Author: R. McKay, J. Arciuli, A. Atkinson, E. Bennett and E. Pheils

Title: Lateralisation of self-esteem: An investigation using a dichotically presented auditory adaptation of the Implicit Association Test

Journal: Cortex **ISSN**: 0010-9452

Year: 2010

Volume: 46

Issue: 3

Pages: 367-373

Abstract: Introduction: Self-esteem is one of the most prominent and influential constructs in psychological science, yet very few neuropsychological/neuroscientific investigations have been undertaken in this area of research. The current study investigated the possibility of hemispheric lateralisation of self-esteem.Methods: By creating an auditory version of the Implicit Association Test (IAT) for self-esteem, we were able to present stimuli dichotically and thereby compare left- versus right-hemispheric measurements of self-esteem in 46 healthy adults.Results: Although left- and right-hemispheric self-esteem measurements were correlated, within-participant analysis revealed that self-esteem levels (as reflected by IAT score) were significantly greater when elicited under right-ear pressentation (reflecting left hemispheric processing).Conclusions: We interpret this asymmetry with reference to the approach-withdrawal model of emotion processing and suggest avenues for future research.

Author Address: rmckay@csu.edu.au

jarciuli@csu.edu.au

URL: http://dx.doi.org/10.1016/j.cortex.2009.05.004

http://www.cortexjournal.net/article/S0010-9452%2809%2900158-0/abstract
https://www.zora.uzh.ch/19581/3/2009_McKay_R_Cortex_in_press.pdf

http://researchoutput.csu.edu.au/R/-?func=dbin-jump-full&object_id=10537&local_base=GEN01-CSU01

CRO Number: 10537

Lateralisation of self-esteem: An investigation using a dichotically presented auditory adaptation of the Implicit Association Test

Ryan McKay[1], Joanne Arciuli[2], Alikki Atkinson[3], Elaine Bennett[3] and Elisabeth Pheils[3]

[1] Institute for Empirical Research in Economics, University of Zurich
[2] Faculty of Health Sciences, University of Sydney
[3] School of Social Sciences and Liberal Studies, Charles Sturt University

Abbreviated title: LATERALISATION OF SELF-ESTEEM

Please address correspondence to:

Dr Ryan McKay
Institute for Empirical Research in Economics
University of Zurich
Bluemlisalpstrasse 10
Zurich CH-8006
Switzerland
Ph: +41 (0) 44 63 43665
Fax: +41 (0) 44 63 44907
ryantmckay@mac.com; rmckay@iew.uzh.ch

Acknowledgement: This study was co-supervised by the first two authors; the order of the last three authors is alphabetical. We thank Drew Fox for valuable discussions and Denika Novello for assistance with data collection. We also acknowledge the helpful comments and suggestions of two anonymous reviewers.

Abstract

Introduction: Self-esteem is one of the most prominent and influential constructs in psychological science, yet very few neuropsychological/neuroscientific investigations have been undertaken in this area of research. The current study investigated the possibility of hemispheric lateralisation of self-esteem.

Methods: By creating an auditory version of the Implicit Association Test (IAT) for self-esteem, we were able to present stimuli dichotically and thereby compare left- versus right-hemispheric measurements of self-esteem in 46 healthy adults.

Results: Although left- and right-hemispheric self-esteem measurements were correlated, within-participant analysis revealed that self-esteem levels (as reflected by IAT score) were significantly greater when elicited under right-ear presentation (reflecting left hemispheric processing).

Conclusions: We interpret this asymmetry with reference to the approach-withdrawal model of emotion processing and suggest avenues for future research.

Keywords not in title: Self-concept, dichotic listening, implicit processing.

Self-esteem is among the most prevailing of all psychological constructs. According to Rhodewalt and Tragakis (2003) the concept ranks alongside negative affectivity and gender as one of "the top three covariates in personality and social psychology research" (p. 66). A range of definitions of self-esteem have been proposed (e.g. Branden, 2001; James, 1890), and a variety of forms have been investigated including global versus specific self-esteem (e.g. Rosenberg et al., 1995), contingent versus true self-esteem (Deci and Ryan, 1995), trait versus state self-esteem (e.g. Brewer and Miller, 1996), personal versus social self-esteem (e.g. Crocker and Luhtanen, 1990) and secure versus defensive self-esteem (Jordan et al., 2003). Given the level of interest in the concept it is surprising that there have been so few neuropsychological/neuroscientifc investigations undertaken in this area. The present study sought to address this gap in the literature by examining the possibility of hemispheric lateralisation of self-esteem.

Self-esteem has traditionally been measured using explicit self-report instruments such as the Rosenberg Self-Esteem Scale (RSE; Rosenberg, 1965). Such measures, however, are susceptible to demand characteristics and social desirability bias (Greenwald and Farnham, 2000). In recent years, a number of new paradigms have been devised that measure self-esteem indirectly and *implicitly*. The most prevalent of these is the Implicit Association Test (IAT; Greenwald et al., 1998) for implicit self-esteem (Greenwald and Farnham, 2000).

