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ARTICLE

# Loneliness is associated with a greater self-reference effect in episodic memory when compared against a close friend

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## Abstract

Loneliness describes a negative experience associated with perceived social disconnection. Despite the clear links between loneliness and mental and physical health, relatively little is known about how loneliness affects cognition. In this study, we tested the effect of loneliness on cognitive distance between the self and others, using a task in which participants completed a surprise memory task for adjectives implicitly encoded in relation to the self, a close friend or a celebrity. We assessed item memory sensitivity, metacognitive sensitivity, metacognitive efficiency and source memory for positive and negative words. In addition, participants reported their trait loneliness and depression. Results revealed an overall self-referential advantage compared with both friend and celebrity encoded items. Likewise, a friend-referential advantage was identified compared to celebrity-encoded items. Individuals who experienced more loneliness showed a greater self-referential bias in comparison to words encoded in relation to a close friend, and a smaller friend-referential bias in comparison to words encoded in relation to celebrity. These findings suggest that loneliness is reflected in a greater cognitive distance between the self and close friends in relation to memory biases. The results have important implications for understanding the social contextual effects on memory and the cognitive ramifications of loneliness.

**KEYWORDS**
depression, episodic memory, metamemory, self-reference effect, social network, source memory

## INTRODUCTION

Humans form close relationships with non-familial others. These relationships are beneficial for well-being (Umberson & Montez, 2010), and a perceived failure to develop close relationships has been associated with poor mental and physical health (Hawkley & Cacioppo, 2010). A perceived social disconnection between oneself and other people is experienced as a feeling of loneliness and is reported by a substantial proportion of the Western world, with some claiming that the West is facing a loneliness epidemic (Jeste et al., 2020). The prevalence of chronic loneliness, coupled with the considerable impact on physical and mental health, has focused research on how individuals who often experience loneliness process social information. In the following study, we use a robust measure of self-other processing, the self-reference effect in episodic memory (Symons & Johnson, 1997), to demonstrate how loneliness is associated with a reduced ability to recognize items encoded in relation to a close friend.

Empirical studies into loneliness and social cognition have predominantly focused on social threat. For example, individuals who experience higher rates of loneliness may report an explicit desire to connect with others, but are also hypervigilant to social threats, impeding their efforts to connect (Cacioppo & Hawkley, 2009). One prominent hypothesis considers loneliness from an evolutionary standpoint, with loneliness serving an adaptive function. The Cacioppo Evolutionary Theory of Loneliness (Cacioppo & Cacioppo, 2018) claims that loneliness evolved as way to signal to an individual the need for social connection and that these needs are not currently being met in the current social environment. Unless the individual can change social environments, the perception of the social environment as non-beneficial requires greater self-reliance, and even selfishness, to maintain a comparable level of evolutionary fitness. Humans tend to show an egocentric bias across a range of cognitive domains, including perception, attention and memory (Amodeo et al., 2021). In line with the Cacioppo Evolutionary Theory of Loneliness, individuals who often experience loneliness should show a greater egocentric bias due to their greater self-reliance and self-focus. However, how self-other processing differs across the continuum of loneliness has received little attention.

Self-biases have been identified across cognitive domains, including memory (Rodman et al., 2017; Scheuplein et al., 2021). According to the Cacioppo Evolutionary Theory of Loneliness, these biases may be exaggerated in individuals who experience loneliness to a greater extent. However, close friends are also integral to our sense of self (Ketay et al., 2019) and shape our future opportunities and success (Burt, 1992). It is therefore not surprising that friend-referential biases are also identified across a range of cognitive domains (Chen et al., 2021; Sui et al., 2012; Symons & Johnson, 1997). The importance of close friends for our sense of self is of heightened importance around late adolescence and early adulthood as we transition away from family focused evaluation, to one dominated by social evaluation from non-familial peers (Somerville, 2013).

Recently, Courtney and Meyer (2020) demonstrated a greater overlap in neural activity between close friends, acquaintances and strangers in those who reported higher levels of loneliness. When participants attended to adjectives in relation to themselves, a close-other, or a stranger, distinct neural clusters of activation were identified in the medial prefrontal cortex (mPFC). Crucially those who reported experiencing higher levels of loneliness had a greater distance between the neural clusters associated with the self and close others. In other words, perceived social isolation was associated with a lonelier 'neural self'. Despite this neural evidence, little is known about how loneliness affects cognitive aspects of self-other processing. One possibility is that if loneliness is associated with greater neural overlap between close friends and strangers (Courtney & Meyer, 2020) then a greater egocentricity effect will only be identified in relation to close friends in individuals who experience higher levels of loneliness.

The relationship between the self and others has been studied at the cognitive level across several domains. A frequently studied area is memory bias for self-encoded compared with other-encoded items, a phenomenon known as the self-reference effect (SRE) which also has been associated with mPFC function (Martin et al., 2019; Northoff et al., 2006; Philippi et al., 2012). Therefore, if loneliness is associated with greater distance between self and close other representations at the neural level, cognitive biases associated with these patterns of neural activity may also be different across the loneliness

continuum. The present study explores cognitive distance between the self and a close friend using the well-established self-reference effect in episodic memory.

The SRE has been demonstrated across a number of studies and is consistent when compared against memory for both other-referent or semantic encoding (e.g. engaging with the meaning of a word rather than whether it describes someone accurately) conditions (Symons & Johnson, 1997). When comparing self-referential to other-referential memory, most studies have used a politician or celebrity, who is familiar to the participant but not personally close (D'Argembeau et al., 2005; Gutchess et al., 2007; Martin et al., 2018, 2019; Santiesteban et al., 2012; Symons & Johnson, 1997). Self-biases are evident by superior memory performance for items encoded in relation to the self. Other studies have investigated whether memories encoded in relation to a close other (e.g., mother) carry a similar bias to those encoded in relation to the self, and found that familiar others engage similar cognitive processes to those elicited by the self, and thus elicit a similar bias in encoding and later retrieval (Aron et al., 1991; Bower & Gilligan, 1979). Despite overlapping cognitive representations, evidence suggests that a self-referential bias still exists over close-other encoded memories (Gutchess et al., 2007). These studies all included the participant's mother as the close-other; however, memories for close friends may also benefit from a bias (i.e. a friend-referential bias), possibly due to a greater mental overlap with self-referential processes (Courtney & Meyer, 2020).

