SPECIAL ISSUE ARTICLE

# Self-referential processing and emotion context insensitivity in major depressive disorder

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## Abstract

We examined whether differential self-perception influences the salience of emotional stimuli in depressive disorders, using a perceptual matching task in which geometric shapes were arbitrarily assigned to the self and an unknown other. Participants associated shapes with personal labels (e.g. "self" or "other"). Each geometric shape additionally contained a happy, sad or neutral line drawing of a face. Participants then judged whether shape-label pairs were as originally shown or re-paired, whilst facial emotion was task-irrelevant. The results showed biased responses to self-relevant stimuli compared to other-relevant stimuli, regardless of facial emotion, for both control and depressed participants. This was reflected in sensitivity ($d'$) and drift rate ($v$) measures, suggesting that self-bias and a bias towards emotion may reflect different underlying processes. We further computed bias scores by subtracting the "neutral" value of each measure (acting as baseline) from the "happy" and "sad" values of each measure, indexing an "emotional bias" (EB) score for "self" and "other" separately. Compared to control participants, depressed participants exhibited reduced "happy" and "sad" emotional biases, regardless of the self-relevance of stimuli. This finding indicates that depressed participants may exhibit generalised Emotion Context Insensitivity (ECI), characterised by hyopoattention to both positive and negative information, at short stimulus presentations. The implications of this are discussed.

**KEYWORDS**

attention, emotion, face processing, perception, self-recognition

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# 1 | INTRODUCTION

Depression is a mood disorder that affects approximately thirty million people worldwide. It has both psychological and physical symptoms, such as low self-esteem, feelings of hopelessness and guilt, reduced concentration and appetite disturbance (Clark, Beck, & Alford, 1999; Orth & Robins, 2013; World Health Organization, 1992). Several theories have sought to explain the nature of depression specific cognitive biases, the longest standing and most influential being Beck's (1967) cognitive theory of depression. The theory stipulates a "negative triad", whereby individuals exhibit a negative view of the self (low self-esteem), a negative view of the world and a negative view of the future. Beck (2008) further proposed that this triad would result in an automatic and systematic negative bias. A wealth of studies using a range of experimental paradigms support the existence of depression specific cognitive biases. The majority have used "impersonal" stimuli not attributed to "self" and "other" conditions. A minority have used self-relevant stimuli that link to the concept of self.

It is typically observed that healthy individuals tend to view themselves favourably, believing they are as good as or better than others (Alicke, 1985; Diener, Kanazawa, Suh, & Oishi, 2015; Taylor & Brown, 1988). In contrast, individuals suffering from depression tend to view themselves negatively. An individual's self-representation is a robust psychological mechanism that affects a range of cognitive processes. Previous research has shown that when stimuli are perceived as self-relevant, self-concept acts as a superordinate schema to influence the salience of emotional stimuli at later stages on information processing (Chen et al., 2014; Zhou et al., 2017), creating a systematic self-bias across the domains of attention, perception and memory (Cunningham, Turk, Macdonald, & Macrae, 2008; Sui & Humphreys, 2015, 2016). Self-relevant stimuli appear to capture attention automatically, receiving preferential access to cognitive resources even if not explicitly attended to (Alexopoulos, Muller, Ric, & Marendaz, 2012). Participants tend to make faster and more accurate judgements about facial expressions when they view their own face compared to the face of a friend or a stranger (Gray, Ambady, Lowenthal, & Deldin, 2004; Ma & Han, 2010), and when information relevant to the self is memorised, it is processed elaboratively and hence more reliably retained (Craik & Lockhart, 1972; Rogers, Kuiper, & Kirker, 1977). This phenomenon has been termed "the self-reference effect". The self-reference effect has been evidenced through the use of functional magnetic resonance imaging (fMRI) techniques, which show that self-relevant stimuli specifically evoke increased activation of the self-related region of the ventromedial prefrontal cortex as well as the memory associated brain regions such as the posterior

cingulate cortex and bilateral angular gyrus (Yaoi, Osaka, & Osaka, 2015).

The influence of self-relevance in information processing has been previously explored. Dichotic listening experiments (Moray, 1959) showed that participants struggle to recall neutral speech from an unattended channel, unless their own name is mentioned. Further studies (Bargh, 1982; cherry, 1953; Wood & Cowan, 1995) similarly reported the superordinate influence of self-concept; however, the use of autobiographical information, such as a participants own name, risks confounding self-reference and familiarity effects.

More recent research has avoided confounding self-reference and familiarity through the use of geometric shape stimuli arbitrarily assigned to "self" and "other" conditions. Sui, He, and Humphreys (2012; see also Stolte, Humphreys, Yankouskaya, & Sui, 2017) conducted a study in which healthy participants associated three different geometric shapes with the pronouns "you", "friend" and "stranger". For example, at the start of the experiment participants were instructed "you are a triangle, a stranger is a square, and Mary [the participant's best friend] is a circle." Shape pronoun pairs were then presented for 100 milliseconds (ms), and participants were asked to indicate if the shape matched with its original pronoun association as quickly and as accurately as possible. Results showed a significant advantage for "you" compared to "friend" and "stranger" pairings, reflected through higher accuracy and faster reaction times. Stolte et al. (2017) conducted a further experiment in which participants associated a new set of shapes with happy, sad and neutral facial expressions. Shape face pairs were then presented for 100ms. Results showed a significant advantage for "happy" compared to "sad" and "neutral" pairings. Together, the results evidence separate biases towards self-referential ("you") and positive (happy face) stimuli in healthy individuals.

Specific emotion-related attentional biases have been observed in depressive disorders. Depressed participants have been shown to exhibit hypoattention to positive stimuli, hyperattention to negative stimuli or a combination of the two, at different time scales (Krompinger & Simmons, 2009; Kuiper & Derry, 1982; McCabe & Gotlib, 1995; Milders et al., 2016; Segal, Gemar, Truchon, Guirguis, & Horowitz, 1995).Further research has suggested that depressed participants exhibit hypoattention to both positive and negative stimuli, termed as Emotion Context Insensitivity (ECI [Rottenberg, Gross, & Gotlib, 2005]). ECI posits that depressed individuals exhibit a general blunted response to emotion, and situates depressive characteristics within an evolutionary framework. Whilst ECI is a relatively unexplored phenomenon, a meta-analysis of emotional reactivity in depressive disorders conducted by Bylsma, Morris, and Rottenberg (2008) concluded that depression is characterised by hypoattention to both

positive and negative stimuli, in accordance with ECI theory. However, it should be noted that whilst the meta-analysis used three methods to assess emotional reactivity (self-report assessment of emotion, emotional behavioural responses measured through electromyography [EMG] and physiological measures), only participants' self-report assessment of emotion and emotional behavioural responses showed evidence of ECI. Whilst there have been significant advances in methods used to investigate cognition since the study's inception, ECI has seldom been explored in recent research.

In the context of exploring ECI, contrasting emotion-related attentional biases have been observed between healthy and depressed individuals. Healthy individuals tend to exhibit a bias towards positive stimuli. This is evidenced by a meta-analysis conducted by Pool, Brosch, Delplanque, and Sander (2016). The analysis included a total sample size of 9,120 healthy participants and found evidence of a significant bias towards positive over negative and neutral stimuli. In contrast, individuals with depression exhibited hypoattention towards positive stimuli. This is evidenced by McCabe and Gotlib (1995) who conducted a deployment of attention task in which positive, negative and neutral word pairs were presented for 750 ms. The words were then replaced by two different coloured bars, with participants required to indicate which coloured bar appeared first. Results showed that control participants were significantly more likely to correctly identify the colour of bars first appearing in the location of positive words, indicating a bias towards positive stimuli. In contrast, depressed participants attended to positive, negative and neutral stimuli equally. This research is further supported by Milders et al. (2016) who conducted an attentional blink task in which happy and sad faces were presented for 100 ms. Results showed that depressed participants detected significantly fewer happy faces compared to control participants. Together, these studies indicate that individuals with depression display hypoattention towards positive stimuli in comparison to healthy individuals, manifesting as a reduced bias towards positivity.

Whilst a range of research has evidenced a depression specific hypoattention towards positive "impersonal" stimuli, little recent research incorporates stimuli that are simultaneously emotional and self-relevant. Kuiper and Derry (1982) conducted an earlier study in which participants made either self-referential ("does this word apply to you?") or semantic ("does this word have specific meaning?") ratings on depressed themed (negative) and non-depressed themed (positive) words. Participants then completed an incidental recall task. The control group showed better recall for self-referenced non-depressed words compared to self-referenced depressed words and semantic words. In contrast, depressed participants showed enhanced recall for both types

of self-referenced words compared to semantic words. These findings suggest that compared to healthy individuals, individuals with depression exhibit hypoattention to positive self-referential stimuli.

