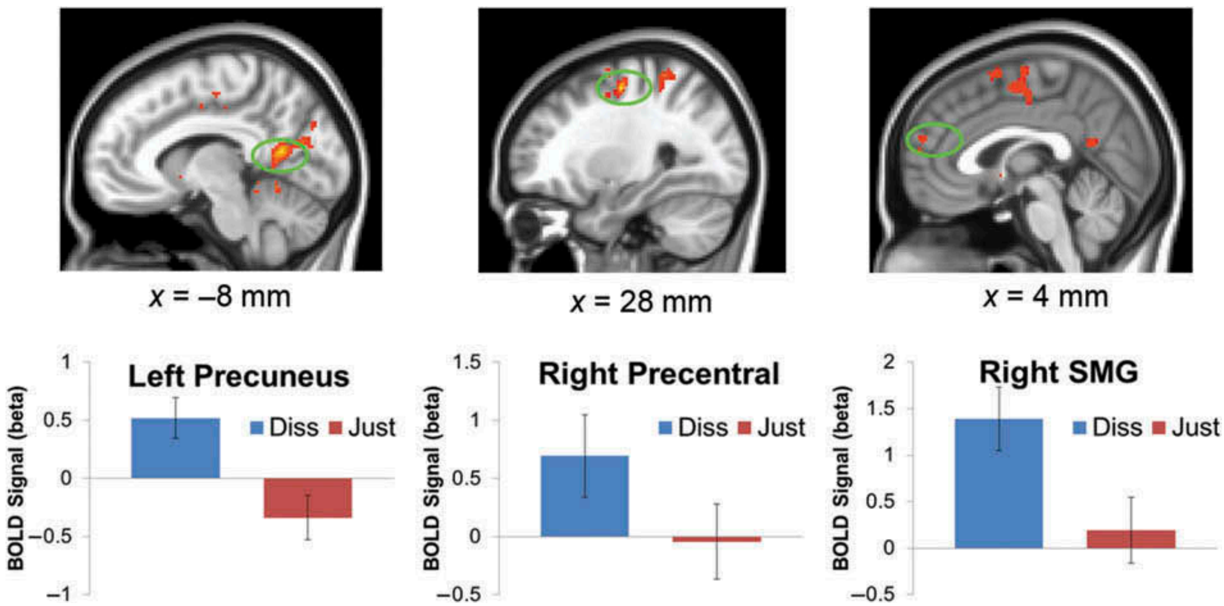


Figure 3. Greater activation for the dissonance versus justification conditions during the reflection stage of the task.

TABLE 4
Results of a *t*-test showing greater activation for dissonance versus non-self-related conditions during the reflection prompt (see Table 2 notes)

Brain area	*# Voxels*	*t-Value*	*MNI coordinates*	*Anatomical label*
Occipital/parietal lobe				
Left middle occipital gyrus	3479	10.24	−26, −60, 38	hIP3: 30%
Parietal lobe				
Left inferior parietal lobule	906	12.08	−34, −40, 42	hIP3: 40%
Left superior parietal lobule	14	5.74	−30, −58, 66	SPL (7A): 70%
Frontal lobe				
Right precentral gyrus	873	8.63	28, −6, 56	Area 6: 20%
Left superior frontal gyrus	188	5.33	−22, −8, 60	Area 6: 30%
Right middle cingulate cortex	157	6.01	8, −20, 32	BA 23
Right precentral gyrus	86	5.79	42, −8, 46	Area 6: 40%
Left middle cingulate cortex	65	6.63	−6, −26, 26	BA 23
Left middle frontal gyrus	59	4.46	−40, 36, 18	Area 45: 30%
Left insula lobe	19	4.90	−40, 16, −8	—
Left SMA	16	4.63	−14, 2, 62	Area 6: 50%
Left ACC	16	4.19	−6, 26, 26	BA 32
Right ACC	15	4.55	8, 30, 20	BA 32
Cerebellum				
Left cerebellum	240	6.70	−4, −44, −12	Lobules I-IV: 88%
Right cerebellum	42	5.73	30, −54, −48	Lobule VIIb: 18%
Right cerebellum	17	4.66	34, −40, 34	Lobule VI: 88%
Occipital lobe				
Right inferior occipital gyrus	63	5.94	38, −68, −10	hOC4v (V4): 20%
Left calcarine gyrus	57	4.75	0, −96, 10	Area 17: 60%
Right superior occipital gyrus	37	5.68	20, −82, 26	BA 19
Right middle occipital gyrus	36	5.07	38, −78, 24	IPC (Pgp): 30%
Right lingual gyrus	11	4.39	124, −56, −6	Area 18: 40%
Temporal lobe				
Right superior temporal gyrus	7	4.75	54, −42, 18	IPC (Pfm): 50%