In addition to simply remembering or recognizing an item, we are often tasked with recalling or recognizing contextual elements of the memory in question. One such contextual element is the ability to source the content of a memory to the correct person, a process known as source memory. Whether source memory reflects a common or unique cognitive process is of considerable debate within the literature (Davachi et al., 2003; Glisky et al., 1995; Guo et al., 2021; Madan et al., 2017; Mather, 2007; Slotnick et al., 2003). Self-reference effects have also been studied in source memory. For example, Durbin et al. (2017) identified a self-referential bias in the ability to correctly source a memory. However, the self-referential bias was specific to positive encoded items. The authors concluded that source memory accuracy depends on how well an item aligns with the self-schema. Therefore, the self-reference effect in source memory supports a self-positivity bias, whereby individuals are motivated to remember positive information associated with the self, to protect their positive self-image (D'Argembeau et al., 2005; D'Argembeau & Van der Linden, 2008). However, it remains unknown whether items encoded in relation to close others confer a similar bias in source memory.

To date, self-reference effects in episodic memory have relied on simple binary yes/no decisions in relation to an encoded item. However, it is also relevant to ask whether self-reference effects exist at the level of confidence for a memory trace, often labelled metamemory (Dunlosky & Thiede, 2013). Assessing confidence in a previously given binary response is a common method to examine metacognition, defined as our ability to monitor or critique the preciseness of our performance. Metamemory can be measured in terms of average confidence for each encoding condition, but this measure will be significantly confounded by first-order performance (i.e., performance on the binary yes/no recall task). Metacognitive sensitivity applies a signal-detection theoretical approach to demonstrate how well second-order confidence judgements track first-order performance. For example, high metacognitive sensitivity indicates higher confidence for correctly remembered items and lower confidence for incorrectly remembered items. Metacognitive sensitivity is measured using meta-$d'$ which indicates the sensitivity ($d'$) that an observer with 'optimal metacognition' and the same first-order response bias, would require to reproduce the participant's metacognitive responses, observed in the current experiment (Maniscalco & Lau, 2012). As metacognitive sensitivity is also affected by first-order sensitivity (see Maniscalco & Lau, 2012), metacognitive efficiency takes a ratio of second-level (meta $d'$) and first-level ($d'$) sensitivity to provide a measure of metacognition independent of first-level performance (meta $d'/d'$ or M-ratio). Therefore, by calculating metacognitive efficiency we can assess whether metamemory differs across encoding condition independent of first-order memory accuracy.

It is important to study the effects of loneliness across different components of episodic memory. A self-bias identified solely for item memory does not provide strong evidence that information has been organized in relation to the self. Source memory refers to the features of a memory trace, such as who

the memory was in relation to. Item and source memory are dissociable (Johnson et al., 1993) and this extends to self-referential biases within item and source memory (Serbun et al., 2011). Self-referential effects in source memory may rely more on how embedded a stimulus is within one's self-schema (Durbin et al., 2017). Therefore, individuals who experience loneliness to a greater extent may show greater attention to self-encoded items in relation to a close friend and therefore a self-reference effect in item memory. However, unless the item aligns with their self-schema, they will not show a greater self-reference effect in source memory. It is also important to understand whether self-referential effects are also observed in one's metacognitive knowledge or beliefs about memory performance. Although we are more likely to be confident in a correct memory, memory performance and metamemory can dissociate (Fleming & Lau, 2014). To date, self-referential effects on measures of metamemory have not been studied. Moreover, individuals who often experience loneliness may also show a greater self-bias in beliefs about their memory performance when compared against memory traces in relation to a close friend. Self-referential effects are often influenced by the valence of the items encoded (D'Argembeau et al., 2005) and are therefore important to consider valence effects across item and source memory, metamemory and the association with loneliness.

Loneliness has often been studied among older adults (Donovan & Blazer, 2020); however, it is younger adults (16–24) who experience loneliness to a greater extent than other age groups (Qualter et al., 2015). Late adolescence to early adulthood is a critical period for the emergence of several psychiatric conditions and is a time of considerable social fluctuation and social cognitive changes (Choudhury et al., 2006). As loneliness fundamentally concerns social connection, understanding how these cognitive biases differ in young adults, who often experience loneliness, may shine a light on the underlying cognitive factors that may subsequently increase the risk of mental health problems, such as depression or psychosis.

In sum, the current study investigated the self-reference effect in episodic memory among young adults, using both a close friend and a public figure/celebrity as a comparison. The inclusion of both a personally and publicly familiar other allows the study of how self-biases differ dependent on the nature of the other person. A perceived social disconnection should only affect biases related to personally known others. Alternatively, if loneliness results in greater egocentrism overall, self-referential biases may be higher compared to both personally-known others and celebrities. Self-referential biases were assessed across first-order accuracy and second-order metacognition for item memory and accuracy in source memory. Items were either positive or negative to assess valence effects on memory biases. Finally, memory biases were correlated with self-reported loneliness to assess whether those that experience higher rates of loneliness present with greater cognitive distance between the self and a close friend. As loneliness and depression are related (Cacioppo et al., 2006, 2010), but distinct (Weeks et al., 1980), constructs, we also assessed participants' depression levels to isolate the effect of loneliness on self-referential processing from effects of depressive traits. In line with previous research, it was expected that self-encoded words would be better remembered than celebrity-encoded words, and friend-encoded words would show an intermediate advantage. This pattern would be reflected in metacognitive sensitivity. We also predicted that source memory would show a comparable pattern, but only for positive words. Crucially, we expected that loneliness would correlate with a stronger self-reference effect in relation to a close friend, and a reduced friend-reference effect compared to celebrity-encoded words, demonstrating that lonelier individuals have reduced self-friend overlap and a greater friend-celebrity overlap. We did not expect depression to account for the relationship between loneliness and self-referential processes.

# METHOD

## Participants

One-hundred and forty-three young adults (Mean age = 19.36 years, *SD* = 1.62, range = 18–31 years; 126 female) were recruited from the Research Participation Scheme as part of the undergraduate Psychology

degree at The University of Kent. The sample was sufficient to detect low-medium strength correlations ($r = \pm.25$) with 80% power at an alpha of .05. All participants were awarded course credit for their participation. All participants were free from a current neurological or psychiatric condition, and all had normal or corrected-to-normal vision.

## Procedure

Testing was completed online using Qualtrics (https://www.qualtrics.com) for all questionnaires and Pavlovia (https://pavlovia.org) for the memory task. Participants were required to make judgements about themselves, a close friend or a celebrity and completed two personality questionnaires. We assessed incidental memory encoding, as participants were unaware that the study contained a memory test. All participants nominated a close friend, and their first name was used as a prompt throughout the study. They then rated the closeness of this friend on a scale between 1 and 9. Participants were informed that the celebrity used in the study would be Boris Johnson and were asked to rate their familiarity on a scale between 1 and 9. After the encoding session and prior to the memory recognition test, participants completed a visual perceptual task for approximately 5 min (results not reported here). At the completion of the study, participants were debriefed and awarded course credits for participation.

