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Noninvasive Brain Stimulation Reduces Prejudice Scores on an Implicit Association Test

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Objective: Inhibiting the anterior temporal lobe (ATL) via repetitive transcranial magnetic stimulation (rTMS) appears to have deleterious effects on people's semantic conceptualization, and left ATL damage is associated with semantic dementia. However, little research has investigated whether rTMS can inhibit conceptual schemata that have potentially *negative* consequences. Our aim was to investigate whether rTMS to the ATLs could reduce scores on a standard measure of prejudice (implicit association test, IAT). ***Method:*** Forty (17 female; mean age 20.6) neurologically normal, right-handed undergraduates participated. Participants were randomly allocated into one of four rTMS stimulation conditions—left ATL, right ATL, control site (motor cortex, Cz), and sham stimulation. All participants completed a modified IAT, where "good" and "bad" words were replaced with "terrorist" and "law-abider" words, and, "Black" and "White" were replaced with "Arab" and "Non-Arab" words. Participants were then given 15 min of rTMS stimulation. Afterward, participants completed a parallel form of the IAT. ***Results:*** To investigate the effects of rTMS on IAT scores, a one-way ANOVA on the difference between pre- and postscores was carried out revealing that there were significant between group differences ($F3,36 = 3.57$; $p = .02$). Planned contrasts revealed that both left and right ATL stimulation significantly reduced IAT scores poststimulation, indicating lower prejudice. ***Conclusion:*** We show that prejudice scores can be significantly reduced by inhibitory rTMS delivered to the bilateral ATLs. This may implicate this area in conceptual associations that lead to overgeneralization and stereotyping of social groups.

Keywords: left anterior temporal lobe (LATL), right anterior temporal lobe (RATL), prejudice, implicit association test (IAT), repetitive transcranial magnetic stimulation (rTMS)

The study of prejudice has delivered many profound insights at a behavioral level. However, relatively little is known about the neural basis of prejudice formation, maintenance, and extinction. Neural investigation of prejudice has largely relied upon revealing brain areas activated after prejudice provoking stimuli, via ERP, PET, fMRI, and similar technologies. These innovative studies have yielded important findings, but are limited by their inability to define causal connections between the events being isolated (Amodio & Devine, 2006).

The cognitive perspective of prejudice, developed by Allport (1979) was the first to analyze prejudice as the product of an automatic and normal categorization process. The ability to categorize is a highly efficient cognitive heuristic and generally occurs with little conscious thought (Ryan, Park, & Judd, 1996). According to this theory, events, objects, and people can be grouped together on the basis of some underlying like properties and can be treated as similar to each other and differentiated from other categories (Medin & Smith, 1984). This cognitive process can be beneficial to simplify the complexity of the social world and also enables us to generate predictions derived from classification inclusion. However, there is also a cost to this efficient information processing; it can lead to irrational, overgeneralized and pervasive stereotypes. These stereotypes generate relatively innocuous errors when applied to objects and events but can be particular damaging when applied to social groups.

A current example of an overgeneralization being applied to a people group is the association of *Arab* and *terrorist* (Oswald, 2005). For some Westerners, one of the underlying properties of being a terrorist is being of Arabic descent, which is a statistically unwarranted generalization. Anti-Arab prejudice has risen post 9/11 as has the association of "Arab" and "terrorist" in world-wide media (Oswald, 2005). Arguably, the concept, "Arab-terrorist" is a strong stereotype primarily because of the frequency with which these two concepts have recently been paired. The current social relevance of this association promotes it as an interesting target for interventions that have the potential to weaken semantic associations.

We considered this concept to be an exemplary case of the way in which the normal processes of classification can be misguided, having potentially negative effects. As it has been previously shown that rTMS to the ATLs differentially retards different classes of concepts (Pobric, Jeffries, & Lambon Ralph, 2009, Pobric, Lambon Ralph, & Jeffries, 2007; Gallate et al., 2009; Lambon Ralph, Pobric, & Jefferies, 2009; Gozzi et al., 2009) we reasoned that a novel and important application of this methodology would be to test whether it was capable of inhibiting a concept that is strong because of its distinctive associative conditioning history and considered to be socially negative.