(*Continued*)

TABLE 4
(Continued)

DISCUSSION

In this study we examined the brain activation accompanying the experience of cognitive dissonance, in particular the dissonance induction phase. In general,

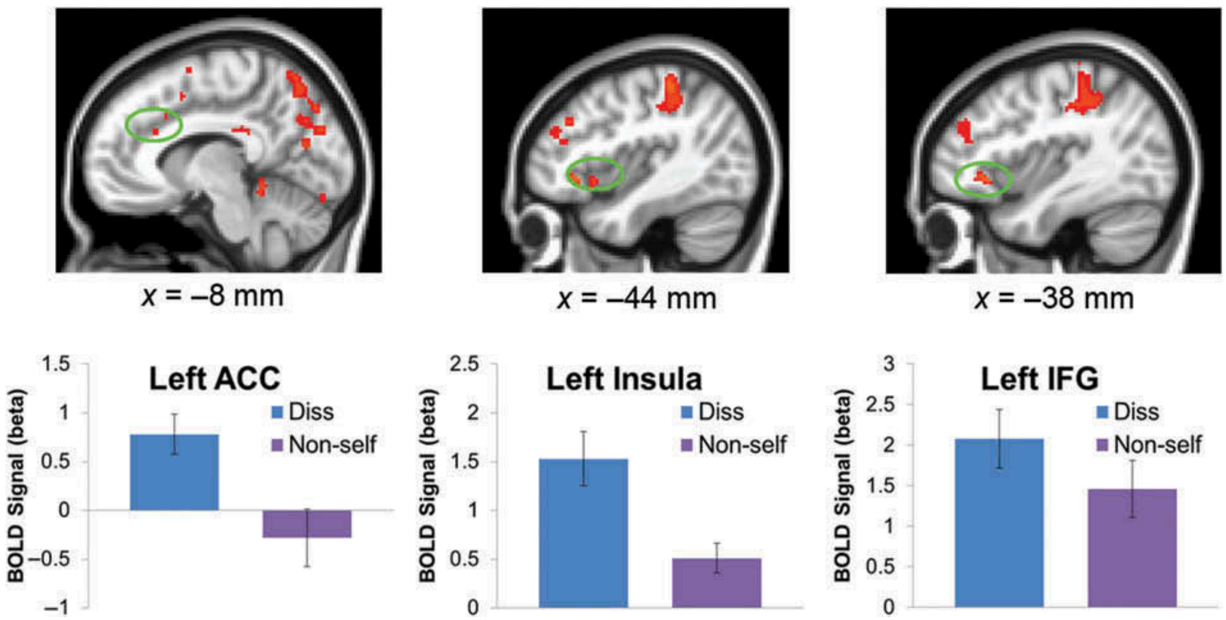


Figure 4. Greater activation for the dissonance versus non-self-related conditions during the reflection stage of the task.