## Memory task

In the encoding task, participants were presented with 60 adjectives and asked to respond on a 9-point scale from 1 (very inaccurate) to 9 (very accurate), how well the adjective described themselves, a close friend or Boris Johnson (20 adjectives for each condition). The words were presented in a random order to avoid any order effects in the subsequent memory task. All word lists were selected from Warriner et al. (2013), and each condition (self, friend, celebrity) contained 10 positive words and 10 negative words according to the valence ratings reported in Warriner et al. (2013). Sixty distractor words were included in the surprise memory task with an equal number of positive and negative words. All word lists were balanced for arousal rating as per Warriner et al. (2013). All words used are presented in the Appendix S1.

In the recognition stage, the 60 encoded words and 60 new distractor words were presented in a random manner. Each word appeared in the centre of the screen and participants were asked, "Do you remember this word?" and instructed to respond, "Yes" or "No". Subsequently they were asked how confident they were in their decision from 1 (Not at all confident) to 9 (very confident). If participants responded "Yes" that they had remembered the word, they were asked a follow up question, "Who was the word in reference to?". Participants had to answer with either "Yourself", "Your Friend" or "Boris Johnson". In both the encoding and recognition stages, participants were informed that they should go at their own pace and that there were no time constraints.

## Questionnaires

Perceived loneliness was assessed using the UCLA loneliness scale (Russell, 1996). The questionnaire consists of 20 questions and is scored on a scale from 1 to 4. A total score between 20 and 80 was calculated and used in all analyses, with higher scores indicating greater loneliness. The UCLA loneliness scale has high internal consistency (Cronbach's $a$ = .89–.94), test–retest reliability ($r$ = .73) and has been validated against other measures of loneliness, interpersonal relationships and health and well-being (Russell, 1996). In the present study, the internal consistency was high, Cronbach's $a$ = .86.

Depression was measured using the Beck's Depression Inventory (BDI-II, Beck et al., 1996). The DPI-II consists of 21 questions scored on a scale from 0 to 3, in terms of severity of depressive symptom. A total score between 0 and 63 was calculated following the prescribed scoring template and used

in all analyses. Higher scores indicate a greater number of depressive traits. It is well validated for use in a healthy, university-aged sample, with high internal consistency ($a$ = .91) and test–retest reliability ($r$ = .93; Beck et al., 1996; Sprinkle et al., 2002; Storch et al., 2004). In the present study, the internal consistency was high, Cronbach's $a$ = .93.

## Statistical analyses

All analyses were completed in JASP (version 0.14.1, http://www.jasp-stats.org). We report both frequentist and Bayesian statistics. For the Bayesian analyses, we adopted the default Cauchy priors as recommended by Wagenmakers et al., 2018. A Bayes factor ($BF$) quantifies the evidence for a particular model. For example, a $BF_{10}$ of 4 equates to data that is 4 times as likely from the alternate model as from the null model. Evidence for the alternate model is interpreted in a linear scale but for the ease of interpretation we conclude $BF_{10}$ = 1–3 as inconclusive or preliminary evidence, 3–10 as moderate, >10 as strong evidence for the alternate model. Likewise, a $BF_{10}$ between 0.33 and 1 should be considered inconclusive or preliminary evidence, between 0.1–0.33 as moderate evidence, and <0.1 as strong evidence in favour of the null model.

Total item memory was calculated for self, friend and celebrity-encoded words (total out of 20 for each condition). In order to calculate signal detection measures of first-order sensitivity ($d'$), second-order sensitivity (meta $d'$) and metacognitive efficiency (meta $d'/d'$ or M-ratio), we employed a single-subject Bayesian estimation using HMeta-$d$ (Fleming, 2017) in MATLAB (version r2021a). All analyses were calculated using participants' accuracy and confidence judgements for each of the three conditions. Accuracy and confidence for correctly labelling the 60 distractor words were used in each comparison (self, friend and celebrity). Meta-$d'$ is theoretically bound at zero. However, when fit using an unbounded maximum likelihood procedure, it can return negative values. The estimation error is relevant across all ranges of meta $d'$, but is most evident when it exceeds the boundary of zero. As the negative values are indicative of estimation error that is consistent across the data, we did not remove negative meta $d'$ values. It should be noted that the general pattern of results was comparable if participants who returned a negative metacognitive sensitivity score were removed ($N$ = 18). Participants were removed from the metacognitive efficiency analyses if their first-level sensitivity ($d'$) was too low ($d' < 0.1$), as this can severely affect the M-ratio score (Lee et al., 2018). This resulted in 20 participants being removed. Two participants M-ratio scores were well over three standard deviations from the mean scores and were removed, resulting in a final sample size of 121 for the metacognitive efficiency analysis. It should be noted that the inclusion of these datapoints did not affect the pattern of results.

Source memory was calculated as the percentage of correctly remembered words correctly sourced to the self, friend or celebrity and was calculated for both positive and negative words.

All effects were assessed using 2 × 3 Repeated-Measures Analysis of Variance (RM-ANOVA) with post-hoc analyses to assess how performance differed according to VALENCE (positive, negative), and the AGENT the word was encoded in relation to (Self, Friend, Celebrity).

Self and friend referential bias scores were calculated by subtracting one condition from another. SRE (friend) refers to self-friend, SRE (celebrity) refers to self-celebrity and FRE refers to friend-celebrity. These were calculated using sensitivity ($d'$), metacognitive efficiency (meta $d'/d'$) and source memory.

Pearson's correlations were used to assess the relationship between loneliness, depression and self or friend referential bias scores. To further clarify the association between loneliness and memory performance across self, close friend and celebrity encoding conditions, significant correlations were followed by linear regression analyses for each encoding condition. We included memory performance for the other two encoding conditions in the null model and included loneliness, depression and closeness of friend rating as predictors. The closeness of friend rating was included in linear regressions to assess potential moderating effects between loneliness and self-referential effects in respect to how close the friend is perceived by the participant. We also assessed whether familiarity with Boris Johnson affected self-referential or friend-referential effects when compared against Boris Johnson.