In contrast to ECI, other research evidences a depression specific hyperattention to negative stimuli. Krompinger and Simmons (2009) used a go/no go paradigm in which positive and negative stimuli (pleasant and unpleasant colour images obtained from the International Affective Picture System) were presented for 300 ms. Results showed that depressed participants uniquely exhibited larger P300 amplitudes in response to negative stimuli compared to positive stimuli and hence allocated more attentional resources to the former. However, this study did not include a self-referential component. Neither did it include a neutral baseline. It is therefore not possible to differentiate between a magnified negative attentional bias and reduced positive attentional bias. Segal et al. (1995) conducted a modified Stroop colour naming task in which positive and negative adjectives primed by emotional statements with varying levels of self-reference were presented for 2,000 ms. Depressed participants showed slower colour naming latencies for negative adjectives primed by self-descriptive statements compared to any other target condition. No differences were observed amongst control participants. This indicates that the depressed participants struggled to disengage from negative self-referential stimuli. In explanation, it is proposed that negative stimuli are more congruent with depressed participants' negative self-perception (Cavanagh & Geisler, 2006; Ilardi, Atchley, Enloe, Kwansy, & Garratt, 2007). The majority of recent research exploring depression specific negative attentional biases have used "impersonal" as opposed to self-referential stimuli.

In summary, past research has shown that whilst both self-referential and emotional stimuli gain preferential access to attentional resources, self-relevance in perception is influential in dictating the salience of emotional stimuli at later stages of information processing. Whilst recent research has avoided confounding self-reference and familiarity effects through the use of arbitrary geometric shape stimuli assigned to "self" and "other" conditions, the influence of self-perception on emotional salience has not yet been explored using this paradigm. Given the central role of low self-esteem and the experience of emotional distress in depression, it is surprising that little research has explored the combined effect of self-perception and emotion in depressive disorders. This study therefore aimed to investigate if self-perception influences emotional salience to produce depression specific cognitive biases, through the attribution of "self" or "other" to emotional stimuli that avoids familiarity confounds. This was achieved through using geometric shape stimuli arbitrarily assigned to "self" or "other" conditions that were additionally filled with emotional face drawings. This study incorporated neutral face drawings in order to avoid limitations faced

in previous studies that result from no baseline comparison measure.

## 2 | MATERIALS AND METHOD

### 2.1 | Participants

All participants had normal or corrected to-normal vision and gave informed written consent prior to the experiment. The study was approved by the University Research Ethics Committee and the Psychology Research Ethics Committee of Oxford Brookes University (reference number 1718/122). All participants gave written informed consent approved by the Research Ethics Committee, in accordance with the Declaration of Helsinki.

### 2.2 | Eligibility

The eligibility of participants and the allocation of participants to groups were determined by the Mini International Neuropsychiatric Interview (M.I.N.I., Sheenan & Lecrubier, 2006). Both control and depressed participants were recruited from a community sample. The M.I.N.I. was conducted by an experienced clinical psychologist, and 20% of the interview was discussed with an experienced psychiatrist to validate diagnostic criteria. The M.I.N.I. is a structured interview for the major Axis I psychiatric disorders as specified by the Diagnostic Manual of Mental Disorders 4th Edition (DSM-IV, American Psychiatric Association, 2000). The interview is used for research assessment purposes and shows high validity and reliability scores with more comprehensive psychological assessments such as the Structured Clinical Interview for DSM-IV Disorders, Patient Edition (SCID-P, First, Spitzer, Gibbon, & Williams, 2002). Four participants were excluded based on information given during the M.I.N.I. A further three participants were excluded from behavioural analysis as they did not engage with the computer-based task. Participants who engaged with the task but showed low levels of accuracy and/or slow reaction times were not excluded. We found no theoretical reason to justify exclusion, because participant accuracy and reaction times may differ as a result of various factors (Caligiuri & Ellwanger, 2000; Schubert, Gidon, Hagemann, & Voss, 2016). Furthermore, our results section displays individual participant scores, as well as the group means, which allows for a higher level of granularity when interpreting the results. After exclusions twenty participants with no history of neurological or psychiatric illness were recruited to the control group (six male; 19 to 52 years of age, $M = 29.85 \pm 11.69$). Twenty participants with a primary diagnosis of unipolar major depressive disorder were recruited to the depressed group (two male; 18 to 45 years

of age, $M = 24.30 \pm 6.99$). Whilst the overall sample size is small for a clinical study, our methodology was based on previous studies using similar experimental paradigms (Stolte et al., 2017; Sui, Ohrling, & Humphreys, 2016). Whilst differences in age and gender may impact reaction time and hence task performance (Bleecker, Bolla-Wilson, Agnew, & Myers, 2009), all efforts were made to ensure that age and gender differences between experimental groups were minimal.

The M.I.N.I was additionally used to assess anxiety co-morbidity. Within the depressed group, 9 out of 20 participants exhibited a secondary generalised anxiety disorder (GAD) comorbidity. The control group exhibited no anxiety. The depressed group had a significantly higher number of participants who met the criteria for GAD compared to the control group ($\chi^2 = 11.6$, $p < .01$).

### 2.3 | Secondary measures

The Beck Depression Inventory (BDI-II, Beck, Steer, & Brown, 1996) was used to confirm the depression status of participants initially determined by the M.I.N.I. The BDI-II explores affective, cognitive and somatic symptoms of depression and contains 21 items on a 4-point scale from 0 (symptoms absent) to 3 (symptoms severe). In non-clinical populations, scores above 20 indicate the presence of depression. For those diagnosed with depression, a score between 0 and 13 indicates no depression, 14–19 low depression, 20–28 moderate depression and 29–63 severe depression (Jackson-Koku, 2016). 19 out of 20 participants in the control group scored below the cut-off point for depression in non-clinical populations (<20, [$M = 5.50$, range = 1–30]). The participant who scored above the cut-off point for depression was evaluated during the M.I.N.I. by two experienced clinicians and was not deemed to meet the criteria for a depressive disorder. There was also evidence of response bias on the BDI-II self-report measure for this participant. Within the depressed group, all participants met the criteria for mild depression at a minimum (>14 [$M = 28.6$, range = 7–46]). Ordinal regression analysis showed that group (control/depressed) predicts BDI-II score outcome ($R^2McF = 0.169$, $\chi^2 = 41.1$, $p < .01$).

The Rosenberg Self-Esteem Scale (Rosenberg, 1965) was used to assess participant self-esteem. It is a 10-item scale that measures global self-worth through evaluating positive and negative feelings about the self. All items are answered using a 4-point Likert scale format (strongly disagree, disagree, agree or strongly agree). Higher scores indicate higher self-esteem. Items 2,5,6,8 and 9 are reverse scored. Scores range from 10 (very low) to 40 (very high). The depressed group ($M = 22.65$, range = 16–36) scored significantly lower on the trait self-esteem scale compared to the control group ($M = 32.05$, range = 21–39). Ordinal regression

analysis showed that group (control/depressed) predicts trait self-esteem scale score outcome ($R^2$McF = 0.130, $\chi^2$ = 29.5, $p < .01$).

## 2.4 | Stimuli and tasks

All stimuli were presented in white on a light grey background on 17-inch monitors (1,280 × 960 pixels at 60 Hz), using E-prime software. One of two filled, geometric shapes (selected from six possible shapes: circle, triangle, diamond, pentagon, hexagon, octagon [Figure 1a]) was presented together with the word "self" or "other", referring to the participant's self or a stranger. The shapes additionally contained a line drawing of a happy, sad or neutral facial expression (Figure 1b). The shapes (3.3° × 3.3° of visual angle) were always presented 1.1° above a fixation cross (0.3° × 0.3°), whilst labels were presented at 1.7° below the fixation cross. Participants judged whether the shape matched the label, according to the original label-shape pairing.

## 2.5 | Procedure

At the beginning of the experiment, written instructions asked participants to remember the two label-shape pairings (e.g. "self = square", "other = circle"). The specific



**FIGURE 1** (a) Geometric shape stimuli. (b) Happy, sad and neutral emotional face stimuli

assignment of people to shapes was counterbalanced across participants. This was followed by a training phase (12 trials) where only shapes and labels were presented without faces depicting an emotion, as participants learnt the association between shape and label ("self" and "other"). In the matching phase, participants were asked to make a speeded response to a shape-label pair, judging whether the pair matched or not. Each shape was additionally filled with a line drawing of a face depicting a positive, negative or neutral emotion which was not task relevant. On a random half of the trials the shape-label pair matched, and on the other half they did not.

The order of presentation for each shape-label pair was randomised. At the beginning of each trial a fixation cross was presented in the middle of the screen (randomised for 800–1,200 ms) followed by a label-shape pair, with the shape containing a face drawing (150 ms). The pair either conformed to the written instructions given at the beginning of the experiment or it was a recombination of a label with a different, nonmatching shape. Participants had 1150 ms to respond from the first appearance of the stimuli (Figure 2). During this interval, participants judged whether the correct shape had been assigned to the self or other condition by pressing one of two response keys as quickly and as accurately as possible. Subsequently, feedback (correct, incorrect or no response) was provided on the screen for 500 ms. Participants completed six blocks of 150 trials and a final block of 60 trials each (80 trials per condition; happy self-match, happy self-nonmatch, neutral self-match, neutral self-nonmatch, sad self-match, sad self-nonmatch, happy other-match, happy other-nonmatch, neutral other-match, neutral other-nonmatch, sad other-match, sad other-nonmatch).