The IAT is a computerised procedure designed to measure the strengths of automatic associations between concepts. Faster responding to a particular pairing of concepts is assumed to index a stronger association between the two concepts. Empirical research has demonstrated that the IAT is reasonably robust against social desirability bias and that it taps cognitive representations not assessed by self-report measures (Nosek et al., 2005). Greenwald and Farnham (2000) adapted the IAT for the measurement of implicit *self-esteem* by assessing automatic associations of the self with positive or negative valence. They demonstrated that the relative ease of making judgements when a *self* category and a *pleasant* category are combined can be used to index a participant's implicit self-esteem (individuals with higher implicit self-esteem should find categorisations easier when *self* and *pleasant* are paired than when *self* and *unpleasant* are paired).

Given the theoretical importance of the *self-esteem* concept, it is surprising that the question of whether self-esteem might be lateralised has not, to date, been investigated. This seems a fruitful line of inquiry when one considers the large body of research pertaining to the cortical lateralisation of emotion. An influential model of emotion processing, the *approach-withdrawal model* (Davidson, 1995), postulates that left- and right-anterior brain regions process emotions associated with approach and withdrawal behaviours, respectively. Approach behaviours are elicited by most positive emotions (e.g. happiness, amusement) and withdrawal behaviours are elicited by most negative emotions (e.g. fear, disgust), although anger – a negative emotion eliciting approach behaviour - is an important exception (Demaree et al., 2005).

The empirical support for the approach-withdrawal model of emotion processing is extensive, and incorporates evidence from sodium amytal injection studies (Rossi and Rosadini, 1967; Silberman and Weingartner, 1986), studies of patients with brain damage (e.g. Adolphs et al., 1996; Heilman et al., 1975; Robinson et al., 1984), and neuroimaging studies (e.g. Passero et al., 1995; Canli et al., 1998). Perhaps the most robust evidence, however, comes from a range of

EEG investigations by Davidson and colleagues (e.g. Davidson et al., 1979; Davidson and Fox, 1982; see also Harmon-Jones and Allen, 1998). Such investigations have found positive emotional states (and anger; see Harmon-Jones and Allen, 1998; Harmon-Jones and Sigelman, 2001) to be associated with a left > right *activation*[1] asymmetry, whereas negative emotional states (including depression; see Henriques and Davidson, 1990; 1991; Davidson and Henriques, 2000) are associated with the reverse: a right > left activation asymmetry.

The construct of self-esteem can be conceptualised within an approach-withdrawal framework (De Raedt et al., 2008). It seems reasonable to expect that higher self-esteem will be associated with approach behaviours and that lower self-esteem will be associated with withdrawal behaviours. Positive self-views, after all, have been found to be associated with positive affect states (Pelham and Swann, 1989), less depression (Tennen and Affleck, 1993) and greater persistence at difficult tasks, but also with aggression and violence (Baumeister et al., 1996). Moreover, Coats et al. (1996) demonstrated that individuals with more avoidance goals evaluated themselves more negatively on measures of self-esteem, optimism and depression.

In short, given the evidence that approach behaviours are left-lateralised, we wondered whether it would be possible to obtain greater measurements of self-esteem with stimuli presented to the left versus the right hemisphere. To our knowledge, this hypothesis has not been previously investigated. However, a recent study by De Raedt et al. (2008) did investigate whether the relationship between frontal EEG alpha asymmetry and depressive symptoms was mediated by self-esteem. Self-esteem was measured using both self-report (RSE) and indirect (IAT) methods. The results indicated that only self-reported (RSE) self-esteem mediated the path from EEG alpha asymmetry to depression. An earlier study by Urry et al. (2004) investigated the relationship between self-reported *well-being* and idiosyncratic EEG alpha asymmetry, finding that higher levels of well-being were associated with greater left than right superior frontal activation. An important difference between these studies and our study is worth emphasising. De Raedt et al. administered participants measures of self-esteem and examined the relationship between performance on such measures and idiosyncratic alpha asymmetry. Similarly, Urry et al. administered participants measures of well-being and examined the relationship between performance on such measures and idiosyncratic alpha asymmetry. In each case self-esteem or well-being varied *between* participants. The present study, in contrast, was designed to investigate whether measurements of self-esteem would diverge as a function of which hemisphere the self-esteem measure was presented to - *within* participants. This was accomplished by presenting an auditory version of the IAT for implicit self-esteem under dichotic listening conditions.

Dichotic listening involves the simultaneous presentation of two competing auditory stimuli, one to each ear. Variants of this basic paradigm have proven particularly useful in investigations of functional brain asymmetries, owing to the facts that under dichotic conditions contralateral auditory pathways are enhanced and ipsilateral auditory pathways are suppressed (e.g. Wexler, 1988; Hugdahl, 2005). Among other techniques, neuroimaging and ERP studies have confirmed the effectiveness of dichotic listening as a method of investigating hemispheric processing (e.g., Eichele et al., 2005; Hugdahl et al., 1999; Thomsen et al., 2004).

The present study utilised the dichotic listening paradigm to enable the selective presentation of IAT stimuli to one ear (and thus to one hemisphere) or the other. This procedure required an adaptation of the IAT to the auditory modality. Whereas the IAT has been used extensively in the visual format (see Devine, 2001; Nosek et al., 2007), no previous published research has utilised the IAT in auditory format. It is worth noting that adaptation to the auditory modality is not as straightforward as simply recording auditory versions of the stimuli presented visually in the standard IAT paradigm. Rather, auditory adaptation requires careful matching on a number of additional lexical and acoustic variables known to affect speech perception.