**TABLE 1** Mean scores for item and source memory across encoding conditions.

| | Self, Mean (*SD*) | Close friend, Mean (*SD*) | Celebrity, Mean (*SD*) |
|---|---|---|---|
| Item memory | | | |
| Total (% correct) | 65.24 (21.13) | 56.64 (20.24) | 46.71 (20.85) |
| Positive | 67.55 (22.37) | 58.46 (21.47) | 47.13 (22.60) |
| Negative | 62.94 (24.72) | 54.83 (22.98) | 46.29 (23.67) |
| Sensitivity ($d'$) | 1.67 (0.73) | 1.41 (0.68) | 1.12 (0.64) |
| Positive | 1.77 (0.76) | 1.51 (0.72) | 1.22 (0.72) |
| Negative | 1.53 (0.71) | 1.31 (0.64) | 1.07 (0.62) |
| Metacognitive sensitivity (meta $d'$) | 1.31 (1.01) | 1.11 (0.93) | 0.86 (0.81) |
| Positive | 1.14 (1.18) | 0.96 (1.12) | 0.75 (1.03) |
| Negative | 1.21 (1.23) | 1.06 (1.10) | 0.85 (0.97) |
| Metacognitive efficiency (meta $d'/d'$) | 0.71 (0.44) | 0.68 (0.52) | 0.67 (0.59) |
| Positive | 0.64 (0.53) | 0.60 (0.62) | 0.52 (0.70) |
| Negative | 0.77 (0.63) | 0.81 (0.73) | 0.79 (0.83) |
| Source memory | | | |
| Total (% correct) | 78.92 (18.24) | 80.22 (16.78) | 73.97 (21.28) |
| Positive | 78.37 (22.62) | 80.45 (21.34) | 66.55 (27.65) |
| Negative | 80.24 (19.98) | 80.25 (20.44) | 81.40 (26.25) |

## RESULTS

The mean loneliness rating was 40.62 ($SD$ = 10.54), with a range of 20–69. The mean depression rating was 11.15 ($SD$ = 8.91), with a range of 0–39. Participants generally reported that they were very close to the friend they selected for the purposes of this study, $M$ = 8.39 (out of 9; $SD$ = 0.90). Likewise, Boris Johnson was rated as familiar, $M$ = 6.36 (out of 9; $SD$ = 2.55).

Self-reported closeness of friend did not correlate with SRE (friend) for sensitivity for item memory, $r(141) = -.07$, $p = .38$ [$BF_{10} = 0.15$], metacognitive efficiency, $r(122) = .03$, $p = .70$ [$BF_{10} = 0.12$] or source memory, $r(135) = .08$, $p = .38$ [$BF_{10} = 0.16$]. Likewise, familiarity with Boris Johnson had no effect on SRE (celebrity) for sensitivity for item memory (Table 1), $r(141) = -.07$, $p = .37$ [$BF_{10} = 0.15$], metacognitive efficiency, $r(122) = -.08$, $p = .37$ [$BF_{10} = 0.17$] or source memory, $r(135) = .01$, $p = .92$ [$BF_{10} = 0.11$].

### Item memory sensitivity ($d'$)

A 3 × 2 RM-ANOVA was computed with VALENCE and AGENT as predictors of item memory sensitivity ($d'$). Main effects of AGENT, $F(2, 284) = 82.83$, $p < .001$ [$BF_{10} = 3.03e+29$], $\eta_p^2 = .19$ and VALENCE were identified, $F(1, 142) = 23.94$, $p < .001$ [$BF_{10} = 5.32e+6$], $\eta_p^2 = .04$, with positive words remembered with higher sensitivity ($d'$ = 1.50 vs. 1.31). Post-hoc analyses demonstrated a self-bias over both friend, $t(142) = 6.14$, $p < .001$ [$BF_{10} = 3.31e+8$], Cohen's $d = 0.51$ and celebrity, $t(142) = 12.87$, $p < .001$ [$BF_{10} = 1.46e+31$], Cohen's $d = 1.08$. A friend-bias was also identified compared with celebrity, $t(142) = 6.83$, $p < .001$ [$BF_{10} = 1.58e+9$], Cohen's $d = 0.56$. See Figure 1. The interaction between AGENT × VALENCE strongly supported no effect, $F(2, 284) = .96$, $p = .38$ [$BF_{10} = 0.05$], $\eta_p^2 = .001$.

### Metacognitive sensitivity (meta $d'$)

Metacognitive sensitivity refers to the extent to which confidence ratings differentiate between correct and incorrect responses. A main effect of VALENCE was not supported, $F(1, 142) = 4.31$, $p = .04$

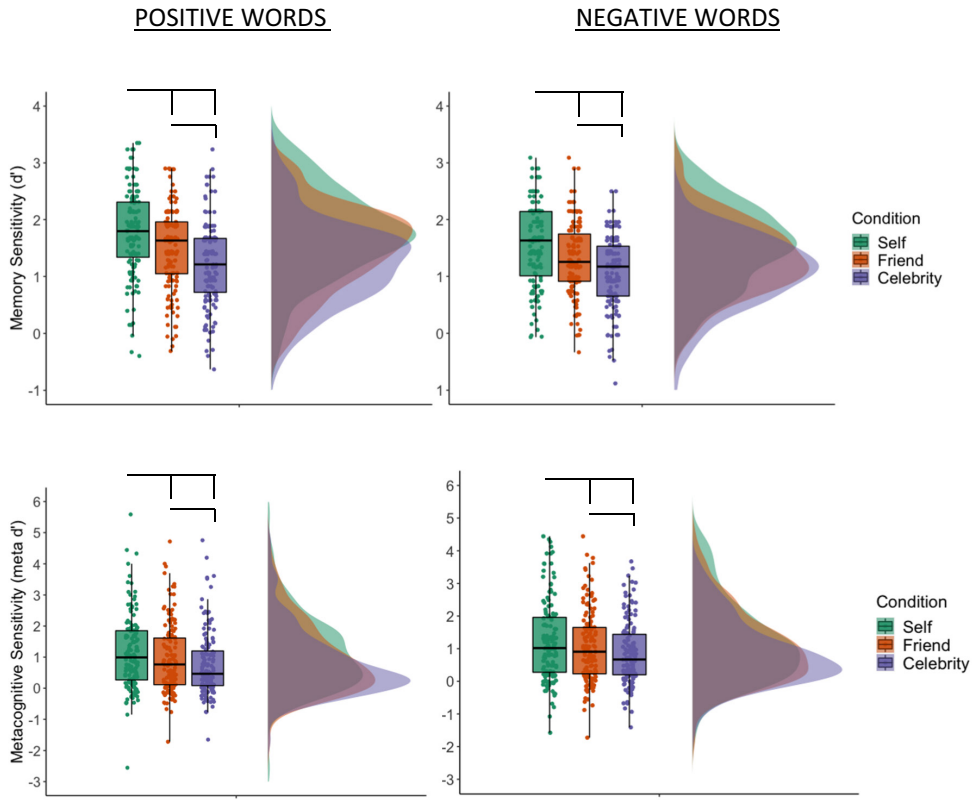


**FIGURE 1** Item memory sensitivity ($d'$) and metacognitive sensitivity (meta $d'$) for self, friend, and celebrity encoded words. Boxplots represent the interquartile range and median and the whiskers extend to the furthest datapoint within 1.5 *SD* from the mean. Distributions are also provided. Bars indicate significant differences (all $p < .001$).