Controversially, the implicit association test (IAT; Greenwald, McGhee, & Schwartz, 1998) has been extensively used to measure prejudice and stereotypical attitudes; however the underlying neural basis of stereotypical attitudes is still elusive (Gozzi et al.,

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2009). Many theorists have suggested that the frontal cortex and the limbic system are key areas implicated in prejudice. Specifically, the amygdala has been found to be critically involved in cognitive and affective learning, including implicit attitudes (Amodio & Devine, 2006; Dolan, Lane, Chua, & Fletcher, 2000; Phelps, Cannistraci, & Cunningham, 2003; Stanley, Phelps, & Banaji, 2008). However, patients with damage to the amygdala still display behavioral evidence of implicit racial prejudice (Amodio & Devine, 2006; Phelps et al., 2003). This suggests activation of the amygdala may be an effect rather than a cause of racial prejudice. Based on the cognitive theory of prejudice, the neural processes that are involved in forming and sustaining prejudice may be closely related to the networks responsible for associative, conceptual thinking. Neuroimaging and neuropsychological studies indicate that semantic cognition is supported by a neural network made up of the prefrontal cortex, temperoparietal junction and the bilateral temporal poles (Jefferies & Lambon Ralph, 2006). Consequently, emerging evidence suggests that the anterior temporal lobes (ATLs) may be an area involved in prejudice via mediating conceptual processing (Snyder, Bossomaier, & Mitchell, 2004). Here, we emphatically state that our hypothesis is not that prejudice "resides" in the ATLs, but posit that the ATLs play a contributory processing role, (possibly only gating select information in their role as an association area between other nuclei) in *all* semantic association processing and, therefore, by extension 'stereotyping.' Racial prejudice is one among many forms of semantic association that the ATLs appear to mediate to some degree. It is, however, one of the more interesting, because its effects have social ramifications.

Much of the research about the ATL has come from the study of semantic (the temporal variant of frontotemporal) dementia. Patients with semantic dementia show significant atrophy of the ATLs, predominantly on the left-side (Chan et al., 2001; Mummery et al., 1999) and are characterized by a progressive loss of semantic memory and knowledge, including face recognition, anomia, and word/story comprehension (Channon & Crawford, 2000; Gainotti, 2007; Mummery et al., 2000). A number of studies have also shown that people become less conceptual and more literal following the onset of semantic dementia (Miller et al., 1998) and the application of low frequency repetitive transcranial magnetic stimulation (rTMS) (Gallate et al., 2009; Pobric et al., 2007; Pobric et al., 2009; Oliveri, Romero, & Papagno, 2004; Snyder, 2009) to the left anterior temporal lobe (LATL). This led to the hypothesis that inhibitory rTMS to the LATL might reduce high implicit association test scores. High scores on a racial IAT reflect strong associations between a certain race (e.g., Arab), and negative attributes (e.g., terrorist), relative to other races—this is often termed the "stereotypical" condition. IATs generally reflect a greater difficulty in associating the target race (compared to other races) with positive or desirable traits rather than vice versa—this is often termed the "counterstereotypical" condition. We reasoned that disruption of these associations may lead to lower and less biased test scores. This evidence generated the first hypothesis of this paper, that rTMS inhibition of the LATL would decrease IAT scores, and consequently the first contrast analysis used in our statistical design.

However, there is contradictory and growing evidence about the role of both the LATL and RATL and how they might interact in semantic processing. Therefore, we designed a comprehensive analysis that was able to discriminate between competing theories that have arisen. The evidence for these different positions follows.

A recent study by Gozzi et al. (2009) showed that patients with lesions to the ATL were associated with increased stereotypical attitudes, measured by higher scores on a gender IAT. Based on the results of this study, it appeared that loss of the right superior ATL function led to higher gender stereotyping, in effect making patients more conceptual and less literal. Neuropsychological studies have reported that patients with frontotemporal dementia with predominant right ATL atrophy show more social behavioral changes, such as lack of empathy (Liu et al., 2004) and disinhibited, eccentric behavior as well as semantic anomia and memory impairments (Edwards-Lee et al., 1997). This suggests that the ATLs may be lateralized in their behavioral function and contribution to associative thinking and stereotypical attitudes. Based on this evidence inhibitory rTMS to the right ATL may lead to an increase in prejudice scores in the Arab-terrorist IAT, because participants are further biased toward their stereotypes. This formed our second hypothesis. The consequent contrast analysis that we designed to test this hypothesis asked if RATL inhibition resulted in different IAT scores compared to control site, sham, and LATL stimulation. (This contrast also enabled us to test an auxiliary hypothesis, that RATL inhibition would decrease prejudice scores. The evidence for this theory is from Boggio et al. (2009) who recently showed that inhibitory transcranial DC stimulation (tDCS) to the RATL made participants less conceptual and more literal on a false memory task.)