## 2.6 | Behavioural analysis

The data obtained were used to compute two measures of performance: measure one: sensitivity index (discriminability-$d'$) and measure two: efficiency index (drift rate-$v$).

## 2.7 | Measure one: Sensitivity index (discriminability-$d'$)

A signal detection approach (Spencer & Barrett, 2014) was employed to compute $d'$ for each association, combining performance for matched pairs (hits) with performance from nonmatched pairs containing the same shape (false alarms). A higher $d'$ value shows increased discriminability for a given stimulus. This can be achieved through correctly matching pairs more often (hit rate) and/or incorrectly matching nonmatched pairs less often (false alarm rate).
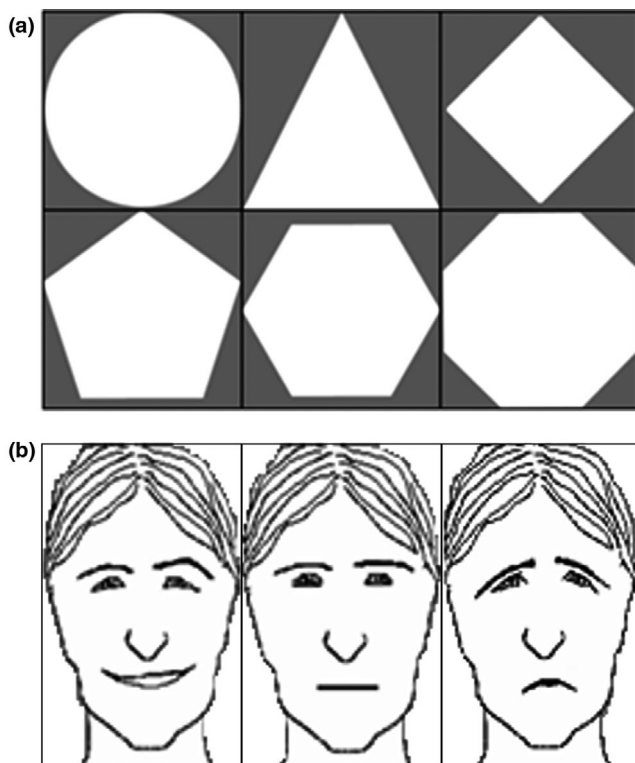
Fixation cross (jittered 800–1200 ms)

Label-shape pair (150 ms)

+
Self

Response (1000 ms)

Correct!

Feedback (500 ms)
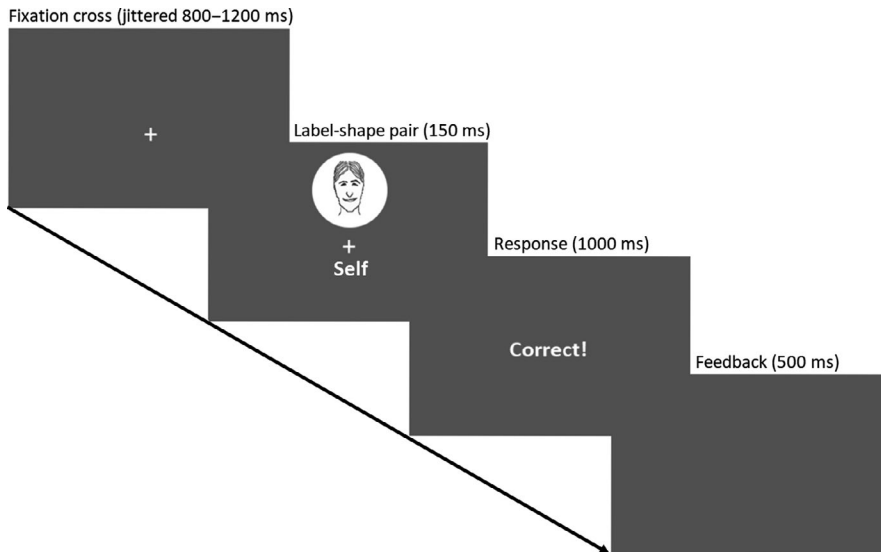
The equation for calculating $d'$ is as follows; $d' = Z$(hit rate) $- Z$(false alarm rate), where $Z$ is the inverse cumulative distribution function of the normal distribution. We used $d'$ rather than considering the accuracy of matched pairs because this measure is not subject to a participant's bias to either select "matched" or "nonmatched" more frequently. For example, a participant who always selected "matched" would show a 100% accuracy rate for matched pairs, but a 0% accuracy rate for nonmatched pairs. Thus, only considering the accuracy rate on matched pairs may be susceptible to participants' response biases.

Mean discriminability was calculated per participant for each of the six conditions (happy self, sad self, neutral self, happy other, sad other and neutral other) via matched and nonmatched trials. In cases where a participant made no false alarms (correctly identifying that a shape does not match with a given label 100% of the time), their false alarm score was corrected to $1/2N$. In cases where a participant made no hit rate errors (correctly identifying that a shape matches with a given label 100% of the time) their hit rate score was corrected to $1-(1/2N)$. In both cases, $N = 80$ (the number of trials for each condition). Correct responses with reaction times faster than 200ms were excluded from analysis (<0.0001% in total).

For analysis one, mixed measures analyses of variance (ANOVAs) were performed on the $d'$ data. The between subjects variable was group (control/depressed). The within subjects variables were shape category (self/other) and emotion valence (happy/sad/neutral).

For analysis two, the value of neutral $d'$ (acting as a baseline for each participant) was subtracted from the happy and sad $d'$ values for "self" and "other" separately in order to produce an "emotional bias" (EB) score based on discriminability. Positive scores reflect a greater discriminability for happy and sad faces compared to neutral faces and thus a greater sensitivity to emotion.

## 2.8 | Measure two: Efficiency index (drift rate-$v$)

The EZ diffusion model (Wagenmakers, Van Der Maas, & Grasman, 2007) was used to compute drift rate ($v$). Drift rate estimates the rate of information acquisition. Thus, it is used as a measure of perceptual processing speed, and therefore efficiency, during decision-making. A higher $v$ value shows increased efficiency in decision-making. The model determines $v$ using the values of mean reaction time, variance in reaction time and proportion of correct responses. The same values are used to calculate boundary separation ($a$). As a participant's drift rate score incorporates mean reaction time, variance in reaction time and the proportion of correct responses, it reflects trade-offs made between speed and accuracy in a way that basic reaction time measures cannot.

The model stipulates that reaction time responses show a degree of right skew that the relative speed of correct and error responses are similar and that the starting point $z$ is intermediate between two responses. The starting point $z$ is calculated such that $z = a/2$, where $a = $ boundary separation. These requirements were met by all data (Figures S1 and S2). Results of a $t$-test showed that correct and incorrect reaction times did not differ significantly per participant, ($t[39] = 1.86, p = .243$). A scaling parameter of 0.1 was used in calculating the drift rate. The scaling parameter is such that if all other parameters are halved along with the scaling parameter, then the result does not change. Thus, the choice of the scaling parameter is arbitrary and does not affect the statistical inferences.

The mean drift rate was calculated for each of the six conditions (happy self, sad self, neutral self, happy other, sad other and neutral other) for matched trials only. Correct response times with reaction times faster than 200 ms were

excluded from analysis (<0.0001% in total). In the case of the reaction time variance calculation, values $\pm$ 3 standard deviations (*SD*) from the mean were excluded as they may exert undue influence on the model.

For analysis one, ANOVAs were performed on the *v* data. The between subjects variable was group (control/depressed). The within subjects variables were shape category (self/other) and emotion valence (happy/sad/neutral). For analysis two, the value of neutral *v* (acting as a baseline for each participant) was then subtracted from the happy and sad *v* values for self and other separately in order to produce an EB score based on drift rate. Positive scores reflect increased perceptual processing speed for happy and sad faces compared to neutral faces and thus suggest a more efficient decision-making process in response to emotion.

# 3 | RESULTS

## 3.1 | Analysis one

Mixed measures analyses of variance (ANOVAs) were performed on *d'* and *v* data. The between subjects variable was group (control/depressed). The within subject variables were shape category (self/other) and emotion valence (happy/sad/neutral).

## 3.2 | Discriminability (*d'*) data

An ANOVA on the *d'* data showed a highly significant main effect for shape category (self/other) $F_{1,38} = 90.90$, $p < .001$, $n^2 = 0.167$, reflecting a higher *d'* for self-pairings. This suggests that participants exhibited a greater sensitivity to "self" compared to "other" pairings regardless of group. Within the control group 16/20 participants exhibited a higher *d'* value for self compared to other pairings across every emotion condition. Of the four remaining participants, two participants exhibited a lower *d'* value for self compared to other pairings across all emotion conditions. Within the depressed group 19/20 participants exhibited a higher *d'* value for self compared to other pairings across every emotion condition. The remaining participant exhibited a higher *d'* value for self compared to other pairings for one out of the three emotion conditions (Figure 3a and b).

The analysis further showed a significant interaction effect between shape category (self/other) and emotion valence (happy/sad/neutral) $F_{2,76} = 3.23$, $p = .045$, $n^2 = 0.001$, and between group (control/depressed) and emotion valence (happy/sad/neutral) $F_{2,76} = 3.90$, $p = .024$, $n^2 = 0.001$.