In summary, the current study contributes to the literature by reporting on an auditory adaptation of the IAT and by presenting this auditory IAT under dichotic listening conditions in order to examine the hemispheric lateralisation of self-esteem. In accordance with previous research regarding the lateralisation of emotion, we predicted that, within participants, presentation of the auditory self-esteem IAT to the right ear (i.e., the left hemisphere) would result in a greater IAT effect (indexing higher implicit self-esteem) than presentation to the left ear (i.e., right hemisphere).

Methods

Participants:

Participants were 46 first-year psychology undergraduates (36 females, 10 males; 35 right-handers, 5 left-handers and 6 ambidextrous participants[2]), who participated in partial fulfillment of course requirements. The age range of the sample was 18 to 46 years (mean age = 21.9 years, SD = 6.4). Informed consent was obtained from all participants. The study was approved by the Ethics in Human Research Committee of Charles Sturt University (Protocol Number 2006/235) and was thus performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

Materials/Apparatus:

A standard lexical IAT incorporates 20 words – five in each of four categories. Specifically, we utilised the *evaluative*[3] IAT for implicit self-esteem (Greenwald and Farnham, 2000), incorporating five positive trait adjectives, five negative trait adjectives, five *self* words and five *other* words.

Recording of candidate words: An initial pool of 60 personally descriptive trait adjectives (30 positive, 30 negative) was recorded, along with ten *self* and *other* words. All words were recorded by a female speaker using *Audacity*, a free open source software program available for download at http://audacity.sourceforge.net. The resulting sound files were trimmed and normalised and the acoustic duration of each (in milliseconds) was measured. The 60 adjectives were taken from the Personal Profile Questionnaire (PPQ; Kinderman, 1994). A separate sample of 30 participants rated these words for imageability (the ease with which a mental image of the word can be brought to mind), using a 7-point Likert scale. As per the procedure of McKay et al. (2007), the ten *self* and *other* words were personal pronouns, comprising the five grammatical forms (subjective, objective, reflexive, first possessive and second possessive) of the first-person singular and third-person plural pronouns (i.e., *I, me, myself, my, mine; they, them, themselves, their, theirs*).

Selection of final adjective sets: Ten trait adjectives (5 positive and 5 negative) were subsequently drawn from the recorded set of 60, chosen such that the groups of positive and negative adjectives were matched on a series of lexical variables obtained from the *Celex* database (Baayen et al., 1995). The two word groups (positive words - *capable, friendly, intelligent, successful, trustworthy;* negative words - *annoying, boring, foolish, obnoxious, weak*) did not differ significantly on number of phonemes, $t(8) = 2.76$, $p = .025$, spoken word frequency, $t(8) = 1.43$, $p = .191$, number of syllables, $t(8) = 1.63$, $p = .141$, or phonemic neighbourhood density (the number of words that differ from the target by a single phoneme), $t(8) = 1.58$, $p = .152$. In addition, there was no significant difference in terms of imageability, $t(8) = .15$, $p = .883$, or acoustic duration, $t(8) = 1.86$, $p = .100$.[4]

The final IAT word sets were thus as follows:

- "positive" words: *capable, friendly, intelligent, successful* and *trustworthy*.
- "negative" words: *annoying, boring, foolish, obnoxious* and *weak*.
- "self" words: *I, me, myself, my* and *mine.*
- "other" words: *they, them, themselves, their* and *theirs.*

Preparation of words for dichotic presentation: As in Arciuli and Slowiaczek (2007) we utilised acoustically reversed versions of targets as the competing auditory stimuli. Thus, four versions of each sound file were prepared – a left-forward version (a standard version of the target word outputting solely through the left channel), a right-forward version (a standard version outputting solely through the right channel), a left-backward version (an acoustically reversed version of the target word outputting solely through the left channel), and a right-backward version (an acoustically reversed version outputting solely through the right channel). Two final stimulus versions of each word were subsequently created – a left-ear version (comprising the left-forward version of that target word combined with its right-backward version) and a right-ear version (comprising the right-forward version of that target word combined with its left-backward version). We then created two different IAT tasks. The left-ear task involved presentation of the left-ear versions of each target word, whereas the right-ear task involved presentation of the right-ear versions of each word. In all other respects the two tasks were identical and utilised identical words.[5]

IAT structure and presentation: The two IATs for implicit self-esteem were programmed and presented using the stimulus presentation software *Inquisit* (http://www.millisecond.com/). We utilised a within-subject design in that each participant completed both IATs. Participants wore headphones in order that the components of each stimulus (target and competitor) could be presented to the left or right ear as appropriate. Each IAT consisted of seven blocks of categorisation trials, as per the procedure outlined in Greenwald et al. (2003; see Table 1). In each block participants pressed either a left or right key on the keyboard to categorise each of a series of stimuli presented auditorily through the headphones (throughout each block target categories remained labeled visually in the top left and right corners of the computer screen). Button presses were made bimanually, i.e. the index fingers of the left and right hands were used to press the left and right keys, respectively.

