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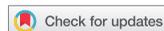
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## Preliminary Evidence of a Missing Self Bias in Face Perception FOR Individuals with Dissociative Identity Disorder

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### ABSTRACT

Failing to recognize one's mirror image can signal an abnormality in one's sense of self. In dissociative identity disorder (DID), individuals often report that their mirror image can feel unfamiliar or distorted. They also experience some of their own thoughts, emotions, and bodily sensations as if they are non-autobiographical and sometimes as if instead, they belong to someone else. To assess these experiences, we designed a novel backwards masking paradigm in which participants were covertly shown their own face, masked by a stranger's face. Participants rated feelings of familiarity associated with the strangers' faces. 21 control participants without trauma-generated dissociation rated masks, which were covertly preceded by their own face, as more familiar compared to masks preceded by a stranger's face. In contrast, across two samples, 28 individuals with DID and similar clinical presentations (DSM-IV Dissociative Disorder Not Otherwise Specified type 1) did not show increased familiarity ratings to their own masked face. However, their familiarity ratings interacted with self-reported identity state integration. Individuals with higher levels of identity state integration had response patterns similar to control participants. These data provide empirical evidence of aberrant self-referential processing in DID/DDNOS and suggest this is restored with identity state integration.

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### KEYWORDS

Dissociative identity disorder; cognitive processes; complex PTSD; dissociative disorders; perception; posttraumatic stress disorder

*You're walking swiftly down the street to meet a friend for tea. It's mid afternoon, and you deftly dodge other walkers on their way past the busy storefronts. Out of the corner of your eye, you catch sight of someone else suddenly at your side. Quickly you realize it's actually your own reflection in a storefront window.*

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This reflection example illustrates how we construct our conscious experience on a moment-to-moment basis (Barrett, 2017; Barsalou, 2009; Wilson-Mendenhall, 2017). Over time, our brain stores different aspects of our experiences (e.g., audition, vision, gustation, tactition, olfaction, interoception, action) in memory. These stored memories serve as a set of learned expectations for how sensations are caused by the environment, and evidence suggests these memories are actively used to predict our sensory and interoceptive experiences of the world (e.g., Barrett & Simmons, 2015; Panichello, Cheung, & Bar, 2012). That is, rather than the brain waiting to receive sensory information through the body's interaction with the environment, it instead activates this information in a top-down manner. To a certain extent, the brain re-enacts or simulates neural activity associated with prior experience across sensory, interoceptive, and visceromotor regions in the context of a specific thought or experience (e.g., Barsalou, 2008, 2009; Simmons, Martin, & Barsalou, 2005; see also predictive coding, Clark, 2013).

In a typically functioning brain, attempts to match and thus reduce error between predicted and received sensory signals are made in different ways. For example, predictions can be rapidly updated by incoming sensory input, or instead the body can be adjusted to match the prediction, or the relevance of incoming sensory signals can be changed (Barrett & Simmons, 2015). In the reflection example above, the initial perception of seeing another person was rapidly adjusted as incoming visual information signaled your own reflection. In this way, our conscious exteroceptive and interoceptive experience emerges from a combination of stored knowledge (past experiences), incoming sensory inputs, and the interplay between the two (e.g., Anderson, Siegel, & Barrett, 2011; Vetter & Newen, 2014). Thus, our ongoing current mental experience is highly context-, past experience-, and learning-dependent (Lebois, Wilson-Mendenhall, Simmons, Barrett, & Barsalou, 2018).

While brief, transitory experiences of errors in visual self-recognition like the reflection example are common (Rochat, 2003; Young & Brédart, 2004), neurologic and psychiatric disorders may feature persistent errors in visual self-recognition. Such pathological visual self-recognition errors could arise from differences in the content of top down activation in the brain, the sensory inputs it is receiving, or the process of reducing the error between the two, or at any of these steps, the generation of incomplete patterns of neural activity that lack a self-component. Therefore, aberrations in visual self-recognition may provide a clue about an individual's current experience of their sense of self, and may hint toward mechanisms of dysfunction and targets for treatment in psychiatric disorders.