The above evidence is, for the most part, parsimonious if the roles of the ATL are lateralized, in as much as inhibition of the LATL decreases conceptual processing and inhibition of the RATL increases reliance on established concepts. However, there is considerable evidence that the ATL bilaterally is important to conceptual processing, that unilateral contribution has not been accurately delineated and that the interaction between the two lobes is unclear. A recent TMS study by Lambon Ralph, Pobric, and Jefferies (2009) investigated the roles of the bilateral ATLs and their role in conceptual knowledge. They found that inhibiting either left or right ATL via rTMS led to a significant slowing in a semantic judgment task. In addition, as previously mentioned, inhibition of the right temporal lobe via tDCS made participants less conceptual and more literal on a false memory task (Boggio et al., 2009). This would suggest a similar role for the ATL bilaterally in semantic conceptual processing and that inhibiting it would lead to a reduction of prejudice as measured by the IAT. This suggested our third hypotheses—inhibiting the left and right ATL compared to sham and control site would result in lowered prejudice scores.

Our fourth hypothesis followed logically from the preceding theory. If both ATLs were effective in reducing prejudice scores, we designed a contrast to ask whether one lobe plays a significantly greater role than the other in this effect. Thus LATL inhibition was compared to RATL inhibition (and the control sites ignored). This contrast also tests a version of lateralization theory (for review, see Snyder, 2009). That is that if LATL inhibition decreases IAT scores and RATL inhibition increases them, the result for this contrast should have been highly significant.

Thus, the inconsistent evidence for the contribution of the left versus right temporal regions to stereotyped and conceptual processing, led to the specific hypotheses and statistical design of the current study. At a broader level our underlying assumption was that people would have an automatic bias to associate Arab sounding names with terrorist words and non-Arab sounding names with 'law-abiding' words in an IAT (this in turn would manifest in higher IAT scores because of either faster processing of the pairing Arab-terrorist (vs. non-Arab-terrorist) and/or slower processing of Arab-law-abider (vs. non-Arab-law-abider). From this we reasoned that if associative conceptual processing is disrupted by rTMS, after stimulation participants would tend to disregard the shared associative connotations of the stimulus words presented in the IAT and complete the task as instructed. Thus, they would tend to treat the stimulus words as discrete entities, producing more balanced responses resulting in lower IAT scores. We predicted that stimulation to a control site and sham stimulation would have no effect on IAT scores.

Four specific, discriminating hypotheses were investigated:

1. Based on the semantic dementia literature, inhibiting conceptual nuclei in the LATL via rTMS would lead to a reduction of scores in an Arab-terrorist IAT compared to the sham, control, and RATL stimulation groups.
2. Based on the research on right ATL lesions (e.g., Gozzi et al., 2009), inhibitory rTMS to the RATL will lead to an increase in scores in an Arab-terrorist IAT, compared to all other conditions.

Contrastingly

3. Based on the Lambon Ralph et al. (2009) studies on conceptual knowledge, rTMS to both right and left ATLs will lead to a reduction in scores on the IAT compared to the sham or control site stimulation groups.
4. The lateralization hypothesis of the ATL (review, Snyder, 2009) would suggest that conceptual thinking is supported by the left ATL whereas literal thinking is supported by the right ATL. Therefore, inhibiting the left ATL will decrease scores in the IAT and inhibiting the right ATL will increase scores.