To understand these interactions further, ANOVAs were performed on the *d'* data for self and other pairings separately and for the control and depressed groups separately.

An ANOVA on the *d'* data ("self") showed no significant main effect of emotion, $F_{2,78} = 2.32$, $p = .105$, $n^2 = 0.002$. An ANOVA on the *d'* data ("other") showed no significant main effect of emotion, $F_{2,78} = 2.18$, $p = .119$, $n^2 = 0.001$. A lack of significance in the "self" and "other" ANOVAs despite a significant interaction effect between shape category and emotion is likely due to the control and depressed groups being considered simultaneously, for each "self" and "other" ANOVA. Thus, participant group is acting as a confounding variable. This is indicated by the subsequent ANOVA, which showed that participants' sensitivity to emotional valence act in opposing directions when considering the control and depressed groups independently; whilst control participants in general showed higher *d'* values for the happy emotion condition, depressed participants in general showed the higher *d'* values for the neutral emotion condition.

An ANOVA on the *d'* data (control group, [Figure 5]) showed a significant main effect of emotion, $F_{2,78} = 3.92$, $p = .024$, $n^2 = 0.002$. Bonferroni post hoc comparisons indicated that the mean *d'* value for the happy emotion condition ($M = 1.70$) was significantly higher than the mean *d'* value for the neutral emotion condition ($M = 1.56$). 14/20 participants in the control group exhibited a higher *d'* value for happy emotion conditions compared to neutral emotion conditions. An ANOVA on the *d'* data (depressed group [Figure 5]) showed no main effect of emotion. $F_{2,78} = 0.37$, $p = .689$, $n^2 = 0.000$. 10/20 participants in the depressed group exhibited a higher *d'* value for happy emotion conditions compared to neutral emotion conditions.

## 3.3 | Drift rate (*v*) data

An ANOVA on the *v* data showed a highly significant main effect of shape category (self/other) $F_{1,38} = 91.42$, $p < .001$, $n^2 = 0.315$, reflecting more efficient decision-making processes in response to self-pairings over other pairings regardless of group. Within the control group, 17/20 participants exhibited a higher *v* value for "self" compared to "other" pairings across every emotion condition. Of the three remaining participants, one participant showed a lower *v* value for self compared to other pairings across all emotion conditions. Within the depressed group, 20/20 participants exhibited a higher *v* value for self compared to other pairings across every emotion condition (Figure 4a and b).

The analysis also showed a significant interaction effect between group and emotion valence $F_{2,76} = 3.92$, $p = .024$, $n^2 = 0.002$. To understand this interaction further, ANOVAs were performed on the *v* data for the control and depressed groups separately. An ANOVA on the *v* data (control group, [Figure 5]) showed a significant main effect of emotion, $F_{2,78} = 4.17$, $p = .019$, $n^2 = 0.003$. Bonferonni post hoc comparisons showed that the mean *v* value for the happy emotion
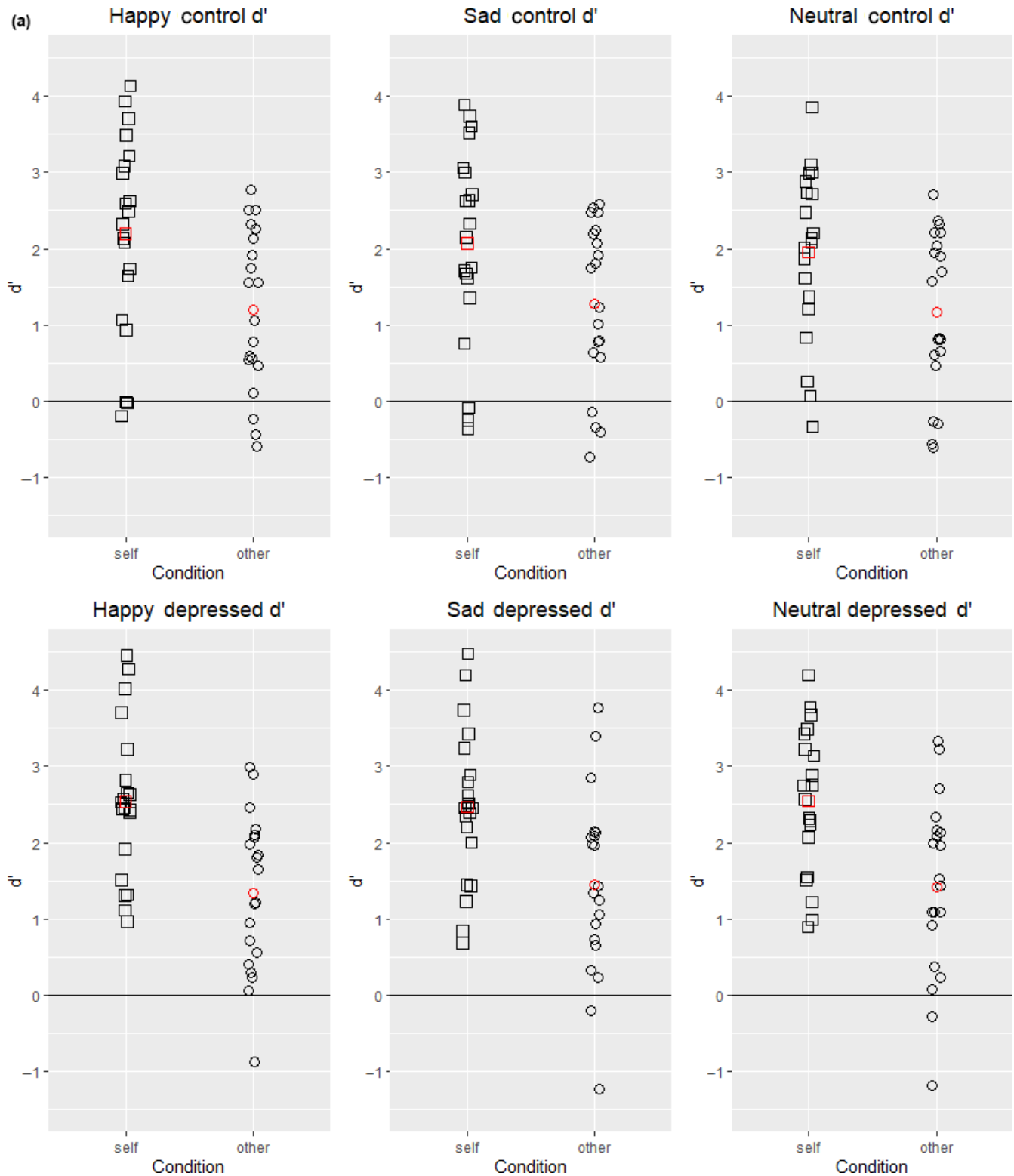
**FIGURE 3** (a) $d'$ per participant across three emotion conditions from self and other perspective. Red shapes denote the group mean. (b) $d'$ per participant across three emotion conditions from self and other perspective. Lines demonstrate pairwise comparisons