[$BF_{10}$ = 0.92], $\eta_p^2$ = .03, although the evidence for the null was inconclusive. A strong main effect of AGENT, $F(2, 284) = 42.76$, $p < .001$ [$BF_{10}$ = 7.38e+13], $\eta_p^2$ = .23 was identified. Post-hoc analyses revealed a self-bias compared with both friend, $t(142) = 4.03$, $p < .001$ [$BF_{10}$ = 1120.51], Cohen's $d = 0.34$ and celebrity, $t(142) = 9.22$, $p < .001$ [$BF_{10}$ = 7.79e+17], Cohen's $d = 0.77$. Metacognitive sensitivity was also higher in the friend condition compared with the celebrity, $t(142) = 5.20$, $p < .001$ [$BF_{10}$ = 119070.27], Cohen's $d = .43$. An interaction between AGENT and VALENCE was not supported, $F(2, 284) = 0.15$, $p = .86$ [$BF_{10}$ = 0.03], $\eta_p^2 = .001$.

## Metacognitive efficiency

As metacognitive sensitivity is somewhat confounded by first-order sensitivity ($d'$), it is important to assess metacognitive efficiency (meta $d'/d'$) which controls for first-order performance. There was a main effect of VALENCE, $F(1, 120) = 27.39$, $p < .001$ [$BF_{10}$ = 3.04e+9], $\eta_p^2 = .09$, such that the M-ratio (meta $d'/d'$) was higher for negative memories compared with positive memories (0.79 vs. 0.59). There was no main effect of AGENT, $F(2, 240) = 1.51$, $p = .22$ [$BF_{10}$ = 0.05], $\eta_p^2 = .004$, nor an AGENT × VALENCE interaction, $F(2, 240) = 2.60$, $p = .08$, [$BF_{10}$ = 0.18], $\eta_p^2 = .006$. Therefore, the metacognitive sensitivity differences identified above reflect differences in item memory accuracy rather than a greater ability to introspect on self-encoded memories. However, participants had a greater ability to introspect on their memory performance for negative words across all encoding conditions (Figure 2).

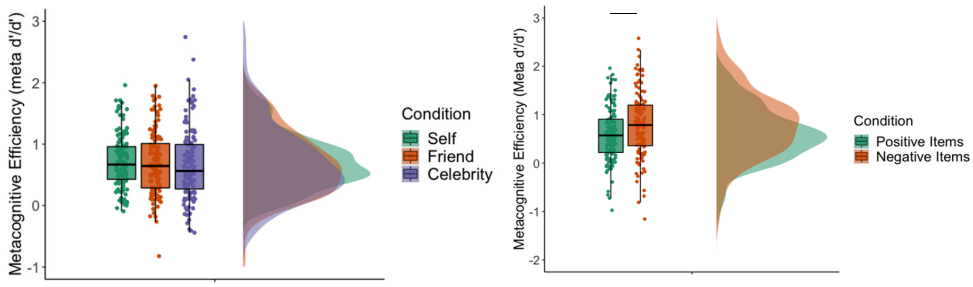


**FIGURE 2** Metacognitive efficiency (meta $d'/d'$) for self, friend and celebrity encoded words. Boxplots represent the interquartile range and median and the whiskers extend to the furthest datapoint within 1.5 *SD* from the mean. Distributions are also provided. Bars indicate significant differences. Bar indicates significant difference ($p < .001$).

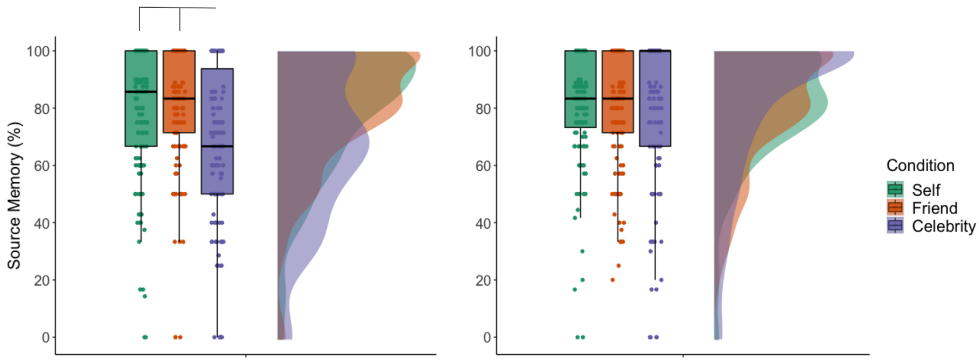


**FIGURE 3** Source memory accuracy for self, friend and celebrity encoded words. Boxplots represent the interquartile range and median and the whiskers extend to the furthest datapoint within 1.5 *SD* from the mean. Distributions are also provided. Bars indicate significant differences ($p \leq .001$).

## Source memory accuracy

For source memory, main effects were identified for AGENT, $F(2, 268) = 7.74$, $p < .001$ [$BF_{10} = 31.24$], $\eta_p^2 = .07$ and VALENCE, $F(1, 134) = 17.17$, $p < .001$ [$BF_{10} = 161.77$], $\eta_p^2 = .11$. However, both were subsumed within an AGENT × VALENCE interaction, $F(2, 268) = 12.44$, $p < .001$ [$BF_{10} = 1678.12$], $\eta_p^2 = .08$. To explore the interaction, we computed two 1 × 3 RM-ANOVAs for negative and positive words, respectively. An effect of AGENT was found for positive words, $F(2, 268) = 16.10$, $p < .001$ [$BF_{10} = 69401.66$], $\eta_p^2 = .11$. Post-hoc analyses identified lower source memory accuracy for the celebrity encoded positive words, compared with both self-encoded words, $t = 4.47$, $p < .001$ [$BF_{10} = 502.01$], Cohen's $d = 0.39$, and friend-encoded words, $t = 5.26$, $p < .001$ [$BF_{10} = 5442.57$], Cohen's $d = 0.45$. There was no difference between self and friend-encoded words, $t = -0.79$, $p = .43$ [$BF_{10} = 0.14$], Cohen's $d = -0.07$ (see Figure 3). There was no effect of AGENT encoding condition on source memory for negative words, $F(2, 268) = 0.20$, $p = .82$ [$BF_{10} = 0.03$], $\eta_p^2 = .002$. Testing effects of valence in each agent condition revealed that the effect was driven by a significant difference between correctly sourcing positive and negative words in the celebrity condition (66.55% vs. 81.40%), $t(134) = -5.31$, $p < .001$ [$BF_{10} = 26796.07$], Cohen's $d = -0.46$. No differences were found in the self condition (78.37% vs. 80.24%), $t(134) = -0.97$, $p = .33$ [$BF_{10} = 0.15$], Cohen's $d = -0.08$ or friend condition (80.45% vs. 80.25%), $t(134) = 0.10$, $p = .92$ [$BF_{10} = 0.10$], Cohen's $d = 0.01$.