the findings support the notion that the experience of cognitive dissonance is accompanied by activation in brain areas that have been implicated in emotional processing, cognitive conflict, and control and social cognition, as well as self-referential memory retrieval and attentional motor control. In no case did we find stronger activation during the induction phase for the control conditions; dissonance always led to higher levels. This is particularly remarkable and suggests that the dissonance experience mobilizes the brain to an extent that the other conditions did not. Furthermore, compared to the control conditions of consonance, justification and non-self-related inconsistency, the experience of cognitive dissonance was associated with increased neural activation in several key brain regions including the ACC, AIC, IFG, and precuneus. The present findings fit in with the perception of joint functioning of ACC and AIC (Medford & Critchley, 2010) which could well be a core aspect of the induction phase of cognitive dissonance. It is noteworthy that activations in AIC and ACC were not different between the dissonance condition and the justification condition. This suggests that even if a justification was provided similar responses to the inconsistency took place. This needs further investigation. The limited differentiation in PFC functioning between the conditions within the present study could also be specific for the fact that dissonance induction rather than reduction took place.

While not hypothesized, the involvement of the precuneus should not surprise us as its role has been documented in the processing of visual imagery during episodic memory retrieval (Fletcher, Shallice, Frith, Frackowiak, & Dolan, 1996). Evidence supports the notion that it is activated in particular during reflection on salient personal past. The fact that the strongest contrast in retrieval-associated activation in the precuneus–IFG network occurred in the comparison between the dissonance and justification conditions suggests that the urgency to search episodic memory was higher when no justification for the dissonance was provided. As well as having a role in self-relevant memory retrieval, the precuneus and other regions of the parietal cortex may be involved in the mental representation of the self (Cavanna & Trimble, 2006; Lou et al., 2004), which might explain their strong involvement in the experience of dissonance in the current study.

Comparison with other dissonance studies

While a thorough review of the cognitive dissonance and fMRI literature is perhaps premature with only five published studies available to date, we would still like to give the reader the opportunity to consider these studies' findings side by side, including our results (see Table 5). It is clear that while the differences in outcomes between the studies in the table are striking, there are also significant similarities, and while the tasks in the present study and Van Veen

TABLE 5
Comparison with the five other fMRI studies on cognitive dissonance (available publications at time of submission)

Authors	*Aspects of dissonance*	*Design*	*Analysis*	*Main findings*
Van Veen et al. (2009)	Dissonance during counter attitudinal expression and attitude change	Induced compliance procedure/Solomon four-group design; scanning took place while participants argued that the uncomfortable scanner was a pleasant environment: dissonance group was instructed to lie to stooge; control group received money to lie	Whole brain	Dissonance group: experienced more activation in dorsal anterior cingulate cortex (dACC) and anterior insula cortex (AIC), this also predicted attitude change
Jarcho et al. (2011)	Dissonance reduction during decision-making attitude change during choice making	Forced choice in scanner between pairs of previously similarly rated paintings and names; post-experiment ratings of the same items demonstrated attitude change in favor of chosen items	Whole brain and region of interest (ROI)	Greater shift in attitude associated with: increased activity in R inferior frontal gyrus (IFG), medial fronto-parietal regions; ventral striatum; and decreased activity in anterior insula (AIC)
Izuma et al. (2010)	Dissonance during choice-induced preference change	Forced choice in scanner between pairs of pre-rated (by the participant) food items. Trials included choices between and within preferred and not preferred items and choices made by the computer	ROI	Higher discrepancy coincides with higher activity in dACC and dorsolateral prefrontal cortex (dPFC)
Qin et al. (2011)	Choice justification during choice-induced preference change	Forced choice in scanner between pairs of pre-rated (by the participant) music CDs. Comparison of preferences for chosen and rejected items (pre-choice and post-choice)	Whole-brain exploratory analysis	Attitude change associated with neural activities in ventral medial prefrontal cortex (mPFC), right temporal parietal junction (TPJ), anterior insula (AIC), and bilateral cerebellum
Kitayama et al. (2013)	Dissonance during choice justification and attitude change	Forced choice in scanner between pairs of pre-rated (by the participant) music CDs. Trials included choices between similarly rated (difficult) and contrastingly rated (easy) choices	Whole-brain and parametric modulation analysis	Difficult choices vs. easy choices: higher activation of dACC and left anterior insula (aINS).Choice justifying attitude change correlated with PCC activation and right nucleus accumbens
Our study	Dissonance during reflection on memories of counter attitudinal behavior	Reflection on personal experiences dissonant with supported values. Comparison of responses with three control conditions: justified dissonance, consonance, and non-self-related inconsistent events	Whole brain	Dissonance induction leads to more brain activity overall; AIC, ACC, inferior frontal gyrus (IFG), and precuneus were activated significantly more in the dissonance condition