condition ($M = 0.17$) was significantly higher than the mean $v$ value for the neutral emotion condition ($M = 0.15$), $p = .039$. 14/20 participants in the control group exhibited a higher $v$ value for the happy emotion condition compared to neutral emotion conditions. In addition, the mean $v$ value for the happy emotion condition ($M = 0.17$) was significantly higher than the mean $v$ value for the sad emotion condition ($M = 0.15$), $p = .048$. 15/20 participants in the control group
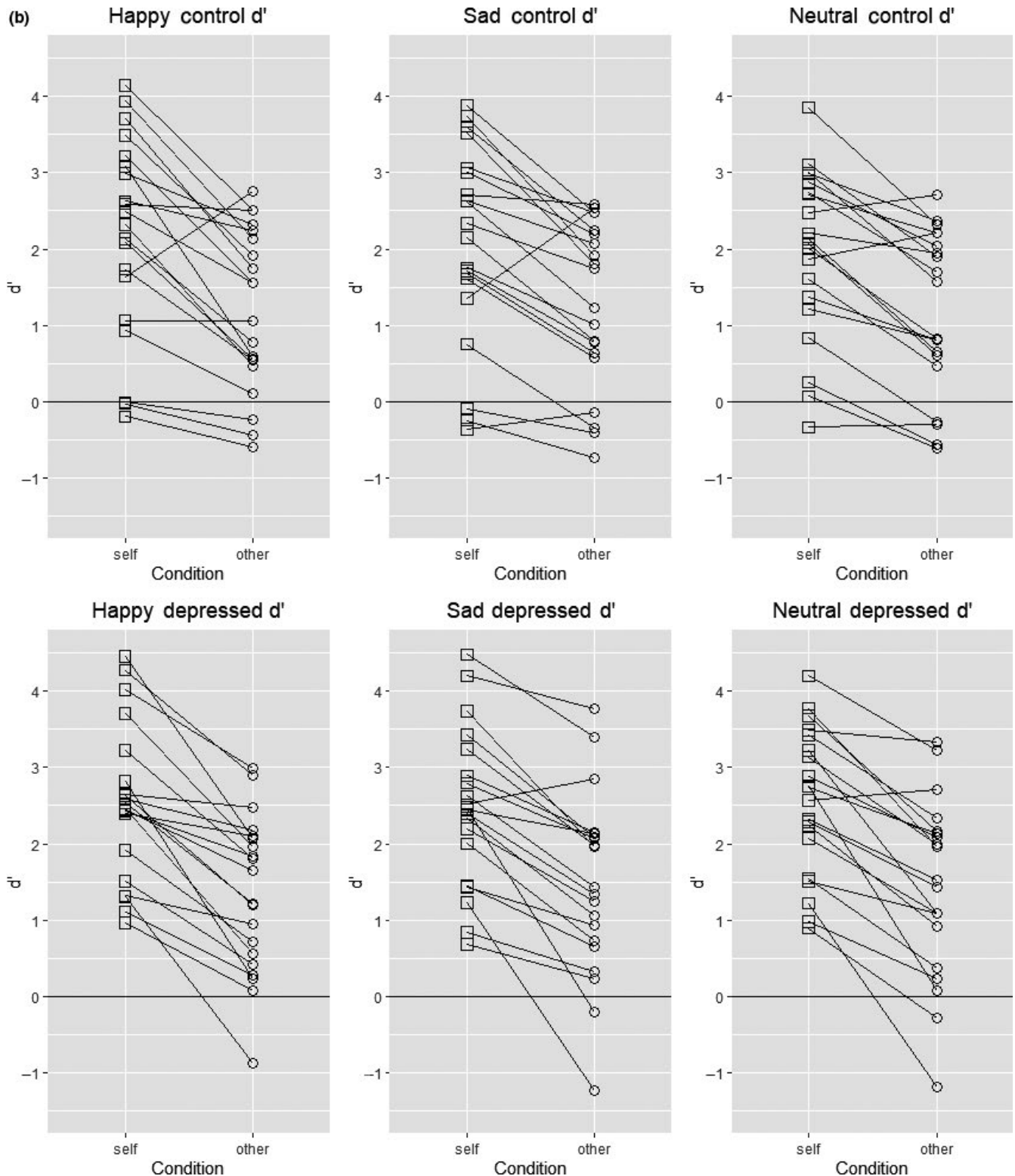
**FIGURE 3** (Continued)

exhibited a higher *v* value for the happy emotion condition compared to the sad emotion condition.

An ANOVA on the *v* data (depressed group, [Figure 5]) showed no main effect of emotion. $F_{2,78} = 2.18$, $p = .119$, $n^2 = 0.001$. 6/20 participants in the depressed group exhibited a higher *v* value for the happy emotion condition compared to the neutral emotion condition. 9/20 participants in

the depressed group exhibited a higher *v* value for the happy emotion condition compared to the sad emotion condition.

## 3.4 | Analysis two (bias scores)

ANOVAs were performed on the change in discriminability ($\Delta d'$) and the change in drift rate ($\Delta v$) from the neutral face
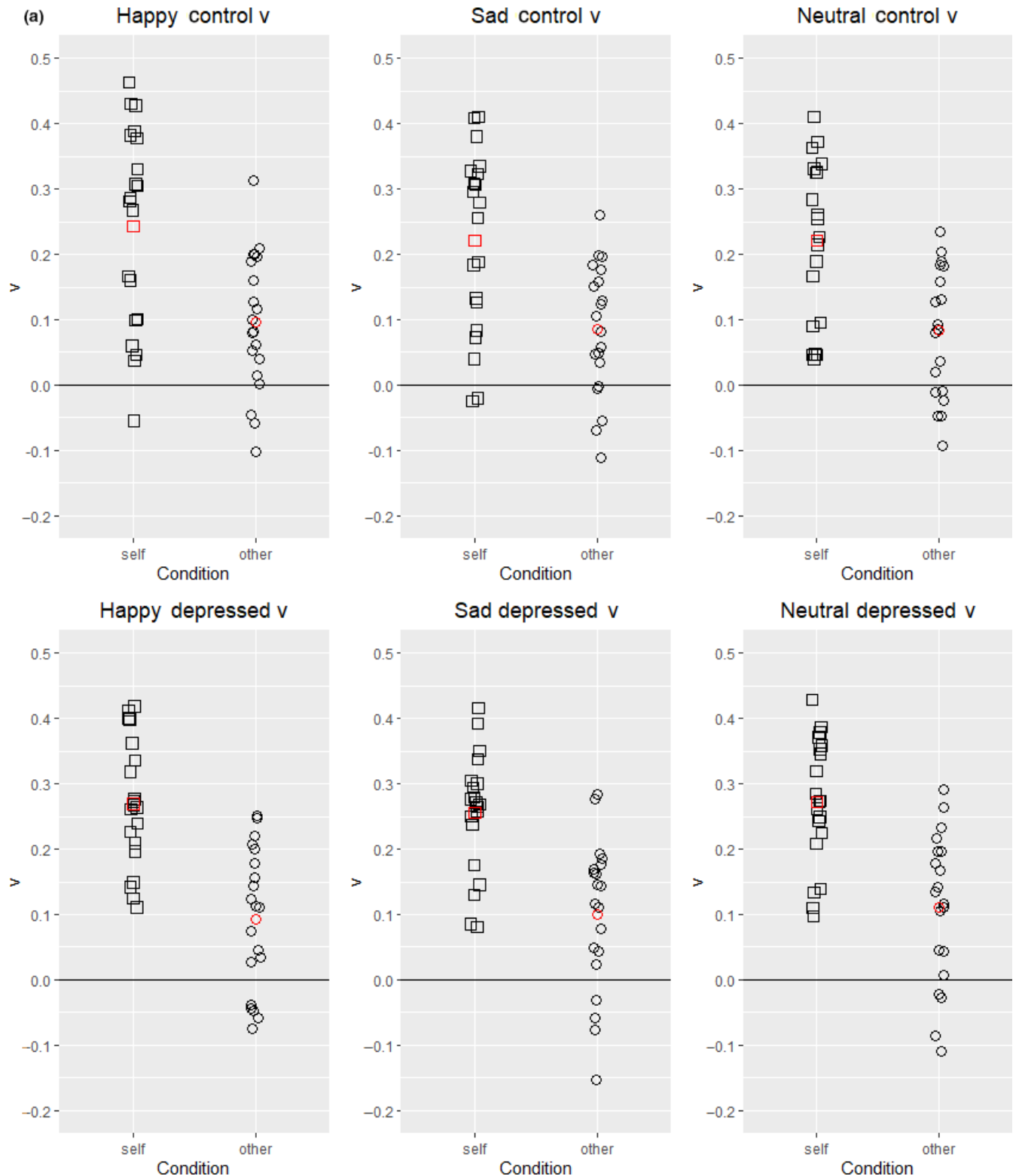
**FIGURE 4** (a) *v* per participant across three emotion conditions from self and other perspective. Red shapes denote the group mean. (b) *v* per participant across three emotion conditions from self and other perspective. Lines demonstrate pairwise comparisons

stimuli compared to the happy or sad face stimuli. The between subjects variable was group (control/ depressed). The within subject variables were shape category (self/other) and EB (happy/sad). Analysis two was incorporated to ensure that participants were compared to their own baseline.