In dissociative identity disorder (DID), a chronic and complex form of developmental posttraumatic stress disorder principally associated with the experience of recurring childhood trauma (Dalenberg et al., 2012), individuals often report instances of not recognizing themselves in the mirror; in

an ongoing study in our lab, 87% of individuals with DID reported “not recognizing yourself in the mirror” at least some of the time ( $N = 31$ ; Multidimensional Inventory of Dissociation item 123, Dell, 2006b). Clinical reports of DID describe this breakdown and others in visual self-recognition (Brand & Loewenstein, 2010; Loewenstein, 1991), and current diagnostic interviews and self-reports assessing for symptoms of dissociation include questions about these experiences (Structured Clinical Interview for DSM-IV Dissociative Disorders, Steinberg, Cicchetti, Buchanan, & Hall, 1993; Dissociative Experiences Scale, Bernstein & Putnam, 1986; Carlson & Putnam, 1993; Multidimensional Inventory of Dissociation, Dell, 2006b). However, to date, no studies have empirically tested the mirror experience or visual self-recognition experiences of individuals with DID. We developed an objective behavioral measure to empirically examine and document visual self-recognition in DID as these errors provide a way to measure dysfunction in one’s sense of self associated with this disorder.

### ***Testing visual self-recognition through the self bias effect***

One way to test visual self-recognition is to take advantage of the self bias effect (see also ‘self reference,’ ‘self advantage,’ ‘self face advantage’ effects). This effect involves enhanced processing for stimuli that are self-related (Sui & Humphreys, 2015). Examples of enhanced processing include superior memory for (Symons & Johnson, 1997) and attentional salience of self-related stimuli (Ma & Han, 2010; Sui, Liu, & Han, 2009; Sui, Zhu, & Han, 2006). Evidence of the self bias effect occurs across cognitive and affective domains, and in performance on behavioral, psychophysiological, and neuroimaging paradigms (Sui & Humphreys, 2016). Self bias effects are evident even when self-related stimuli are processed subliminally, that is, they are consciously “invisible” (Geng, Zhang, Li, Tao, & Xu, 2012). Together, this literature suggests self bias effects are robust and difficult to override (Humphreys & Siu, 2015), further implying an absence of these effects could signal an abnormality in one’s sense of self and self-related processing.

The developmental, cognitive, and social construction of one’s sense of self (Harter, 2015) likely establishes several mechanisms underlying self bias effects. Specifically, current cognitive capacities constrain one’s present experience of self while the valence and content of self is influenced heavily by social experience (Harter, 2015). Through childhood and adolescence, individuals gradually develop the capacity to conceptualize higher level generalizations and later abstractions about the self that promote the experience of a coherent, continuous, unified self across contexts and time (Harter, 2015). At least in part, feelings of familiarity, positive valence, and reward associated with one’s sense of self that are constructed over typical development underlie self bias effects (birthday effects: Finch & Cialdini, 1989; name

effects: Johnson, 1986; object ownership: Kahneman, Knetsch, & Thaler, 1990). Self bias effects may also arise because of a sense of embodiment associated with one's self (Sun, Fuentes, Humphreys, & Sui, 2016). That is, the cognitive representation of "self" is grounded in one's experience of the physical body, and sensorimotor and interoceptive neural activity (Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005).

If we return to the reflection example, visually perceiving one's own face triggers neural activity associated with one's category of "self" including, for example, internal bodily states, and sensorimotor experience – one's past experience with and knowledge of "self." This activation is coupled with the incoming visual perception of one's face in the current context. This situated (i.e., context-dependent) conceptualization of self may include feelings of familiarity, positive valence, reward, and embodiment – aspects hypothesized to play direct causal roles in the emergence of self bias effects (Humphreys & Sui, 2015; Sui & Humphreys, 2015, 2016).