et al. (2009) were different from the other four, similarities were found across the board. The increased activation of the ACC in dissonance processing in our study is shared with three of the other studies (Izuma et al., 2010; Jarcho et al., 2011; Van Veen et al., 2009); the increased activation of the anterior insula is shared with two of the other studies (Izuma et al., 2010; Van Veen et al., 2009). It is noteworthy that Jarcho et al.'s (2011) study found decreased activity in the anterior insula. The involvement of the IFG is shared with Jarcho et al. (2011), although they found it in the right hemisphere and we did in the left, but with none of the other studies, while the precuneus activity is entirely unique for our study. In light of its role in memory processes this makes sense, because none of the other studies asked participants to reflect on their memories.

The association of the PFC with dissonance is documented elsewhere (E. Harmon-Jones et al., 2008) and mostly suggests that it has a role in dissonance reduction (Van Veen & Carter, 2006). Although we did find greater PFC activation in response to dissonance in all three contrasts, in areas including the inferior and middle frontal cortex, and the anterior cingulate, we did not find activation in medial PFC, as reported by Izuma et al. (2010). This region has more typically been linked with top-down control however, and given that our study focused on dissonance induction rather than reduction, this finding is not surprising. As intended, the quick succession of items in our study will most likely not have permitted our participants much time to engage with regulatory mechanisms.

Strengths and limitations of the study

Although previous studies have examined the brain activation associated with cognitive dissonance, the current study was unique in that it focused specifically on the experience of dissonance induction, rather than subsequent efforts to reduce dissonance, such as through attitude change. The task was also ecologically valid in the sense that it drew on people's own experiences in everyday life, making the results and insights about brain activation more applicable to our understanding of the daily experience of cognitive dissonance. The significant differences in brain activation between the dissonance and control conditions contrast with the behavioral findings which suggest that participants were only aware of experiencing less discomfort in the consonance condition. This demonstrates again the relevance of fMRI efforts, as we may have limited awareness of differential affective and cognitive complexity.

The main limitation of the study is the small sample size, which did not allow us to isolate the most effective items and still retain statistical power. With increased power it would be feasible to conduct more sophisticated statistical analyses of the data, including those which can measure functional connectivity. An obvious choice in the current context might be a psychological PPI analysis (McLaren, Ries, Xu, & Johnson, 2012) which would allow for the testing of task-dependent functional connectivity between key regions such as the anterior insula and ACC, or the precuneus and IFG. Another limitation, which is also an ethical concern, is the intensity of dissonance that would be acceptable in an fMRI study. The study was designed to avoid lingering discomfort to the participants. And as the debriefing results suggest, our efforts to err on the side of caution were successful.

CONCLUSION

This fMRI study used a novel paradigm for the study of cognitive dissonance in fMRI research. It shows promise in the sense that (a) the behavioral response suggests that the task was effective in its experimental manipulation; (b) the fMRI findings demonstrate higher activations at the dissonance induction stage in the dissonance condition in comparison with the other conditions in the study; in particular the anterior insula, ACC, IFG, and precuneus were activated significantly more in the dissonance condition; (c) core findings concur with some of the other fMRI studies on dissonance. The comparison with the other five dissonance and fMRI studies may provide the impetus for a more concerted effort to consider different approaches for the study of dissonance. So far, it is not entirely clear whether differences in outcomes could be task-related or the result of a different focus in the data analysis. Notwithstanding Fiske's (2000, p. 214) warning that "[brain] geography is not inherently theoretical" (implying that models arising from social psychological research may not coincide with how the brain's processing is organized in actuality), it is evident that progress is made in our efforts at tracing the neuroscience foundation of cognitive dissonance. Perhaps dissonance theory can contribute to integrating the often fragmented efforts to study the neuroscience of cognitive conflict, error-monitoring, unfairness, norm violations, moral choices, and other topics with cognitive or behavioral inconsistency at its core.