Materials and Method

Participants

Forty (17 female; mean age 20.6, $SD = 7.2$) neurologically normal, right-handed undergraduates participated. Candidates were screened using the TMS Adult Safety Screen (Keel, Smith, & Wassermann, 2001). Participants were naïve to the hypotheses of the experiment and randomly allocated into one of four stimulation conditions—left ATL stimulation, right ATL stimulation, control site Cz (motor cortex) stimulation and sham. The experiment was conducted in accordance with the Declaration of Helsinki and was approved by the University of Sydney Human Research Ethics Committee.

IAT

The IAT was adapted from the standard 'Black-White' prejudice test (developed by Project Implicit, Nosek, Greenwald and Banaji). We modified the test because the stimulus pairing, Arab-terrorist, has been prevalent in the media in recent years; thus, maximizing the chance that participants had developed that prejudicial association. We used an IAT because these have been shown to be a technically reliable measure of implicit prejudice (Greenwald, Nosek, & Banaji, 2003; Nosek, Greenwald, & Banaji, 2005), and they have superior predictive validity to explicit measures of prejudice in socially sensitive contexts (Stanley et al., 2008). The test was coded in Javascript and presented online.

The standard IAT was modified by replacing bad words with terror words (e.g., "hijacker") and good words with law-abider words (e.g., "taxpayer"). Participants categorized Arab versus non-Arab sounding names (e.g., "Habib" vs. "Benoit"). They also categorized terrorist versus law abiding words (e.g., "sniper" vs. "citizen").

The task consisted of a total of 120 trials spread across five conditions. Condition 1 required subjects to discriminate between Arab and non-Arab names ($n = 20$ trials). Conditions 2 and 4 required subjects to discriminate words from one of two stereotypical attributes—terrorist and law-abiding ($n = 20$ trials for each condition). The critical blocks are Conditions 3 and 5 that combine category and attribute stimuli and involved mapping either a stereotypically consistent attribute (e.g., Arab + terrorist vs. non-Arab + law-abiding) or a counterstereotypically consistent attribute (Arab + law-abiding vs. non-Arab + terrorist) to the same hand ($N = 40$ trials for each condition). The order of stereotypical versus counterstereotypical pairings were counterbalanced across subjects as well as across pre- and poststimulation phases.

Response accuracy and latency were collected and the "IAT effect" was calculated by subtracting the difference in average response latency between the critical trial blocks and dividing by the pooled standard deviation (Greenwald et al., 2003). Higher difference scores (D-scores) indicate a stronger implicit association of Arab sounding names with terrorism and non-Arab sounding names with law-abiding than Arab sounding names with law-abiding and non-Arab sounding names with terrorism. In accordance with Greenwald et al.'s (2003) improved scoring methods for the IAT, RTs (where initial errors occurred) were comprised of the sum of the incorrect RT and the time required to produce the correct response to the stimulus. The mean error rate was 7%. This rate is similar to the error rates found in previous studies using a racial IAT (for e.g., Beer et al., 2008; Karpinski & Hilton, 2001; Smith-McLallen et al., 2006). We adhered to the improved IAT scoring methods proposed by Greenwald et al. (2003) using Cohen's D as the IAT effect. Greenwald and his colleagues (2003) also suggest that any RTs over 10,000 ms should be deleted and to exclude subjects who had 10% of their responses less than 300 ms. However, there were no RTs above 10,000 or below 300 ms in our data set. We believe this was because our participants performed the task in a controlled laboratory setting, compared to the unsupervised online testing done by Greenwald et al. The new scoring algorithm gives final IAT scores that are less contaminated by extraneous factors (Greenwald et al., 2003). In particular relevance to the current study, the algorithm reduces sensitivity to prior IAT experience which was a factor in using a pretest, posttest design.