In the first block of the *congruent-incongruent* condition (see below) participants categorised words into *pleasant* (i.e., positive) and *unpleasant* (i.e., negative) categories, by pressing the right key for *pleasant* words and the left key for *unpleasant* words. In the second block presented items were categorised into *self* (right key) and *other* (left key) categories. In the third and fourth blocks participants categorised items into two combined categories, consistent with the key-concept pairings of the first two blocks (i.e. *self* or *pleasant* for the right key and *other* or *unpleasant* for the left key). The fifth block involved participants pressing the right key for *other* words and the left key for *self* words. This block provided practice for the reversed key assignment of the sixth and seventh blocks (*other* or *pleasant* for the right key and *self* or *unpleasant* for the left key). In the *incongruent-congruent* condition the positions of the second, third and fourth blocks were swapped with those of the fifth, sixth and seventh blocks, respectively.

At the commencement of each IAT participants were informed that all target stimuli for that task would be presented to either their left or right ear (as appropriate). Participants were instructed to respond as quickly as possible in categorising each stimulus, but not so fast that they made many errors (they were told that occasional errors were okay). The order in which the two IAT tasks (left- and right-ear) were completed was counterbalanced across participants, as was the order in which the congruent (*self* paired with *pleasant* and *other* paired with *unpleasant*) and incongruent (*self* paired with *unpleasant* and *other* paired with *pleasant*) blocks were presented within each IAT, i.e., half of the participants in each of the IAT tasks completed the *congruent-incongruent* condition (detailed above - congruent blocks first, incongruent blocks second) and the other half completed the *incongruent-congruent* condition (incongruent blocks first, congruent blocks second). The accuracy and latency (in msec) of each response was recorded. A new stimulus word was presented 500 msec after a response key was depressed.

Insert Table 1 about here

Results

For each participant two IAT scores were computed – one for the left-ear IAT and one for the right-ear IAT. It is important to note that each of these two IAT scores incorporates responses to two different trial types (*congruent* and *incongruent*). This differs from more traditional utilisation of the dichotic listening technique and cannot be compared with previous studies where the left ear measure is derived in a straightforward way from a single type of response and the right ear measure is derived from a single type of response.

We used the improved IAT scoring algorithm developed by Greenwald et al. (2003): The mean of correct latencies for each of Blocks 3, 4, 6 and 7 was computed,[6,7] as were two pooled *SDs* –

one for all trials in Blocks 3 and 6, and one for all trials in Blocks 4 and 7. Each error latency was subsequently replaced with the mean of the relevant block plus a penalty of 600 msec, and then the resulting values for each of the four blocks were averaged (see Table 2). Two differences were computed: The mean of Block 6 minus the mean of Block 3, and the mean of Block 7 minus the mean of Block 4. Each difference was then divided by its associated pooled-trials *SD*, and the resulting quotients were averaged to arrive at the final IAT score.

Insert Table 2 about here

Positive IAT scores indicate a response advantage for the *congruent* blocks (where *self* is paired with *pleasant* and *other* with *unpleasant*) relative to the *incongruent* blocks (where *self* is paired with *unpleasant* and *other* with *pleasant*), whereas negative IAT scores indicate the opposite pattern. Thus, an IAT score incorporates two kinds of responses and a higher IAT score reflects a greater level of self-esteem. In the absence of an IAT effect, IAT scores should not differ significantly from zero. Single-sample t-tests (test value = 0) indicated a significantly positive IAT score for both the left-ear IAT (Mean = .41, $SD = .38$, $t(45) = 7.30$, $p < .001$, $d = 1.08$, two-tailed) and the right-ear IAT (Mean = .54, $SD = .40$, $t(45) = 9.26$, $p < .001$, $d = 1.35$, two-tailed). The correlation between the left- and right-ear IATs was significant and positive, $r = .40$, $p < .05$.

A paired-samples t-test revealed that, as predicted, the IAT effect for the right-ear (left-lateralised) IAT was significantly greater than that for the left-ear (right-lateralised) IAT, $t(45) = 2.07$, $p < .05$, $d = .34$, one-tailed.[8]

Discussion

Self-esteem is one of the most widely investigated of all psychological constructs. Despite its theoretical importance, however, no previous study has investigated whether, within participants, self-esteem is lateralised. Given the considerable evidence for the left-lateralisation of approach-related emotions (see Demaree et al., 2005, for a review), we predicted that higher self-esteem (which can be conceptualised as an approach construct; De Raedt et al., 2008) would be associated with the brain's left hemisphere. To test this prediction we adapted the most widely used indirect measure of self-esteem, the self-esteem IAT (Greenwald and Farnham, 2000), to the auditory modality. This adaptation enabled us to then present the IAT task under dichotic listening conditions and thus to examine hemispheric lateralisation.