Original manuscript received 26 June 2014
Revised manuscript accepted 18 November 2014
First published online 16 December 2014

REFERENCES

Aronson, E. (1968). Dissonance theory: Progress and problems. In R. P. Abelson, E. Aronson, W. J. McGuire, T. M. Newcomb, M. J. Rosenberg, & P. H. Tannenbaum (Eds.), *Theories of cognitive consistency: A sourcebook*. Chicago, IL: Rand McNally.

Aronson, E. (2003). *The social animal* (9th ed.). New York, NY: Worth.

Aronson, E., Fried, C. B., & Stone, J. (1991). Overcoming denial and increasing the intention to use condoms through the induction of hypocrisy. *American Journal of Public Health*, *81*(12), 1636–1638. doi:10.2105/AJPH.81.12.1636

Botvinick, M. M. (2007). Conflict monitoring and decision making: Reconciling two perspectives on anterior cingulate function. *Cognitive, Affective, & Behavioral Neuroscience*, *7*(4), 356–366. doi:10.3758/CABN.7.4.356

Brehm, J. W. (1956). Postdecision changes in the desirability of alternatives. *The Journal of Abnormal and Social Psychology*, *52*(3), 384–389. doi:10.1037/h0041006

Carter, C. S., & Van Veen, V. (2007). Anterior cingulate cortex and conflict detection: An update of theory and data. *Cognitive, Affective, & Behavioral Neuroscience*, *7* (4), 367–379. doi:10.3758/CABN.7.4.367

Cavanna, A. E., & Trimble, M. R. (2006). The precuneus: A review of its functional anatomy and behavioural correlates. *Brain*, *129*(Pt3), 564–583. doi:10.1093/brain/awl004

Cooper, J. (2007). *Cognitive dissonance: 50 years of a classic theory*. London: Sage.

Cox, R. W. (1996). AFNI: Software for analysis and visualization of functional magnetic resonance neuroimages.

Computers and Biomedical Research, *29*(3), 162–173. doi:10.1006/cbmr.1996.0014

Denke, C., Rotte, M., Heinze, H.-J., & Schaefer, M. (2014). Belief in a just world is associated with activity in insula and somatosensory cortices as a response to the perception of norm violations. *Social Neuroscience*, *9*(5), 514–521. doi:10.1080/17470919.2014.922493

Dickerson, C. A., Thibodeau, R., Aronson, E., & Miller, D. (1992). Using cognitive dissonance to encourage water conservation1. *Journal of Applied Social Psychology*, *22* (11), 841–854. doi:10.1111/j.1559-1816.1992.tb00928.x

Eickhoff, S., Stephan, K. E., Mohlberg, H., Grefkes, C., Fink, G. R., Amunts, K., & Zilles, K. (2005). A new SPM toolbox for combining probabilistic cytoarchitectonic maps and functional imaging data. *NeuroImage*, *25* (4), 1325–1335. doi:10.1016/j.neuroimage.2004.12.034

Elliot, A. J., & Devine, P. G. (1994). On the motivational nature of cognitive dissonance: Dissonance as psychological discomfort. *Journal of Personality and Social Psychology*, *67*, 382–394. doi:10.1037/0022-3514.67.3.382

Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford, CA: Stanford University Press.