Source memory and item memory sensitivity showed a strong correlation, $r(133) = .753$, $p < .001$ [$BF_{10} = 7.81e+22$]. However, self and friend referential effects in item and source memory were not correlated, [all $BF_{10}$ between 0.12 and 0.45].

## Relationship between loneliness, depression and self and friend referential effects

All correlations between loneliness and self (SRE) and friend (FRE) reference effects are presented in Table 2 with scatterplots provided in Figure 4. The correlation between loneliness and self or friend-referential effects did not differ according to valence, except for a marginal difference for metacognitive sensitivity, demonstrating that individuals who experience higher levels of loneliness, have superior insight into their memories for words encoded in relation to themselves compared with a close friend, but only for positive words. See Appendix (S1) for full analyses.

The correlations between loneliness and SRE (friend) and loneliness and SRE (celebrity) were significantly different, $Z = 2.91$, $p = .004$. The correlations between depression and SRE (friend) and depression and SRE (celebrity) were not significantly different, $z = 1.58$, $p = .11$.

A positive correlation was observed between loneliness and depression, $r(141) = 0.377$, $p < .001$ [$BF_{10} = 4549.67$]. Weak evidence was found in favour of a correlation between loneliness and self-reported closeness of friend, $r(141) = -.206$, $p = .01$ [$BF_{10} = 2.16$] but closeness of friend did not correlate with any self-referential or friend-referential biases [$BF_{10}$ between 0.10 and 0.46]. To assess how loneliness affected memory for self, friend and celebrity-encoded items, controlling for depression and explicit closeness rating of their friend, we ran linear regression analyses for all significant correlations between loneliness and self or friend-referential effects. Full models are provided in the Appendix S1.

## Item memory

To show loneliness is associated with reduced memory sensitivity for close friend encoded words rather than increased memory performance for self-encoded words, we ran a series of linear regression analyses. First, we included loneliness, depression and friend closeness rating as predictors of memory sensitivity for friend-encoded words and controlled for memory sensitivity for self-encoded and celebrity-encoded words. A model containing only loneliness was the best model, $BF_{10} = 160.49$.

**TABLE 2** Correlations between loneliness, depression and all self and friend reference effects.

| | Loneliness | | | Depression | | |
|---|---|---|---|---|---|---|
| | *r* | *p* | $BF_{10}$ | *r* | *p* | $BF_{10}$ |
| Item memory accuracy (*d*) | | | | | | |
| SRE friend | .275 | .001 | 24.69 | .259 | .002 | 13.07 |
| SRE celebrity | .025 | .77 | 0.11 | .124 | .14 | 0.31 |
| FRE | −.236 | .005 | 5.65 | −.124 | .14 | 0.31 |
| Metacognitive sensitivity (Meta *d*) | | | | | | |
| SRE friend | .111 | .19 | 0.25 | .019 | .82 | 0.11 |
| SRE celebrity | −.152 | .07 | 0.53 | −.035 | .68 | 0.11 |
| FRE | −.248 | .003 | 8.57 | −.054 | .52 | 0.13 |
| Metacognitive efficiency (Meta *d*/*d*) | | | | | | |
| SRE friend | −.008 | .93 | 0.11 | −.137 | .13 | 0.34 |
| SRE celebrity | −.092 | .32 | 0.19 | .006 | .95 | 0.11 |
| FRE | −.112 | .22 | 0.24 | .070 | .45 | 0.15 |
| Source memory | | | | | | |
| SRE friend | −.013 | .88 | 0.11 | −.127 | .15 | 0.30 |
| SRE celebrity | .008 | .93 | 0.11 | −.205 | .02 | 1.63 |
| FRE | .018 | .84 | 0.11 | −.068 | .44 | 0.15 |