Stimulation Protocol

Participants were randomly assigned to stimulation condition. They received 15 min of either sham or rTMS (1 Hz) stimulation to the LATL, RATL, or control site. The resting motor threshold was determined by placing the coil over the left primary motor area and establishing the minimum amount of stimulator output (amplitude) required to produce a motor-evoked potential in the right first dorsal interosseous muscle. The motor thresholds ranged from 35 to 58% of stimulator output. The LATL stimulation site was determined by measuring halfway between T7 and FT7 on the International 10–20 System for electrode placement. This positioning method has been shown to correlate highly with MRI-based neuronavigation approaches, and is considered appropriate for studies that require a "medium grain of precision" (Herwig, Satrapi, & Schonfeldt-Lecuona, 2003). The location of stimulation was kept constant by using a chin restraint and a fixed magnetic coil. The RATL stimulation site was directly opposite the former, approximately half way between T8 and FT8. The control stimulation site used was the vertex (Cz).

rTMS was administered via Medtronic MagPro stimulator with a 70 mm butterfly coil (MCF-B65). Participants received 90% of motor-threshold stimulation at 1 pulse per second. The coil was inverted in the sham condition so that subjects could hear audible clicks identical to those produced during active rTMS, but were exposed to negligible magnetic stimulation. Because we used a between subject design, none of the sham participants had received active rTMS stimulation to compare it with, so sham stimulation was an effective placebo.

Procedure

Participants completed the IAT, which took ~8 min, and then received 15 min of sham or rTMS stimulation. After stimulation, they completed a parallel form of the IAT test (versions were counterbalanced). Finally, participants completed a self-report questionnaire. Biographical data and prejudice ratings (3-point Likert scale) were collected and participants were asked whether they were favorably disposed toward people of Arabic descent.

Analysis

Data was analyzed with SPSS version 16.0 software. One-way analysis of variance (ANOVA) was run on the difference between D-scores from pre- to postmeasures. Planned contrasts were then carried out to test each of the 4 hypotheses. It is customary to run no more than k-1 contrasts (that would be, in our case, 3), to control the family wise error rate. However, we can justify using k contrasts by using the Bonferroni correction method, which is regarded as conservative. This involves dividing the alpha rate by the number of contrasts, that is 0.05/4 = 0.0125.

Results

Figure 1 presents the mean D-scores for each condition, before and after stimulation. A one-way ANOVA on prescores showed that there were no between group differences in baseline scores on the IAT, and on average participants had positive scores indicating a moderate-high implicit bias to associate Arab names with terrorist attributes and non-Arab names with law-abider attributes (compared to vice versa). Overall error rates were stable across conditions (LATL 8.1%, RATL 5.7%, Cz 7.4% sham 7.8%) and did not change significantly between pre- and posttreatment for stereotypical or counterstereotypical pairings (see Table 1).

To investigate the effects of rTMS on IAT scores, a one-way ANOVA on the difference between pre- and postscores was car-

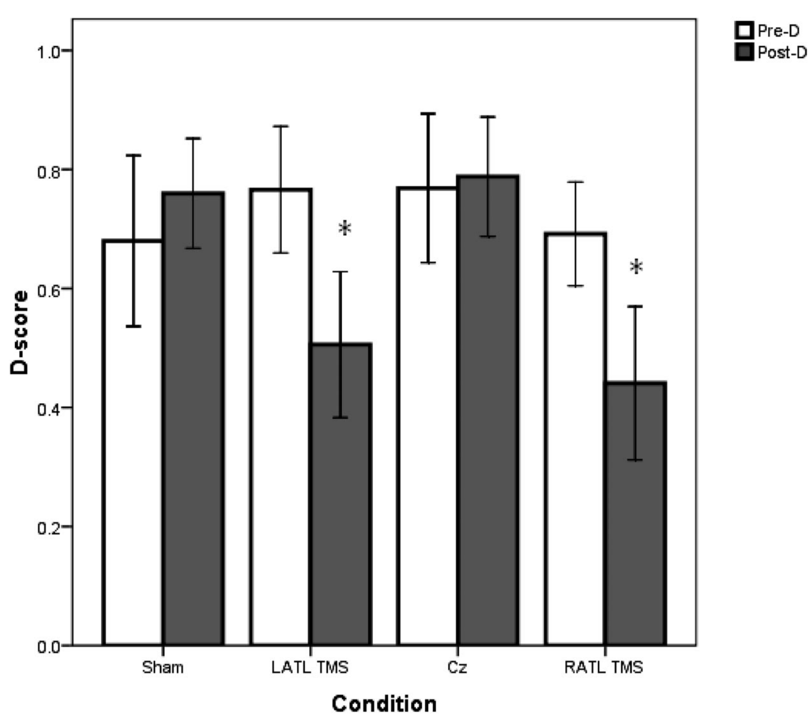

Figure 1. Mean D-scores of participants on the Arab prejudice IAT before and after rTMS and sham stimulation. Higher scores indicate greater prejudice.