Our results supported our hypothesis. As might be expected, left- and right-ear self-esteem measurements were correlated. Importantly, however, we found that, within participants, self-esteem levels were significantly higher (as indexed by a greater IAT effect) when the IAT was presented to the left hemisphere (via the right ear) than when presented to the right hemisphere (via the left ear). In addition to its methodological contribution, therefore (a successful modality adaptation of one of experimental psychology's most established measurement tools), our study indicates that levels of self-esteem diverge as a function of hemisphere. It should be noted that the result we report here cannot be attributed to left hemispheric specialisation for the processing of linguistic stimuli. This is because IAT scores incorporate responses to two different trial types. Thus the greater IAT effect under right-dichotic presentation cannot simply reflect superior linguistic processing in the left hemisphere, but rather reflects a greater response advantage in that hemisphere for *congruent* trials (where *self* is paired with *pleasant* and *other* with *unpleasant*) relative to *incongruent* trials (where *self* is paired with *unpleasant* and *other* with *pleasant*).

An important limitation of our study stems from the fact that we employed the standard IAT (albeit in auditory format). An inherent limitation of this standard version is that it cannot reveal participants' evaluative associations with a single target concept (Karpinski and Steinman, 2006). Because it utilises complementary pairs of concepts and attributes, the standard IAT is limited to measuring the relative strengths of *pairs* of associations (e.g. the strength of the association between *self* and *pleasant* relative to the strength of the association between *other* and *unpleasant*) rather than the absolute strengths of single associations (i.e. it cannot measure only evaluative associations with the self with no complementary category; Greenwald and Farnham, 2000; Karpinski and Steinman, 2006). This feature of the IAT means that an IAT adapted for the measurement of self-esteem will conflate positive attitudes toward the self with negative attitudes toward others (and vice versa).

Despite this conceptual limitation of the IAT, however, there is considerable evidence that the standard self-esteem IAT is a valid measure of self-esteem (see, for example, Bosson et al., 2000; Greenwald et al., 2002; Meagher and Aidman, 2004). Nevertheless, it is worth noting that a new

IAT methodology has been developed - The Single Category Implicit Association Test (SC-IAT; Karpinski & Steinman, 2006) - that overcomes the above limitations by using only a single attitude category (e.g. *self*) rather than pairs of complementary attitude categories (e.g. *self* vs. *other*). Future attempts to replicate our findings might profitably employ this new version of the IAT in an effort to eliminate some of the ambiguity in the interpretation of IAT scores and in order to better clarify what is driving the IAT effects in our experiment.

Although the current study contributes to our understanding of self-esteem, additional neuropsychological/neuroscientific studies are required to provide a more comprehensive overview of what is likely to be a multi-faceted construct. For example, it would be valuable to undertake lesion studies using the methodology presented here. Imaging techniques would also be useful in providing a more fine-grained assessment of the *relative* activation of the left versus the right hemisphere in the representation and processing of self-esteem (the results we report here do not rule out right hemisphere involvement – our correlational analysis indicates a relationship between the hemispheres) and in providing detail concerning anterior/posterior and cortical/subcortical involvement. Recent studies have indicated an important role for the medial prefrontal cortices in decisions related to self-referential judgements (Kelley et al., 2002; Vogeley et al., 2004; Mitchell et al., 2005) and future research could undertake to reconcile such findings with research concerning the lateralisation of emotion and self-esteem. Finally, replications of our results with non-linguistic stimuli (perhaps utilising presentation of Picture IAT stimuli to alternate visual hemifields) would be valuable.

The methodology we have developed here might be extended in a number of other directions. Our findings replicated the standard *visually presented* IAT effect for implicit self-esteem (Greenwald and Farnham, 2000) - overall, participants responded much more rapidly when associating *self* with *pleasant* items. Although this was the case for both left- and right-ear presentation, the magnitude of the effect was greater under right-ear (left-hemispheric) presentation. In view of this asymmetry, it may be worth exploring the utility of the auditory dichotic IAT in other (non self-esteem) domains. For example, Gray et al. (2005) used the standard (visually presented, "bilateral") IAT to demonstrate that paedophiles have an implicit association between children and sex (for non-paedophilic offenders the implicit association is between adults and sex). Might this association be stronger with stimuli presented to one hemisphere than to the other? Mendez et al. (2000) described two cases of late-life paedophilia, each of whom showed right temporal lobe hypometabolism on positron emission tomography (PET). These authors concluded that bilateral temporal lobe disturbances with a right sided predominance result in hypersexuality (see Baird et al., 2007 for further discussion). Whereas the present study utilised an auditory dichotic adaptation of the self-esteem IAT to examine hemispheric lateralization of self-esteem, auditory dichotic adaptations of other IAT tasks might well shed further light on these and related issues.

Text footnotes

[1] Not to be confused with *alpha* asymmetry. Alpha power is inversely correlated with activation (see Davidson et al., 1990), so a right > left *alpha* asymmetry indicates greater left than right activation.

[2] Handedness was assessed with the Edinburgh Handedness Inventory (Oldfield, 1971), using the following cut-offs: below -40 = left-handed; between -40 and +40 inclusive = ambidextrous; above +40 = right-handed. See footnote 8 for a description of the results with only right-handers included.

[3] Evaluative self-esteem IATs measure the associations of *self* versus *other* with positive and negative trait adjectives, whereas affective versions measure associations with words of positive and negative affective valence such as *freedom* and *vomit* (Greenwald and Farnham, 2000). Greenwald and Farnham (2000) utilised both affective and evaluative versions of the self-esteem IAT and found no difference between them.