Festinger, L., & Carlsmith, J. M. (1959). Cognitive consequences of forced compliance. *The Journal of Abnormal and Social Psychology*, *58*(2), 203–210. doi:10.1037/h0041593

Fiske, S. T. (2000). Stereotyping, prejudice, and discrimination at the seam between the centuries: Evolution, culture, mind, and brain. *European Journal of Social Psychology*, *30*(3), 299–322. doi:10.1002/(SICI)1099-0992(200005/06)30:3<299::AID-EJSP2>3.0.CO;2-F

Fletcher, P. C., Shallice, T., Frith, C. D., Frackowiak, R. S., & Dolan, R. J. (1996). Brain activity during memory retrieval. The influence of imagery and semantic cueing. *Brain*, *119*(5), 1587–1596. doi:10.1093/brain/119.5.1587

Fointiat, V. (2004). “I know what I have to do, but. . .” When hypocrisy leads to behavioral change. *Social Behavior & Personality: An International Journal*, *32*(8), 741–746. doi:10.2224/sbp.2004.32.8.741

Freud, S. (1923). *The Ego and the Id*. (J. Riviere, Trans., 1961, J. Strachey, ed.). New York, NY: W. W. Norton.

Fried, C. B. (1998). Hypocrisy and identification with transgressions: A case of undetected dissonance. *Basic and Applied Social Psychology*, *20*(2), 144–154. doi:10.1207/s15324834basp2002_6

Gawronski, B. (2012). Back to the future of dissonance theory: Cognitive consistency as a core motive. *Social Cognition*, *30* (6), 652–668. doi:10.1521/soco.2012.30.6.652

Güroğlu, B., van den Bos, W., van Dijk, E., Rombouts, S. A. R. B., & Crone, E. A. (2011). Dissociable brain networks involved in development of fairness considerations: Understanding intentionality behind unfairness. *NeuroImage*, *57*(2), 634–641. doi:10.1016/j.neuroimage.2011.04.032

Harmon-Jones, E., Gerdjikov, T., & Harmon-Jones, C. (2008). The effect of induced compliance on relative left frontal cortical activity: A test of the action-based model of dissonance. *European Journal of Social Psychology*, *38*(1), 35–45. doi:10.1002/ejsp.399

Harmon-Jones, E., & Harmon-Jones, C. (2002). Testing the action-based model of cognitive dissonance: The effect of action orientation on postdecisional attitudes. *Personality and Social Psychology Bulletin*, *28*(6), 711–723. doi:10.1177/0146167202289001

Harmon-Jones, E., Harmon-Jones, C., & Amodio, D. M. (2012). A neuroscientific perspective on dissonance, guided by the action based model. In B. Gawronski & F. Strack (Eds.), *Cognitive consistency: A fundamental principle in social cognition* (pp. 47–65). New York, NY: Guilford Press.

Harmon-Jones, E., Lueck, L., Fearn, M., & Harmon-Jones, C. (2006). The effect of personal relevance and approach-related action expectation on relative left frontal cortical activity. *Psychological Science*, *17*(5), 434–440. doi:10.1111/j.1467-9280.2006.01724.x

Harmon-Jones, E., Peterson, H., & Vaughn, K. (2003). The dissonance-inducing effects of an inconsistency between experienced empathy and knowledge of past failures to help: Support for the action-based model of dissonance. *Basic and Applied Social Psychology*, *25*(1), 69–78. doi:10.1207/S15324834BASP2501_5

Heider, F. (1958). *The psychology of interpersonal relations*. New York, NY: Wiley.

Izuma, K., Matsumoto, M., Murayama, K., Samejima, K., Sadato, N., & Matsumoto, K. (2010). Neural correlates of cognitive dissonance and choice-induced preference change. *Proceedings of the National Academy of Sciences*, *107*(51), 22014–22019. doi:10.1073/pnas.1011879108

Jarcho, J. M., Berkman, E. T., & Lieberman, M. D. (2011). The neural basis of rationalization: Cognitive dissonance reduction during decision-making. *Social Cognitive and Affective Neuroscience*, *6*(4), 460–467. doi:10.1093/scan/nsq054

Kitayama, S., Chua, H. F., Tompson, S., & Han, S. (2013). Neural mechanisms of dissonance: An fMRI investigation of choice justification. *NeuroImage*, *69*, 206–212. doi:10.1016/j.neuroimage.2012.11.034