## 3.5 | Discriminability (*d′*) data

An ANOVA on the $\Delta d′$ data showed a highly significant main effect of group (control/depressed) $F_{1,38} = 8.64$, $p = .006$, $\eta^2 = 0.0.185$, reflecting a higher $\Delta d′$ for the control
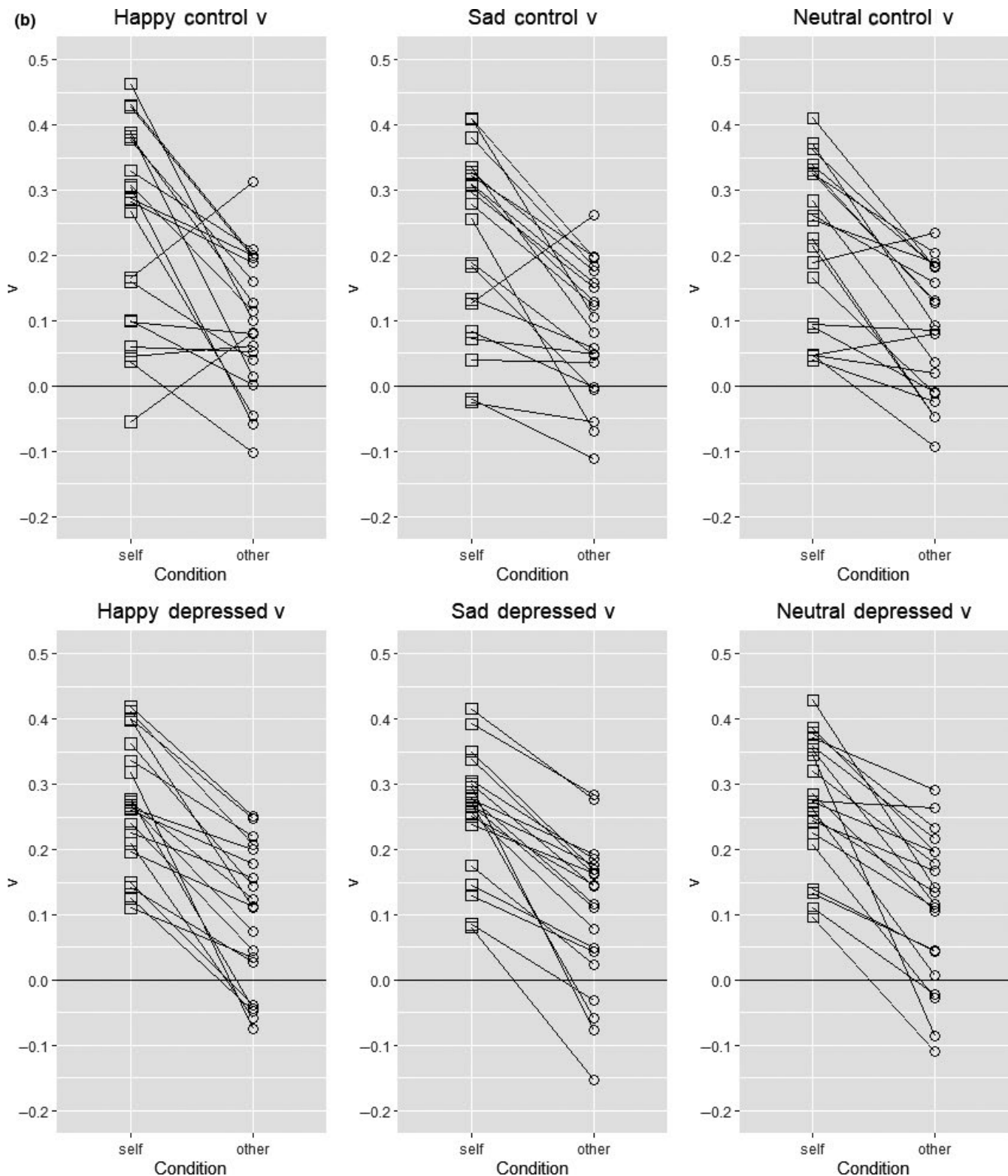
**FIGURE 4**  (Continued)

group (Figure 6). This suggests that the control group exhibited an increased sensitivity to emotional faces compared to the depressed group, regardless of shape category (self/other) and EB (happy/sad). 15/20 participants in the control group exhibited a greater sensitivity to happy over neutral faces (self-condition), compared to 11/20 in the depressed group. 13/20 participants in the control group exhibited a greater sensitivity to sad over neutral faces (self-condition), compared to 8/20 in the depressed group. 10/20 participants in the control group exhibited a greater sensitivity to happy over neutral faces (other condition) compared to 10/20 participants in the depressed group. 12/20 participants in the control group exhibited a greater sensitivity to sad over neutral faces (other condition) compared to 10/20 in the depressed group.
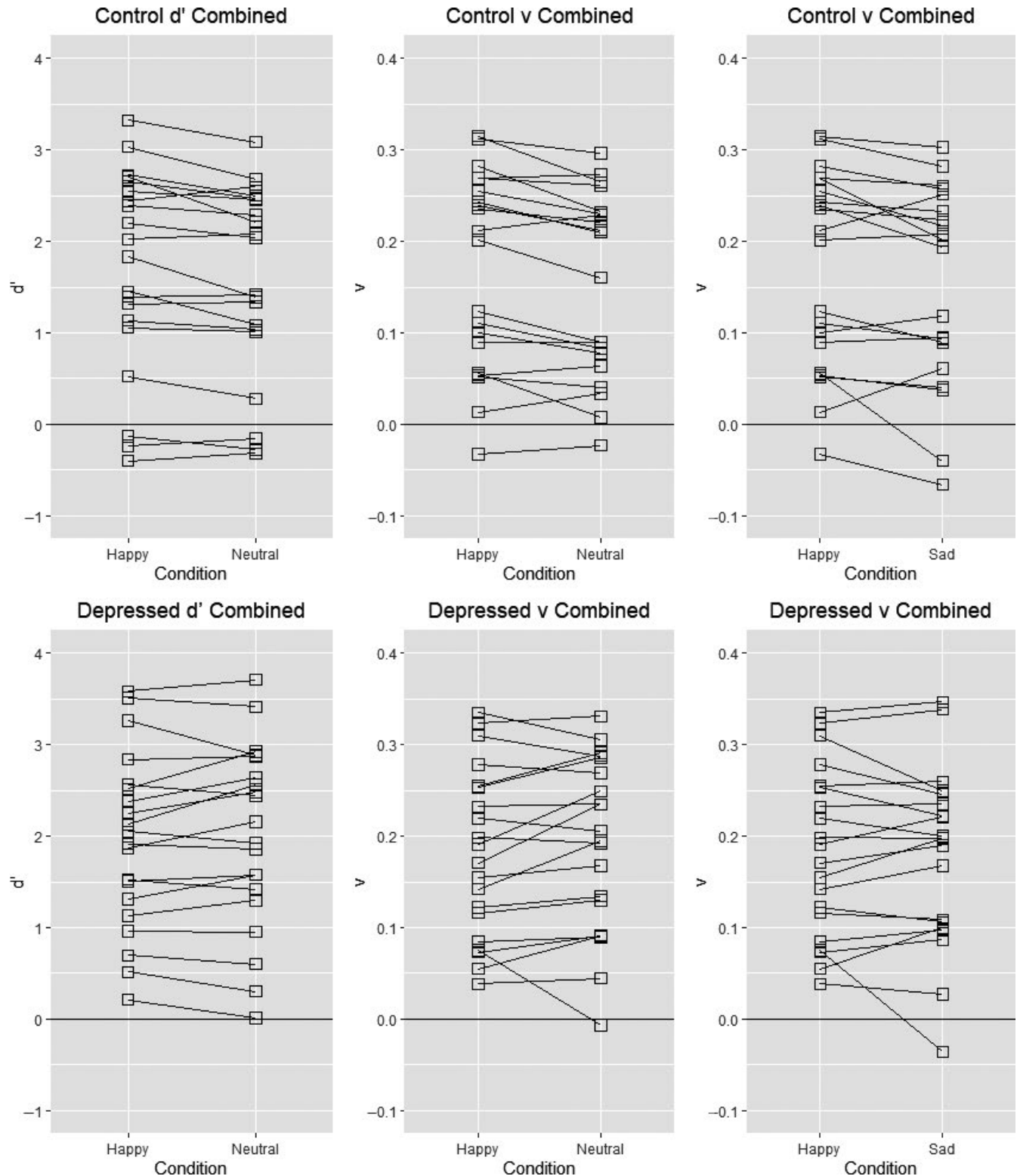
**FIGURE 5** Mean $d'$ and $v$ per participant across two emotion conditions: self and other combined

The analysis showed a significant interaction between shape category (self/other) and EB (happy/sad) $F_{1,38} = 6.37$, $p = .016$, $\eta^2 = 0.143$. There were no further significant interactions.

To understand this interaction further, ANOVAs were performed on the $\Delta d'$ data for self and other pairings