[4] A Bonferroni-corrected alpha level of .008 was adopted for these comparisons.

[5] We are happy to share our dichotic listening stimuli with other researchers – please contact the first author (ryantmckay@mac.com).

[6] At this point the data for *incongruent-congruent* IATs (incongruent blocks presented first, congruent blocks presented second) were realigned and relabeled such that data from the incongruent blocks (3 and 4) were swapped with data from the congruent blocks (6 and 7).

[7] The Greenwald et al. (2003) scoring algorithm requires that any trials with latencies in excess of 10,000 ms be eliminated, and also that any participants for whom more than 10% of trials had latencies less than 300ms be eliminated. In the present data set, however, there were no trials with latencies in excess of 10,000 ms (less than 1% of trials had latencies in excess of *3*,000 ms) and no participants for whom more than 10% of trials had latencies less than 300 ms, so no exclusions were made on these bases.

[8] The pattern of results was virtually identical with all non-right-handers excluded, which is to be expected given that most non-right-handers (~70%) have language lateralisation equivalent to that of right-handers (Rasmussen and Milner, 1977; Josse and Tzourio-Mazoyer, 2003). In particular, our key finding was unchanged: The right-ear IAT effect (Mean = .54, SD = .43) remained significantly greater than that for the left-ear (Mean = .39, SD = .39), $t(34) = 1.87$, $p < .05$, $d = .36$, one-tailed.

References

ADOLPHS R, DAMASIO H, TRANEL D, and DAMASIO AR. Cortical systems for the recognition of emotion in facial expressions. *The Journal of Neuroscience,* 16: 7678-7687, 1996.

ARCIULI J and SLOWIACZEK L. The where and when of linguistic word-level prosody. *Neuropsychologia,* 45: 2638-2642, 2007.

BAAYEN RH, PIEPENBROCK R, and GULIKERS L. *The celex lexical database (release 2) [cd-rom]. Secondary Titl*. Philadelphia, PA: Linguistic Data Consortium, University of Pennsylvania [Distributor], 1995.

BAIRD AD, WILSON SJ, BLADIN PF, SALING MM, and REUTENS DC. Neurological control of human sexual behaviour: Insights from lesion studies. *Journal of Neurology, Neurosurgery, and Psychiatry,* 78: 1042-1049, 2007.

BAUMEISTER R, SMART L, and BODEN J. Relation of threatened egotism to violence and aggression: The dark side of self-esteem. *Psychological Review,* 103: 5–33, 1996.

BOSSON JK, SWANN WBJ, and PENNEBAKER JW. Stalking the perfect measure of implicit self-esteem: The blind men and the elephant revisited? *Journal of Personality & Social Psychology,* 79: 631-643, 2000.

BRANDEN N. *The psychology of self-esteem: A revolutionary approach to self-understanding that launched a new era in modern psychology*: Jossey-Bass, 2001.

BREWER MB and MILLER N. *Intergroup relations*. Buckingham, UK: Open University Press, 1996.

CANLI TT, DESMOND JE, ZHAO Z, GLOVER G, and GABRIELI JDE. Hemispheric asymmetry for emotional stimuli detected with fmri. *Neuroreport,* 9: 3233-3239, 1998.

COATS EJ, JANOFF-BULMAN R, and ALPERT N. Approach versus avoidance goals: Differences in self-evaluation and well-being. *Personality and Social Psychology Bulletin,* 22: 1057–1067, 1996.

CROCKER J and LUHTANEN R. Collective self-esteem and in-group bias. *Journal of Personality and Social Psychology,* 58: 60-67, 1990.

DAVIDSON RJ. Cerebral symmetry, emotion, and affective style. In Davidson R.J. and Hugdahl K. (Eds.), *Brain asymmetry*. MIT Press: Cambridge, MA, 1995, pp. 361-387.

DAVIDSON RJ, CHAPMAN JP, CHAPMAN LJ, and HENRIQUES JB. Asymmetrical brain electrical activity discriminates between psychometrically-matched verbal and spatial cognitive tasks. *Psychophysiology,* 27: 528–543, 1990.

DAVIDSON RJ and FOX NA. Asymmetrical brain activity discriminates between positive versus negative affective stimuli in human infants. *Science,* 218: 1235-1237, 1982.

DAVIDSON RJ and HENRIQUES JB. Regional brain function in sadness and depression. In Borod J.C. (Ed.) *The neuropsychology of emotion*. New York: Oxford Press, 2000, pp. 269-297.

DAVIDSON RJ, SCHWARTZ GE, SARON C, BENNETT J, and GOLEMAN DJ. Frontal vs. Parietal eeg asymmetry during positive and negative affect. *Psychophysiology,* 16: 202-203, 1979.

DE RAEDT R, FRANCK E, FANNES K, and VERSTRAETEN E. Is the relationship between frontal eeg alpha asymmetry and depression mediated by implicit or explicit self-esteem? *Biological Psychology,* 77: 89-92, 2008.