Lou, H. C., Luber, B., Crupain, M., Keenan, J. P., Nowak, M., Kjaer, T. W., … Lisanby, S. H. (2004). Parietal cortex and representation of the mental self. *Proceedings of the National Academy of Sciences*, *101* (17), 6827–6832. doi:10.1073/pnas.0400049101

McLaren, D. G., Ries, M. L., Xu, G., & Johnson, S. C. (2012). A generalized form of context-dependent psychophysiological interactions (gPPI): A comparison to standard approaches. *NeuroImage*, *61*(4), 1277–1286. doi:10.1016/j.neuroimage.2012.03.068

Medford, N., & Critchley, H. D. (2010). Conjoint activity of anterior insular and anterior cingulate cortex: Awareness and response. *Brain Structure and Function*, *214*(5–6), 535–549. doi:10.1007/s00429-010-0265-x

Morita, T., Tanabe, H. C., Sasaki, A. T., Shimada, K., Kakigi, R., & Sadato, N. (2014). The anterior insular and anterior cingulate cortices in emotional processing for self-face recognition. *Social Cognitive and Affective Neuroscience*, *9*(5), 570–579. doi:10.1093/scan/nst011

Ochsner, K. N., & Gross, J. J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences*, *9*(5), 242–249. doi:10.1016/j.tics.2005.03.010

Ochsner, K. N., & Gross, J. J. (2008). Cognitive emotion regulation: Insights from social cognitive and affective neuroscience. *Current Directions in Psychological Science*, *17* (2), 153–158. doi:10.1111/j.1467-8721.2008.00566.x

Qin, J., Kimel, S., Kitayama, S., Wang, X., Yang, X., & Han, S. (2011). How choice modifies preference: Neural correlates of choice justification. *NeuroImage*, *55*(1), 240–246. doi:10.1016/j.neuroimage.2010.11.076

Rogers, C. R. (1951). *Client-centered therapy.* Cambridge, MA: The Riverside Press.

Sharot, T., De Martino, B., & Dolan, R. J. (2009). How choice reveals and shapes expected hedonic outcome. *The Journal of Neuroscience*, *29*(12), 3760–3765. doi:10.1523/JNEUROSCI.4972-08.2009

Stone, J., Aronson, E., Crain, A. L., Winslow, M. P., & Fried, C. B. (1994). Inducing hypocrisy as a means of encouraging young adults to use condoms. *Personality and Social Psychology Bulletin*, *20*(1), 116–128. doi:10.1177/0146167294201012

Takaku, S. (2001). The effects of apology and perspective taking on interpersonal forgiveness: A dissonance-attribution model of interpersonal forgiveness. *The Journal of Social Psychology*, *141*(4), 494–508. doi:10.1080/00224540109600567

Tryon, W. W., & Misurell, J. R. (2008). Dissonance induction and reduction: A possible principle and connectionist mechanism for why therapies are effective. *Clinical Psychology Review*, *28*(8), 1297–1309. doi:10.1016/j.cpr.2008.06.003

Van Veen, V., & Carter, C. S. (2006). Error detection, correction, and prevention in the brain: A brief review of data and theories. *Clinical EEG and Neuroscience*, *37*(4), 330–335. doi:10.1177/155005940603700411

Van Veen, V., Krug, M. K., Schooler, J. W., & Carter, C. S. (2009). Neural activity predicts attitude change in cognitive dissonance. *Nature Neuroscience*, *12*(11), 1469–1474. doi:10.1038/nn.2413

Vinski, E. J., & Tryon, G. S. (2009). Study of a cognitive dissonance intervention to address high school students' cheating attitudes and behaviors. *Ethics & Behavior*, *19*(3), 218–226. doi:10.1080/10508420902886692

Young, L., & Dungan, J. (2012). Where in the brain is morality? Everywhere and maybe nowhere. *Social Neuroscience*, *7*(1), 1–10. doi:10.1080/17470919.2011.569146

Zanna, M. P., & Cooper, J. (1974). Dissonance and the pill: An attribution approach to studying the arousal properties of dissonance. *Journal of Personality and Social Psychology*, *29*(5), 703–709. doi:10.1037/h0036651