separately. An ANOVA on the $\Delta d'$ data ("self") showed a main effect of emotion approaching significance, $F_{1,39} = 3.46$, $p = .071$, $n^2 = 0.016$. An ANOVA on the $\Delta d'$ data ("other") showed a main effect of emotion approaching significance, $F_{1,39} = 3.10$, $p = .086$, $n^2 = 0.029$. A lack of significance in the "self" and "other" ANOVAs despite
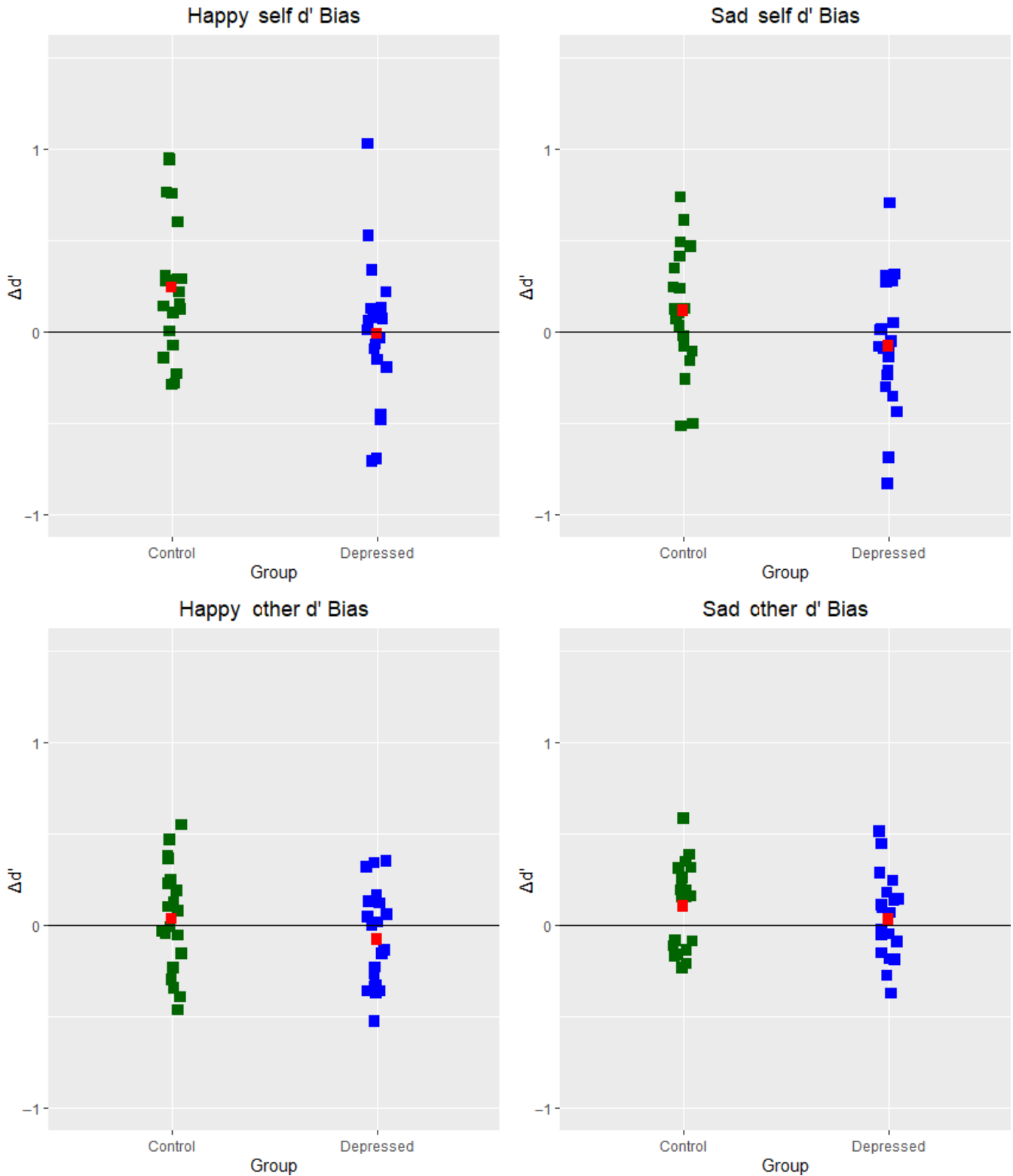
**FIGURE 6** Mean $\Delta d'$ per participant for happy and sad emotional biases from self and other perspective. Red shapes denote the group mean

a significant interaction effect between shape category and emotion is again likely due to the control and depressed groups being considered simultaneously for each "self" and "other" ANOVA. Thus, participant group is again acting as a confounding variable. Whilst the control group showed the largest $\Delta d'$ difference for the happy emotion condition, the depressed group showed the largest $\Delta d'$ difference for the sad emotion condition.

## 3.6 | Efficiency (*v*) data

An ANOVA on the Δ*v* data showed a highly significant effect of group (control/depressed) $F_{1,38} = 8.11$, $p = .007$, $\eta^2 = 0.176$ (Figure 7). There were no further significant interactions. This suggests that the control group exhibited increased efficiency in decision-making in response to emotional faces compared to the depressed group, regardless of shape category (self/other) and EB (happy/sad). 13/20 participants in the control group exhibited increased efficiency
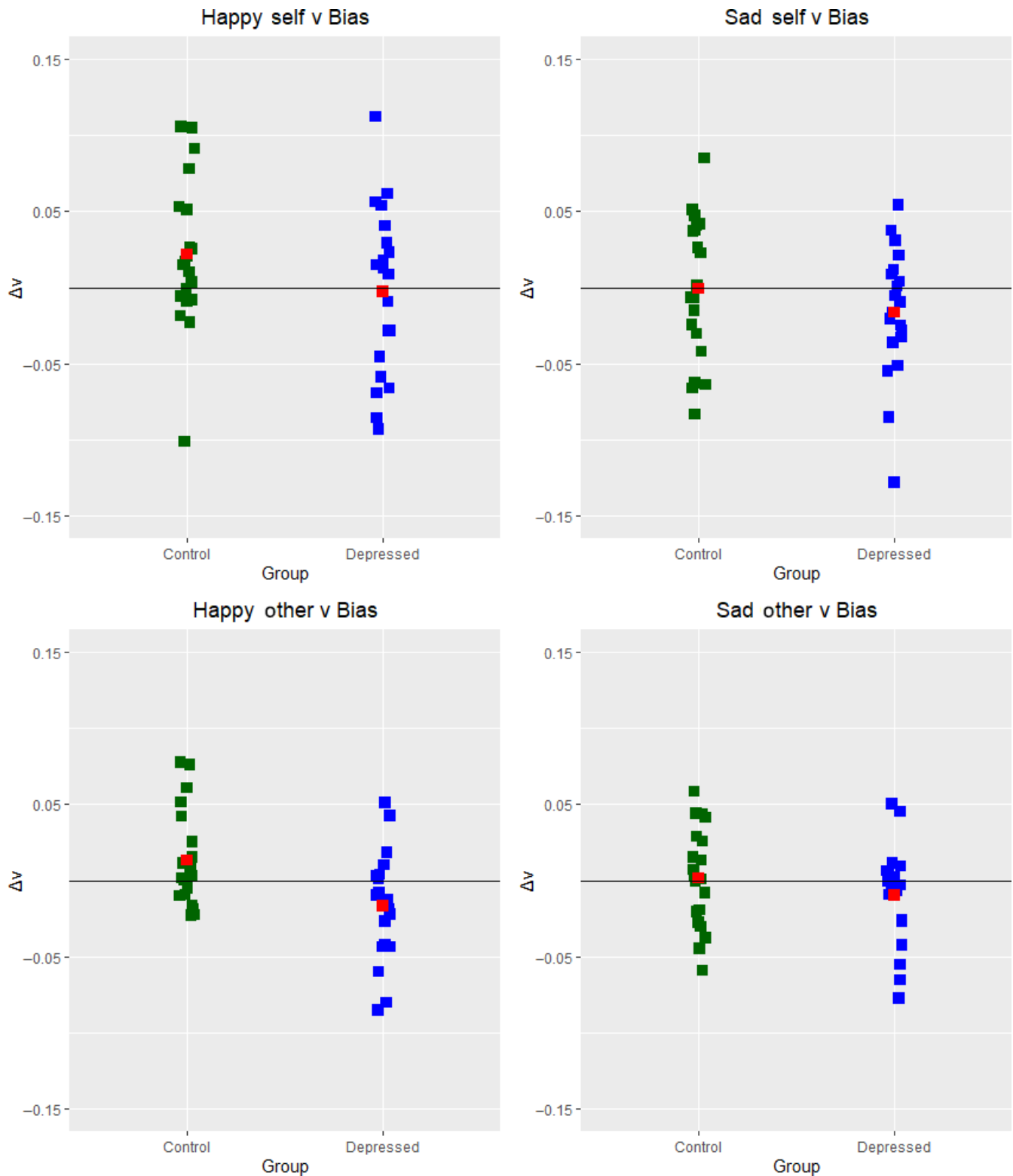


**FIGURE 7** Mean Δ*v* per participant for happy and sad emotional biases from self and other perspective. Red shapes denote the group mean

in decision-making in response to happy faces compared to neutral faces (self-condition), compared to 11/20 in the depressed group. 10/20 participants in the control group exhibited increased efficiency in decision-making in response to sad faces compared to neutral faces (self-condition), compared to 7/20 in the depressed group. 12/20 participants in the control group exhibited increased efficiency in decision-making in response to happy faces compared to neutral faces (other condition), compared to 7/20 in the depressed group.11/20 participants in the control group exhibited increased efficiency in decision-making in response to sad faces compared to neutral faces (other condition), compared to 7/20 in the depressed group.

# 4 | DISCUSSION

Information processing research has shown that self-relevant stimuli receive preferential access to attentional resources (Alexopoulos et al., 2012; Gray et al., 2004; Ma & Han, 2010). In addition, emotional stimuli are shown to more effectively capture attention compared to neutral stimuli (Leppänen & Hietanen, 2003; Pourtois, Schettino, & Vuilleumier, 2013). The separate influences of self-referential and emotional stimuli on attentional allocation in healthy participants have been explored by Stolte et al., (2017) who found evidence of separate attentional biases towards self-referential and emotional (happy face) stimuli. This study first aimed to investigate if self-relevance in perception acts as a superordinate schema to influence emotional salience, and second aimed to investigate if self-relevance in perception influences emotional salience in depressive disorders specifically.

## 4.1 | The influence of self-perception on emotional salience

The results from analysis one show that participants exhibited a highly significant bias towards self-relevant pairings compared to other-relevant pairings, regardless of group and emotion condition. These results lend support to research which suggests that self-perception acts as a superordinate schema. This may influence the perceived salience of emotional stimuli at later stages of information processing (Chen et al., 2014; Zhou et al., 2017); however, no clear interactions between "self"/"other" concept and emotional valence were observed in this study. Furthermore, we suggest that the influence of "self" is solely a reflection of participants' internalised self-schema, because this study avoided confounding self-reference and familiarity. This finding is particularly informative because whilst previous studies have used more basic measures such as reaction time and discriminability

($d'$) to index bias (Stolte et al., 2017; Sui et al., 2012), the drift rate ($v$) measure used in the current study was calculated using correct response proportion, reaction time and reaction time variance. Hence, the measure better reflects trade-offs between speed and accuracy. This study has therefore found evidence of a superordinate self-bias using a more robust analysis method.