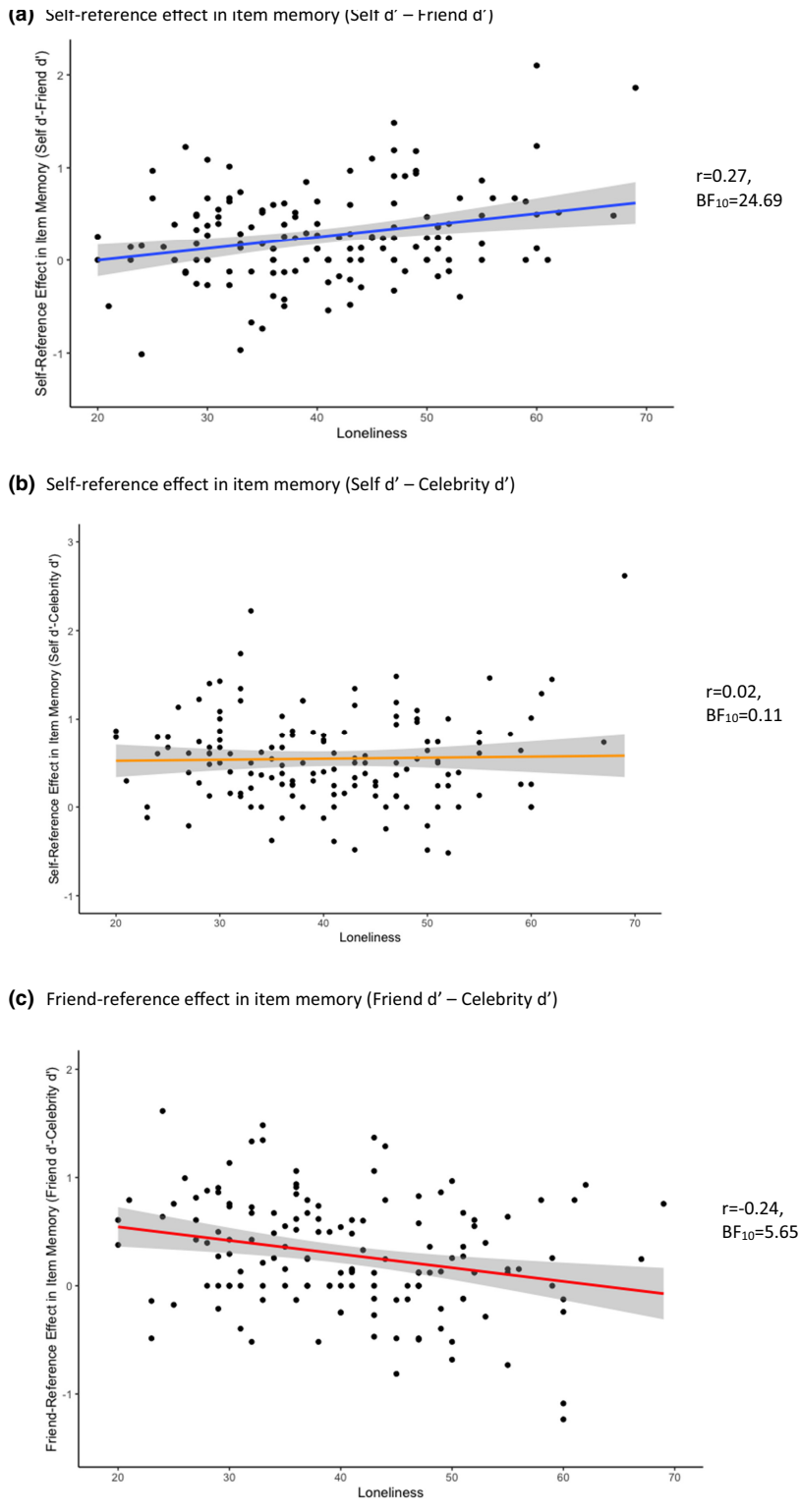


**FIGURE 4** Correlations between loneliness and self and friend referential effects in item memory sensitivity (*d*).

Loneliness, $BF_{10}$ was supported for inclusion, $BF_{10}$ = 21.28 but neither depression, $BF_{10}$ = 0.78 or friend closeness rating, $BF_{10}$ = 0.23 were supported. Therefore, loneliness predicted reduced memory sensitivity for friend-encoded words, and this was not explained by depression or friend closeness rating.

For self-encoded words, only depression was weakly supported for inclusion in the model, $BF_{10}$ = 1.15. For celebrity-encoded words, the null model was supported.

### Metacognitive sensitivity

The model for metacognitive sensitivity for friend-encoded words controlling for celebrity- and self-encoded words was weakly supported, $BF_{10}$ = 2.44, with loneliness the only predictor, $BF_{10}$ = 1.14. The models for metacognitive sensitivity for self and celebrity-encoded words both favoured the null model.

Therefore, loneliness was associated with greater overlap for metacognitive sensitivity between close friend and celebrity-encoded words, and this is not explained by either depression or closeness of friend rating. However, the evidence is weak and far from conclusive.

## DISCUSSION

The present study used first- and second-order signal detection analyses to investigate self-biases in episodic memory and explore the relationship with loneliness. A self-reference effect was identified for item memory for both negative and positive words. Positive words were remembered with higher first-order sensitivity, but lower second-order metacognitive sensitivity across all agent conditions, resulting in a valence effect on metacognitive efficiency. A self-reference effect was identified for source memory, and this was limited to positive words, with the effect driven by a reduced accuracy for sourcing positive words to the celebrity. Finally, we showed that individuals who experience higher rates of loneliness show greater overlap between memory performance for a close friend and celebrity resulting in a greater self-reference effect when compared with a close friend.

Consistent with previous studies (Bower & Gilligan, 1979; Martin et al., 2017; Rogers et al., 1977), we demonstrated a self-reference effect for words encoded in relation to the self in comparison with a celebrity. We extended this body of research by showing that friend-encoded words show an intermediate advantage that is greater than celebrity but less than a self-referential advantage. This contrasts with previous research showing a comparable memory advantage for self and close-other encoded items (Aron et al., 1991; Bower & Gilligan, 1979) and supports previous evidence showing that a self-referential advantage still exists when compared to items encoded in relation to a close-other (Gutchess et al., 2007). The nature of the sample and the close other used may explain inconsistent results. For example, a close friend in a cohort of university students may not have the same duration of shared experience as a family member. However, to the authors' knowledge, this has not been empirically assessed and should be explored in future research.

Loneliness can be defined as a discrepancy between desired and actual social contact or connection. This is the first study to show that this discrepancy is reflected in a greater cognitive distance between the self and a friend relevant to memory retrieval. This builds on previous research showing a reduced self-friend overlap at the level of neural activity when simply reflecting on the self or close others (Courtney & Meyer, 2020). Overall, the increased cognitive distance between self and friend in individuals who often experience loneliness provides further evidence that social connection can be reflected at the cognitive level (Cacioppo & Hawkley, 2009). The increased self-reference in episodic memory somewhat supports the Cacioppo Evolutionary Theory of Loneliness, which predicts a greater self-focus in individuals who often experience loneliness, but crucially only when compared against close friends, rather than greater egocentricity in general. As the Cacioppo Evolutionary Theory of Loneliness claims that a greater self-bias or reliance is adaptive against a non-beneficial social environment, it is somewhat consistent

that the predicted greater self-bias is only in relation to those within close social proximity, rather than a general effect.

A greater egocentricity bias is observed across several affective conditions, such as depression, anxiety and schizophrenia (Bora et al., 2009; Bora & Berk, 2016; Erle et al., 2019; Pittelkow et al., 2021; Schreiter et al., 2013), and future research should assess the role of loneliness in cognitive biases across affective conditions, especially in relation to individuals within close social proximity. One key area of discovery will be the direction of effects. For example, do these cognitive biases precede or follow experience of loneliness. Cognitive biases may in fact dictate social connection and subsequent feelings of loneliness, rather than loneliness causing changes in social cognition. A study by Gong and Nikitin (2021) identified mutual effects of loneliness on social behaviour over the short and long-term and a similar study incorporating cognitive biases related to self-other processing is warranted. Understanding this relationship has important implications for understanding how loneliness may precede or follow on from mental and physical health problems (Cacioppo et al., 2006, 2010).

Memory may also act as a social glue and is crucial for establishing and maintaining social bonds. For example, it has been shown that episodic memory predicts the size of one's social network size (Stiller & Dunbar, 2007). The ability to maintain and update a mental database of social relationships is likely a key requirement for maintaining social connections. The results of the current study suggest individuals who often experience loneliness may have a reduced capacity to form memories in relation to close others to the extent observed in those who seldom experience loneliness. Reduced social network is often a consequence of conditions resulting in amnesia (Davidson et al., 2012), further emphasizing the crucial role for episodic memory in social connection.

Depression is associated with social withdrawal (Hirschfeld et al., 2000) and a greater focus on the self (Mor & Winquist, 2002). As loneliness is associated with greater depressive symptoms (Cacioppo et al., 2006, 2010), it was important to show that effects of loneliness in the current study were not explained by increased depressive traits. This also advances on the work from Courtney and Meyer (2020), demonstrating that greater distance between the self and close others is explained by loneliness, rather than depressive traits. In our study, higher levels of depression were associated with greater self-close other cognitive distance in memory, but depression did not modulate the SRE relative to celebrity or the friend-celebrity memory advantage. This unique contribution of depression on the self-reference effect compared with a close friend warrants further examination. To the best of our knowledge, this is the first study to incorporate a friend into the study of self-referential memory in relation to depression. Future research could test whether the increased cognitive distance between the self and a close friend seen in individuals with greater depressive traits may lead to, or be a consequence of, depression-related social withdrawal.