DECI EL and RYAN RM. Human autonomy. The basis for true self-esteem. In Kernis H.M. (Ed.) *Efficacy, agency, and self-esteem*. New York: Plenum, 1995, pp. 31-49.

DEMAREE HA, EVERHART DE, YOUNGSTROM EA, and HARRISON DW. Brain lateralization of emotional processing: Historical roots and a future incorporating "Dominance". *Behavioral and Cognitive Neuroscience Reviews,* 4: 3-20, 2005.

DEVINE PG. Implicit prejudice and stereotyping: How automatic are they? Introduction to the special section [special section: Implicit prejudice and stereotyping: How automatic are they?]. *Journal of Personality and Social Psychology,* 81: 757–759, 2001.

EICHELE T, NORDBY H, RIMOL LM, and HUGDAHL K. Asymmetry of evoked potential latency to speech sounds predicts the ear advantage in dichotic listening. *Cognitive Brain Research,* 24: 405-412, 2005.

GRAY NS, BROWN AS, MACCULLOCH MJ, SMITH J, and SNOWDEN RJ. An implicit test of the associations between children and sex in pedophiles. *Journal of Abnormal Psychology,* 114: 304-308, 2005.

GREENWALD AG, BANAJI MR, RUDMAN LA, FARNHAM SD, NOSEK BA, and MELLOTT DS. A unified theory of implicit attitudes, stereotypes, self-esteem, and self-concept. *Psychological Review,* 109: 3-25, 2002.

GREENWALD AG and FARNHAM SD. Using the implicit association test to measure self-esteem and self-concept. *Journal of Personality & Social Psychology,* 79: 1022-1038, 2000.

GREENWALD AG, MCGHEE DE, and SCHWARTZ JLK. Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality & Social Psychology.,* 74: 1464-1480, 1998.

GREENWALD AG, NOSEK BA, and BANAJI MR. Understanding and using the implicit association test: I. An improved scoring algorithm. *Journal of Personality & Social Psychology,* 85: 197-216, 2003.

HARMON-JONES E and ALLEN JJB. Anger and frontal brain activity: Eeg asymmetry with approach motivation despite negative affective valence. *Journal of Personality and Social Psychology,* 74: 1310-1316, 1998.

HARMON-JONES E and SIGELMAN J. State anger and prefrontal brain activity: Evidence that insult-related relative left-prefrontal activation is associated with experienced anger and aggression. *Journal of Personality and Social Psychology,* 80: 797-803, 2001.

HEILMAN KM, SCHOLES R, and WATSON RT. Auditory affective agnosia: Disturbed comprehension of affective speech. *Journal of Neurology, Neurosurgery and Psychiatry,* 38: 69-72, 1975.

HENRIQUES JB and DAVIDSON RJ. Regional brain electrical asymmetries discriminate between previously depressed and healthy control subjects. *Journal of Abnormal Psychology,* 99: 22–31, 1990.

HENRIQUES JB and DAVIDSON RJ. Left frontal hypoactivation in depression. *Journal of Abnormal Psychology,* 100: 535-545, 1991.

HUGDAHL K. Symmetry and asymmetry in the human brain. *European Review,* 13: 119-133, 2005.

HUGDAHL K, BRONNICK K, KYLLINGSBAEK S, LAW I, GADE A, and PAULSON OB. Brain activation during dichotic presentations of consonant-vowel and musical instrument stimuli: A 15o-pet study. *Neuropsychologia,* 37: 431-440, 1999.

JAMES W. *The principles of psychology*. New York: Holt, 1890.

JORDAN CH, SPENCER SJ, ZANNA MP, HOSHINO-BROWNE E, and CORRELL J. Secure and defensive high self-esteem. *Journal of Personality and Social Psychology,* 85: 969-978, 2003.

JOSSE G and TZOURIO-MAZOYER N. Review: Hemispheric specialization for language. *Brain Research Reviews,* 44: 1-12, 2003.

KARPINSKI A and STEINMAN RB. The single category implicit association test as a measure of implicit social cognition. *Journal of Personality & Social Psychology,* 91: 16-32, 2006.

KELLEY WM, MACRAE CN, WYLAND CL, CAGLAR S, INATI S, and HEATHERTON TF. Finding the self? An event-related fmri study. *Journal of Cognitive Neuroscience,* 14: 785–794, 2002.

KINDERMAN P. Attentional bias, persecutory delusions and the self-concept. *British Journal of Medical Psychology,* 67: 53-66, 1994.

MCKAY R, LANGDON R, and COLTHEART M. The defensive function of persecutory delusions: An investigation using the implicit association test. *Cognitive Neuropsychiatry,* 12: 1-24, 2007.

MEAGHER BE and AIDMAN EV. Individual differences in implicit and declared self-esteem as predictors of response to negative performance evaluation: Validating implicit association test as a measure of self-attitudes. *International Journal of Testing,* 4: 19-42, 2004.

MENDEZ MF, CHOW T, RINGMAN J, TWITCHELL G, and HINKIN CH. Pedophilia and temporal lobe disturbances. *The Journal of Neuropsychiatry and Clinical Neurosciences,* 12: 71-76, 2000.