Table 1
Mean IAT RTs Pre- and Poststimulation/Sham for Stereotypical and Counterstereotypical Pairings (Plus Error Rates)

Condition	Stereotypical pre-	Error rate	Counterstereotypical pre-	Error rate	*SD* pre-	Stereotypical post-	Error rate	Counterstereotypical post-	Error rate	*SD* post-
LATL	976.423	7.25%	1,520.438	20%	748.975	1,035.020	10.5%	1,279.890	18%	672.040
RATL	959.573	7.25%	1,403.29	18.75%	606.138	915.95	7.25%	1,075.478	15%	428.562
Cz	978.918	5%	1,530.589	18.5%	745.738	930.014	4%	1,313.466	12.5%	594.1054
Sham	977.593	8.25%	1,417.100	17.75%	749.411	866.590	4.25%	1,262.668	15.25%	532.307
Total	973.1268	6.94%	1,467.85	18.75%	712.566	936.894	6.5%	1,232.88	15.19%	556.754

Note. All scores in milliseconds, Stereotypical pre-/post- = mean RT for pairing Arab names with terror words (non-Arab names with law-abiding words); Counterstereotypical pre-/post- = mean RT for pairing Arab with law-abiding words (non-Arab with terror words); $N = 20$.

ried out revealing that there were significant between group differences ($F3{,}36 = 3.57$; $p = .02$). Planned contrasts were carried out to investigate where these differences occurred and to test the 4 hypotheses stated in the introduction. Contrast 1, which tested if the LATL group had lower scores compared to all other groups, was not significant ($t = 1.87$; $p = .07$). Contrast 2 investigated whether the RATL stimulation significantly increased scores relative to the other groups and was also found to be nonsignificant ($t = 1.81$; $p = .08$). As seen from Figure 1, the RATL condition had lower IAT scores after stimulation, similar to the LATL group. The third contrast based on the Lambon-Ralph et al. (2009) results, that both LATL and RATL stimulation would lead to a decrease in IAT scores relative to the control conditions was found to be highly significant ($t = 3.19$; $p = .003$). The final contrast was asking the question whether rTMS to the LATL reduced scores and RATL increased scores relative to sham and the control site condition. This was also found to be nonsignificant ($t = .036$; $p = .97$).

Paired *t* tests confirmed that both the RATL and LATL group had significantly lower IAT scores after stimulation (RATL: $t = 3.16$, $p = .01$; LATL: $t = 3.42$, $p < .01$). The sham and the control site group had no change in IAT scores poststimulation. No participant selected "yes" for being prejudiced and 95% claimed to be favorably disposed toward people of Arabic descent.

Discussion

The results of the current study demonstrated that LATL and RATL rTMS stimulation was capable of reducing prejudice scores on an IAT. Before stimulation participants associated Arab sounding names with negative-trait words and non-Arab sounding names with positive-trait words. (This may parallel reports of societal increases in *explicit* anti-Arab prejudice since the events of 9/11 [Oswald, 2005].) High scores on the IAT contradicted participants' expressed attitudes as the majority responded that they were not prejudiced. After stimulation, participants in the Left and Right ATL stimulation group had significantly lower prejudice scores while those in the sham and control site groups did not.

It is numerically counterfactual to associate Arab and terrorist (but not non-Arab with law-abiding). Many terrorists are not Arabic, a highly insignificant percentage of Arabs are terrorists and most people's direct experience of Arabs is undifferentiated from that of any other race. In addition, racial prejudice and blatant bias are socially unacceptable in modern society (Utsey, Joseph, & Jerlym, 2008). However, we found that rTMS to either the left or right ATL was able to reduce IAT scores and we posit that this was primarily because inhibitory rTMS was able to temporarily weaken the dominant stereotypical associations Arab-terrorist and non-Arab-law-abider and strengthen the counterstereotypical associations Arab-law-abider and non-Arab-terrorist. This was the only hypothesis that attained statistical significance, supporting the work of Lambon-Ralph et al. (2009) that the ATLs, bilaterally, are involved in semantic cognition.