Another key area for future research will be to understand how social disconnection is reflected at the neural level. Several lines of research point to the medial prefrontal cortex (mPFC) as a key brain region, within the broader default mode and mentalizing networks, for representing and navigating social relationships. It is consistently related to processes related to both self and other, with evidence for self-other overlap (Denny et al., 2012). The mPFC distinguishes between friends and strangers (Krienen et al., 2010), codes stable personality traits of others (Hassabis et al., 2014; Moran et al., 2011) and is active when an inference about another person is required (Wagner et al., 2012). The mPFC also has a key role in representing our personal connection to others. For example, Parkinson et al. (2017) found mPFC activation tracked the social network status of others. Social isolation, and the subsequent feeling of loneliness, is associated with altered activity within the default mode and mentalizing networks (Schmälzle et al., 2017; Spreng et al., 2020). Recently, mPFC activity in lonelier individuals showed less overlap between self and close others, suggesting that social disconnection is reflected in a lonelier self-representation at the neural level (Courtney & Meyer, 2020). The results of the present study provide cognitive evidence to complement the existing neural evidence for a reduced overlap between the self and close friends in individuals who often experience loneliness. Interestingly, rumination and self-referential processing in depressed patients have also been associated with mPFC activity (Nejad et al., 2013). Therefore, future research should focus on both loneliness and depression and how these alter neural representations relevant to self-other processing, with a strong focus on the mPFC.

In the present study, we also provide the first evidence for self-referential effects in second-order metacognitive judgements that reflect those observed in first-order sensitivity. A self-referential bias in metacognitive sensitivity was shown over both friend and celebrity-encoded words. Therefore, participants were not only more accurate at recognizing self-encoded words, but also showed a greater difference in confidence for correct and incorrect responses. The evidence against any self-referential or friend-referential effects for metacognitive efficiency suggests that second-order confidence judgements consistently matched first-order accuracy sensitivity across the self, friend and celebrity encoding conditions. Therefore, the extent of higher confidence for correct responses and lower confidence for incorrect responses was consistent across the self, close friend and celebrity conditions. Evidence for a self-referential effect also extended to source memory, but unlike the general effect observed in item memory, the self-bias was specific to positive words and was only observed in relation to the celebrity condition. This is consistent with previous research showing valence effects on source memory and not item memory (Durbin et al., 2017). The SRE in source memory compared with distant others is consistent with previous studies that have tested action-related source memory (Rosa & Gutchess, 2011) and studies assessing memory for contextual details at the time of encoding (Leshikar & Duarte, 2012; Serbun et al., 2011). The lack of a difference between self and close others contrasts with previous results (Rosa & Gutchess, 2011). Finally, an incidental finding of considerable interest demonstrated that participants were less sensitive in recognizing negative items but were more metacognitively efficient (see Appendix S1 [Supplementary 4] for further discussion on these additional findings).

The results of the current study should be interpreted in the context of some limitations. Whilst Boris Johnson was rated as highly familiar to most participants, we did not collect data on the participant's opinion of him. It is possible that negative attitudes towards Boris Johnson may have reduced the accuracy of sourcing positive items to the celebrity condition. This could be examined in future studies using a celebrity rated more favourably by the study cohort or by collecting data on participants' opinion of the celebrity in question. Moreover, although a close friend is justified in the study of loneliness, future research could assess the relationships with other close others (e.g. siblings, parents, romantic partners, work colleagues). Self-referential processing is relevant across many cognitive domains (Cunningham & Turk, 2017; Sui & Humphreys, 2015), although evidence suggests self-biases are unique to each domain (Nijhof et al., 2020). An association between loneliness and egocentricity has been identified using a visual perspective taking paradigm (De Lillo et al., 2022), but further research is required to assess whether loneliness is associated with consistent or unique differences in self-other processing across cognitive domains. Likewise, although we included depression in the present study, other individual differences such as anxiety and psychotic traits (Fung et al., 2017; Le et al., 2019) have been associated with loneliness and should be considered in future research.

The study sample was made up of undergraduate psychology students, with a large majority of females, and a more diverse sample would improve generalisability. For example, it is important to assess whether a similar relationship between loneliness and self-referential biases in episodic memory exists across the healthy lifespan. Future studies should adopt a longitudinal approach to investigate the direction of effects between loneliness and self-biases in memory and other cognitive domains. Loneliness can be conceptualized as both social and emotional loneliness (DiTommaso & Spinner, 1997), referring to a perceived lack of a wider social network or the lack of a close attachment or meaningful relationship, respectively. Future research could explore the association between self-referential effects in respect to romantic partners, close friends, and members of broader social networks in respect to the different forms of loneliness. It should also be noted that the study was completed during the Covid-19 pandemic (2020–2021), which had a considerable impact on loneliness (Werner et al., 2021) and social connection (Okabe-Miyamoto et al., 2021), and may have influenced self-referential processes manipulated in the present study, especially in relation to close friends.

In sum, we identified self- and friend-referential effects in item memory for both accuracy and metacognitive sensitivity. A similar effect was identified for source memory but only for positive words. Loneliness predicted reduced self-friend overlap and greater friend-celebrity overlap for item memory, and this was independent of depressive traits. Individuals who reported more feelings of social isolation and

loneliness showed a greater cognitive distance between themselves and their close friend. The results are important for understanding the cognitive effects of loneliness and provide insights to inform possible cognitive interventions for improving social connection, with possible implications for subsequent mental health outcomes.

## AUTHOR CONTRIBUTIONS

**Laureta Kokici:** Data curation; formal analysis; writing – original draft; writing – review and editing. **Gratiela Chirtop:** Data curation; formal analysis; writing – original draft; writing – review and editing. **Heather J. Ferguson:** Supervision; writing – original draft; writing – review and editing. **Andrew K. Martin:** Conceptualization; data curation; formal analysis; investigation; methodology; project administration; resources; supervision; visualization; writing – original draft; writing – review and editing.

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## CONFLICT OF INTEREST STATEMENT

The authors report no conflicts of interest.

## OPEN RESEARCH BADGES

This article has earned an Open Data badge for making publicly available the digitally-shareable data necessary to reproduce the reported results. The data is available at https://osf.io/aydt5/.

## DATA AVAILABILITY STATEMENT

The analyses were not preregistered. All data and code are provided at https://osf.io/aydt5/.

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