Furthermore, the results show that participants exhibited a highly significant bias towards self-relevant pairings compared to other-relevant pairings, regardless of group. If an intimate relationship between self-perception and positive emotion exists, an attenuated self-bias effect could reasonably be expected in depressed compared to control participants given the central role of negative self-perception and low self-esteem in depressive disorders (Clark et al., 1999; Orth & Robins, 2013; World Health Organization, 1992). However, a depression specific attenuated self-bias was not observed in the current study. This supports Stolte et al.'s (2017) notion that independent processes underlie self and positive emotion biases. Our results are further supported by evidence of separable neural mechanisms for "self" and emotion. Moran, Macrae, Heatherton, Wyland, and Kelly (2006) showed that whilst self-relevant stimuli promote activity in the medial prefrontal cortex, the emotional valence of stimuli promotes activity in the ventral anterior cingulate cortex. There is therefore emerging evidence to suggest that self-relevance and emotional valence are processed in different brain regions.

## 4.2 | Depression specific hypoattention to positive stimuli

Our results showed that compared to the control group, the depressed group exhibited significantly reduced "happy self" and "happy other" biases. This was reflected in lower sensitivity and less efficient decision-making processes in response to happy faces in comparison to neutral faces for both "self" and "other" conditions.

Moreover, whilst overall the control group exhibited significantly higher sensitivity and efficiency in decision-making processes in response to happy faces in comparison to neutral faces, the depressed group did not. These findings support experimental research which shows that depressed participants display hypoattention to positive stimuli (McCabe & Gotlib, 1995; Milders et al., 2016). Earlier research by Kuiper and Derry (1982) suggests that depressed participants show hypoattention to positive self-relevant information specifically. Whilst our results showed that the difference in "happy self" bias magnitude for the control and depressed groups was greater than the difference in "happy other" bias magnitude, the difference in magnitudes was not significant. We are therefore unable to provide further evidence in support

of Kuiper and Derry's (1982) work, although our findings suggest that further research in this area may be warranted.

## 4.3 | Emotion context insensitivity

A depression specific hyperattention to sad face stimuli was not observed in this study. In explanation, this may be because hyperattention to negative stimuli is more commonly observed at longer stimulus presentations (De Raedt & Koster, 2010; Duque & Vázquez, 2015; Shane & Peterson, 2007). It has been proposed that rather than initially orienting towards negative self-referential information, individuals with depression may struggle to disengage from it in time. This may manifest as increased rumination over negative self-relevant information, which in turn induces low mood (Segal et al., 1995). Further research could explore this possibility using the current paradigm through presenting label-shape pairings at longer stimulus presentations.

Interestingly, our results evidenced a depression specific hypoattention to negative (sad face) as well as positive (happy face) stimuli, reflected in reduced "happy" and "sad" biases within the depressed group for both "self" and "other" conditions. This general blunted response to emotion has been described previously as ECI by Rottenberg et al. (2005). Our findings further support earlier research conducted by Bylsma et al. (2008), who concluded that depression is characterised by hypoattention to positive and negative stimuli simultaneously. The ECI evidenced in the current study does not conform to Beck's (1967, 2008) cognitive theory of depression, whose emphasis remains on a rapid and involuntary bias towards negative stimuli on account of depressed individuals' negative self-perception. Instead, a general blunted response to emotion may be the result of a demotivated mood state that diminishes the ability of depressed individuals to effectively respond to social situations and emotional events. In explanation, evolutionary psychologists have suggested that a demotivated mood state may have served an adaptive function in *Homo sapiens* evolutionary history, in which humans would have competed for social rank, resources and mates. In the event of a "loss" in any of these domains, depressive symptoms such as lethargy and social withdrawal may have served as a deterrent against further conflict, increasing the chances of individual survival (Hendrie & Pickles, 2009). However, in the absence of such pressures, depressive symptoms are maladaptive and damaging, reducing quality of life (Clark et al., 1999; Orth & Robins, 2013; World Health Organization, 1992).

## 4.4 | Methodological Implications

To understand biases directly "happy" and "sad" emotional bias scores were calculated by subtracting the neutral values

from the happy and sad values of each measure for each participant. This method has both advantages and limitations. The advantage of this method is that individual participant variation was to some extent accounted for because participants were compared to their own "baseline". This baseline is important as certain measures; for example, drift rate and reaction time are susceptible to individual differences. Drift rate reflects rate of information acquisition, which is shown to correlate with cognitive ability, which varies between individuals (Schubert et al., 2016). Depressed participants may have exhibited longer reaction times on account of motor retardation, a symptom of depression experienced by 40%–60% of sufferers (Caligiuri & Ellwanger, 2000).

The bias score calculation also created limitations. First, it may be that depressed participants paid more attention to neutral self-relevant stimuli compared to control participants purely because the stimuli lacked positivity. This would mean that the neutral values of each measure did not reflect a true "baseline". Secondly, whilst self-referential emotion processing was explored in analysis two, a true self-reference effect was not. In explanation, whilst any given participant could have exhibited a significantly lower drift rate for all "other" stimuli, compared to "self" stimuli, the difference would have been masked through the bias score calculation which reflects only the difference between neutral and positive stimuli ("happy bias") and neutral and negative stimuli ("sad bias") for each of the "self" and "other" conditions separately. However, this limitation was addressed through the inclusion of analysis one, which analysed happy, sad and neutral discriminability and efficiency values for each participant separately.

A further methodological limitation of this study it that whilst $d'$ and $v$ measures were used to create an emotional "bias" score, $d'$ and $v$ measure sensitivity and decision-making efficiency respectively. As such, the "biases" exhibited by participants may reflect different underlying cognitive constructs. A final limitation of this study is that 9 out of 20 depressed participant's exhibited comorbid anxiety. This may have confounded results, as hypoattention to positive stimuli has been correlated with anxiety as well as depression (Watson & Naragon-Gainey, 2010). As such, the hypoattention to positive stimuli observed in depressed participants may be the result of the dual effects of anxiety and depression on cognition. However, the attentional bias most often observed in anxious individuals is an orientation towards threat cues in visual search paradigms (Leppänen & Hietanen, 2003; Mogg & Bradley, 2005), neither of which were a feature of this study.

## 5 | CONCLUSIONS AND PRACTICAL IMPLICATIONS

In this study, participants on average exhibited a bias towards self-relevant compared to other-relevant stimuli, regardless

of experimental group allocation. Furthermore, participants in the depressed group exhibited hypoattention to emotional stimuli in comparison to those in the control group, regardless of "self" or "other" relevance. This was reflected in their diminished "happy" and "sad" bias scores. This study has therefore not found evidence of a relationship between self-bias and emotion bias in the context of depression.

Whilst a great deal of research has investigated the cognitive biases underlying depression, a minority have incorporated self-referential components. Those studies which do, have often use autobiographical stimuli familiar to the participant. This study used a novel perceptual matching task which avoids confounding self-reference and familiarity effects. Our results have shown that in general, both control and depressed participants exhibit a bias towards self-relevant compared to other-relevant stimuli.

Interestingly, depression specific biases towards neutral faces over happy and sad faces were observed at short (150ms) stimulus presentations. Our findings do not therefore conform to Beck's (1967, 2008) influential theory of depression, which suggests that individuals with depression show a rapid, automatic bias towards negative information. Instead, there is evidence that depressed participants exhibit generalised ECI at short stimulus presentations. ECI theory is a relatively uncharted phenomenon and would benefit from further research.

The majority of current cognitive behavioural therapy (CBT) techniques are modelled on Beck's (1967) cognitive theory of depression and are focused primarily on modifying negative thoughts (National Health Service, 2016). Whilst CBT has been shown to be hugely beneficial for many sufferers, it could be used in conjunction with new techniques that "train" depressed individuals to actively take stock of positive events and occurrences that healthy individuals appear to automatically attend to, increasing their receptivity to positive experiences.

## CONFLICT OF INTEREST STATEMENT
The authors certify that they have no affiliations with or involvement in any organisation or entity with any financial interest or non-financial interests in the subject matter or materials discussed in this manuscript.

## AUTHOR CONTRIBUTIONS
**LM** designed the experiment, collected the data, analysed the data and wrote the manuscript; **JS** studied the concept, designed the experiment and wrote the manuscript; **TM** studied the concept, participant's eligibility assessment and wrote the manuscript; **DD** analysed the data, wrote the manuscript; **SK** studied the concept, designed the experiment, collected the data, analysed the data and wrote the manuscript.

## DATA AVAILABILITY STATEMENT
All raw E-prime and questionnaire data have been uploaded onto figshare. https://figshare.com/s/e1391ebe3f11e8d70d9f (participant E-Prime data) and https://figshare.com/s/0619e c5decfb4dd3d1d1 (participant questionnaire/demographic information).

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.