Close inspection of the results in Table 1 indicate that the LATL and RATL D-scores can be dissociated by the relative contribution of stereotypical and counterstereotypical pairings. After LATL stimulation the stereotypical pairing reaction times actually became slower than prestimulation, whereas in the RATL condition the score was largely the result of faster processing of the counterstereotypical condition after stimulation. (However, a post hoc $2 \times 2 \times 2$ ANOVA revealed no significant interaction differences between the LATL and RATL conditions on stereotypical and counterstereotypical pairings and pre- and poststimulation). Although overall reaction time appeared to get faster in the poststimulation test across all the conditions (see Table 1), only the LATL and RATL groups became significantly faster in the counterstereotypical phase (LATL: $t = 4.36$, $p = .002$; RATL: $t = 3.81$, $p = .00$). No group significantly changed in their stereotypical phase reaction times from pre- to poststimulation.

Our contention is that the significant change in D-score for the LATL condition is primarily because of the decreased reaction times for counterstereotypical pairings and, to a lesser extent, to the minor slowing of the stereotypical pairing. We conjecture that people's preexisting prejudicial views about Arabs (the most likely cause of the initial high D-scores) are somehow reduced via inhibitory rTMS. Possibly, rTMS to the LATL enables counterstereotypical pairings to seem less incongruent, enabling faster processing of Arab-law abider and non-Arab-terrorist. Similarly, in reducing the initial prejudice, LATL rTMS interferes with the usually rapid processing of stereotypical pairings, producing a slight (nonsignificant) slowing.

It is also entirely plausible that rTMS to both the left and right ATL had no effect (direct *or* indirect) on the stereotypical pairing but that instead it enabled participants to be open to *any* association, including the counterstereotypical pairings Arab-law-abider and non-Arab-terrorist. Thus, these associations were processed more quickly in comparison to their pre-TMS baseline times.

None of these contentions, however, answer the question of why the response pattern for the LATL and the RATL are different. That is, why there is no slowing in the sterorotypical pairings in the RATL condition (while there is some minor slowing in the LATL condition). Our theory is incapable of adequately answering this question, it remains an interesting theoretical puzzle. As previously stated, lateralization between the hemispheres may result in the left and right ATLs having variable degrees of similarity and discordance in their function. As previously summarized, there is evidence for both similar and differentiated functionality of the left and right ATLs in regards to semantic processing. This may have contributed to our results but at this point it remains speculation. We also acknowledge that the IAT is a complex task involving many cognitive processes. At the lower level of processing, attention, perception, and motor control all contribute to responding in the IAT (e.g., Richeson et al., 2003) and higher level processes include (but are not limited to) working memory, task switching, and general cognitive ability (Mierke & Klauer, 2001). Any (or all) of these may have been affected, either negatively or positively, by rTMS to the ATLs and therefore could logically account for our results. However, as overall reaction times tended to decrease after stimulation, and error rates indicate that this is not because of a simple speed/accuracy trade off, it could be assumed that rTMS *facilitates* whichever of these process is potentially contributing to our results (also, the increase was specific to stimulation of the ATLs and not the control site). There is some preliminary evidence that TMS has resulted in modest increases in attention, and arguably perception, but there is little evidence that inhibitory rTMS can consistently improve any of the other processes mentioned above. If rTMS was having a debilitating effect on one of these cognitive capacities and therefore indirectly reducing semantic associations, it is hard to see why error rates would not have risen as a result. However it is possible that a debilitation of one of these processes could have resulted in an indirect but specific interference with semantic associations and therefore account for our results.

Perhaps the strongest challenge to our interpretation comes from evidence that salience may be the cause of the IAT effect rather than associative strength (e.g., see Rothermund & Wentura, 2004). It is apparent that both Arab and terrorist are probably more salient than non-Arab and nonterrorist. If the IAT is in fact a salience matching task and rTMS is capable of reducing salience then the results produced would be the same as ours. However, this would raise the question of how rTMS was able to reduce salience.