MITCHELL JP, BANAJI MR, and MACRAE CN. The link between social cognition and self-referential thought in the medial prefrontal cortex. *Journal of Cognitive Neuroscience,* 17: 1306-1315, 2005.

NOSEK BA, GREENWALD AG, and BANAJI MR. Understanding and using the implicit association test: Ii. Method variables and construct validity. *Personality and Social Psychology Bulletin,* 31: 166-180, 2005.

NOSEK BA, GREENWALD AG, and BANAJI MR. The implicit association test at age 7: A methodological and conceptual review. In Bargh J.A. (Ed.) *Automatic processes in social thinking and behavior*. Philadelphia, PA, USA: Psychology Press, 2007.

OLDFIELD RC. The assessment and analysis of handedness: The edinburgh inventory. *Neuropsychologia,* 9: 97-113, 1971.

PASSERO S, NARDINI M, and BATTISTINI N. Regional cerebral blood flow changes following chronic administration of antidepressant drugs. *Progress in Neuropsychopharmacology and Biological Psychiatry,* 19: 627-636, 1995.

PELHAM W and SWANN W. From self-conceptions to self-worth: On the sources and structure of global self-esteem. *Journal of Personality and Social Psychology,* 57: 672-680, 1989.

RASMUSSEN T and MILNER B. The role of early left-brain injury in determining lateralization of cerebral speech functions. *Annals of the New York Academy of Science,* 299: 355-369, 1977.

RHODEWALT F and TRAGAKIS MW. Self-esteem and self-regulation: Toward optimal studies of self-esteem. *Psychological Inquiry,* 14: 66-70, 2003.

ROBINSON RG, STARR LB, and PRICE TR. A two year longitudinal study of mood disorders following stroke: Prevalence and duration at six-months follow up. *British Journal of Psychiatry,* 144: 256-262, 1984.

ROSENBERG M. *Society and the adolescent self-image*. Princeton, NJ: Princeton University Press, 1965.

ROSENBERG M, SCHOOLER C, SCHOENBAH C, and ROSENBERG F. Global self-esteem and specific self-esteem: Different concepts, different outcomes. *American Sociological Review,* 60: 141-156, 1995.

ROSSI GF and ROSADINI GR. Experimental analyses of cerebral dominance in man. In Millikan D.H. and Darley F.L. (Eds.), *Brain mechanisms underlying speech and language*. New York: Grune & Stratton, 1967.

SILBERMAN EK and WEINGARTNER H. Hemispheric lateralization of functions related to emotion. *Brain and Cognition,* 5: 322-353, 1986.

TENNEN H and AFFLECK G. The puzzles of self-esteem: A clinical perspective. In Baumeister R.F. (Ed.) *Self-esteem: The puzzle of low regard*. New York: Plenum, 1993, pp. 241-262.

THOMSEN T, RIMOL LM, ERSLAND L, and HUGDAHL K. Dichotic listening reveals functional specificity in prefrontal cortex: An fmri study. *NeuroImage,* 21: 211-218, 2004.

URRY HL, NITSCHKE JB, DOLSKI I, JACKSON DC, DALTON KM, MUELLER CJ, ROSENKRANZ MA, RYFF CD, SINGER BH, and DAVIDSON RJ. Making a life worth living. Neural correlates of well-being. *Psychological Science,* 15: 367–372, 2004.

VOGELEY K, MAY M, RITZL A, FALKAI P, ZILLES K, and FINK GR. Neural correlates of first-person perspective as one constituent of human self-consciousness. *Journal of Cognitive Neuroscience,* 16: 817– 827, 2004.

WEXLER B. Dichotic presentation as a method for single hemisphere stimulation studies. In Hugdahl K. (Ed.) *Handbook of dichotic listening: Theory methods and research*. Great Britain: John Wiley & Sons, 1988.

Table 1

Sequence of Trial Blocks in the Congruent-Incongruent[a] *Condition of an IAT for Implicit Self-Esteem*

Block	**No. trials**	**Function**	**Items left-key**	**Items right-key**
1	20	Practice	Unpleasant	Pleasant
2	20	Practice	Other	Self
3	20	Practice	Oth/Unpl	Self/Pleas
4	40	Test	Oth/Unpl	Self/Pleas
5	20	Practice	Self	Other
6	20	Practice	Self/Unpleasant	Other/Pleasant
7	40	Test	Self/Unpleasant	Other/Pleasant

[a] In the *incongruent-congruent* condition the positions of Blocks 2, 3, and 4 are switched with those of Blocks 5, 6, and 7, respectively.

Table 2

Averaged Mean Post-penalty Latencies (ms) and Averaged Pooled-trials SDs (ms) for the Crucial IAT Blocks (Standard Deviations in Parentheses)

	Left Ear Presentation	**Right Ear Presentation**
Mean of Block 3 (congruent)	908 (219)	873 (187)
Mean of Block 4 (congruent)	883 (176)	880 (206)
Mean of Block 6 (incongruent)	1099 (338)	1088 (298)
Mean of Block 7 (incongruent)	1025 (293)	1042 (263)
Pooled-trials *SD* Blocks 3 and 6	378 (230)	344 (199)
Pooled-trials *SD* Blocks 4 and 7	360 (239)	379 (260)