We suggest, consistently with the majority of the literature, that the most likely explanation for our results is an interference with the associative strength of the pairings, (weakening the stereotypical pairings and/or strengthening the counterstereotypical pairings), and as stimulation condition was the independent variable that we manipulated it is the strongest candidate to be the cause of this change in IAT effect. However, we acknowledge, that there are possible confounds that may have affected our results, and that because of these, our conclusions must remain circumspect. This leaves open the possibility of discovering new effects of rTMS on cognitive performance within this paradigm.

Many cogent theories, with good predictive validity, have addressed how prejudice develops at a behavioral level, as a byproduct of adaptive, efficient cognitive processes (see, e.g., Tobena, Marks, & Dar, 1999; Utsey et al., 2008). Integrated threat theory explains how media events could possibly induce implicit prejudice. Integrated threat theory (Stephan & Stephan, 2000) posits that a perceived, or symbolic, threat is capable of creating prejudice, in a similar way to realistic threats. In this sense, a specific racial prejudice can be a socially learned construct—a sort of enduring concept or association that is manipulable by stimuli other than direct experience.

We reasoned that the pervasive pairing of terrorism (and the threat of terrorist acts) with Arabic stimuli in the public domain strengthened an associative concept that broadly aggregates the two concepts Arab and terrorist (without, for the most part, direct experience) and also inversely strengthens the association of not-Arab with not-terrorist (when contrasted with Arab-terrorist). Importantly, because of the conceptual nature of this association, we predicted that it could be temporarily weakened by rTMS inhibition of areas of the brain that are important to conceptual processing. An analogous reduction was found in false memories using a similar stimulation protocol (Gallate et al., 2009). Further, attempts to reduce prejudice in social psychology have used the theory of "decategorization" (Brewer & Miller, 1984). As a key feature of prejudice or stereotypes is the deindividuation or overgeneralization of members of an outgroup, attempts to reduce category salience and promote more attention to personal characteristics at the individual level have been shown to reduce category stereotypes (Brewer & Gaertner, 2004). Similarly, rTMS to the ATLs may function in a roughly similar way by facilitating attention to each individual stimulus in the task, as the association between the stereotypical pairing of Arab and terrorist becomes weakened. Alternatively, rTMS may have enabled participants to allow the counterstereotypes of non-Arab-terrorist and Arab-law-abider to be held more strongly. This would have had a decategorizing effect by allowing counterexamples to be members of stereotypical categories such as terrorist.

There is empirical evidence to suggest that the ATLs are important conceptual centers of the brain (Mummery et al., 2000; Noppeney et al., 2007; Pobric et al., 2007; Rogers et al., 2004). Pobric et al. (2007) argue that it is central to processing semantic information. Several studies of acquired semantic dementia show damage to the ATLs, predominantly on the left side (Miller et al., 2000; Miller et al., 1998; Treffert, 2006). Relatedly, there is evidence that inhibiting this area via rTMS reduces a person's reliance on concepts or schemas (Pobric et al., 2007; Snyder, 2009). The pairings Arab-terrorist and non-Arab-law-Abider are compound concepts, and when these broad order concepts were putatively weakened via rTMS inhibition of the ATLs, people completed the IAT with less bias and therefore produced lower prejudice scores. That is, participants were able to pair non-Arab with terrorist, and Arab with law-abider (and Arab with terrorist and non-Arab with law-abider) as instructed. The slightly diminished effect of the preexistent stereotypes is manifest in the reaction times between stereotypical and counterstereotypical parings converging.

If our interpretations of the findings are correct, it would imply that the ATLs may be involved in the regulation of implicit prejudice. Dolan et al. (2000) identified the anterior temporal lobe and left amygdala as key areas involved in memories with strong emotional valence. Amodio and Devine (2006) suggest that the neural substrate of prejudice has both affective and cognitive components, with the amygdala circuit subserving the emotional. We posit that the ATL may be a component of the cognitive system (Fuggetta et al., 2008; Lambon-Ralph et al., 2008; Pobric et al., 2007) connected via efferent neurons to the amygdala that receives input from the sensory to the higher cognitive (Stanley et al., 2008).

Our results suggest that implicit prejudice scores can, at least temporarily, be reduced by noninvasive brain stimulation. These findings are consistent with the view that the ATL may be one of the brain areas involved in prejudicial biases, and to conceptual processing more generally.

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