In summary, familiarity, positive valence, reward and embodiment may at various times be a part of our representation of self, and active in our perception of self-related stimuli. Together these mechanisms may also contribute to the feeling of a coherent, integrated, consistent self across contexts and time (Van der Hart, Nijenhuis, & Steele, 2006). The presence of a coherent self-structure has been hypothesized to act as an integrative influence on information processing, which may also underlie self bias effects (Sui & Humphreys, 2015).

### ***Potential disruptions in the self bias effect for individuals with DID***

Critically, mechanisms of the self bias effect may be disrupted in DID, contributing to errors in visual self-recognition. Evidence suggests individuals who have experienced childhood abuse and neglect develop a negatively valenced self-concept as opposed to the developmentally typical positive association with self and have altered coherence in their sense of self (Calverley, Fischer, & Ayoub, 1994; Schneider-Rosen & Cicchetti, 1991; Toth, Cicchetti, Macfie, Maughan, & VanMeenen, 2000). Studies specifically in individuals with dissociative disorders have shown they experience high levels of shame and guilt (Dorahy et al., 2015). They also exhibit an extreme aversion to their own thoughts, feelings, and body that some authors describe as phobia-like (Van der Hart et al., 2006). An aversion to one's self can lead to maladaptive avoidance behaviors or obsessive fixation on, for example, parts of one's body (Van der Hart et al., 2006) that could impact the familiarity of self-related stimuli. Furthermore, current research suggests that self bias effects can be diminished (Sui, Ohrling, & Humphreys, 2016) and removed altogether (Ma & Han, 2010) in nonpsychiatric samples with

a negative self priming manipulation. This suggests a negatively valenced self-concept and self aversion in DID could disrupt self bias effects.

In addition, a prominent symptom in DID is a profound sense of detachment from one's body (i.e., depersonalization; Steinberg et al., 1993; Steinberg & Schnall, 2010). Individuals often describe feeling like they do not have a body (Loewenstein, 1991). Recent research suggests self bias effects can be modulated by the extent to which stimuli line up with the participant's own perspective and body (Sun et al., 2016). If one does not feel their body, it logically follows that this lack of embodiment could disrupt self bias effects.

Furthermore, a lack of self-coherence may contribute to errors in visual self-recognition in DID/DDNOS. An important point about DID is that the problem is not having multiple selves, but it is having a sense of "not me" related to one's self (Spiegel, 2006). That is, sometimes one's own thoughts, feelings, behaviors, and bodily sensations feel nonautobiographical – like the experience is not one's own, despite knowing it must be (Dell, 2006a, 2009). For individuals with DID, though their capability for reality testing is intact, this "not me" experience of self is an organizing conceptual framework for how they perceive and experience their mind and body (Brenner, 2001, 2004). The "not me" sense of self experienced in DID may, at least in part, result from a failure to integrate context or state dependent experiences of self that all children encounter (Putnam, 1997). This gives rise to the feeling in DID that one's self is not unified in adulthood (Dalenberg et al., 2012). These "not me" dissociative experiences could disrupt self bias effects. A lack of self-coherence may influence the mechanisms hypothesized to be part of producing the self bias, namely, familiarity, positive valence, reward, and embodiment. Alternatively, aberrations in feelings of familiarity, self-concept valence, reward processing, and embodiment may contribute to the feeling of a "not me" self.

In summary, aberrations in feelings of familiarity, self-concept valence, reward processing, embodiment, and self-coherence could disrupt self bias effects for individuals with DID. These aberrations are likely developed over time, stemming from chronic traumatic experiences in childhood, and are stored in memory. Furthermore, these experiences could influence both the content of sensory, motor, interoceptive, and visceromotor predictions about the environment and the experience of incoming sensory inputs (and possibly the interplay between the two) – producing errors in visual self-recognition for individuals with DID.

### ***Recovery from DID could influence self bias effects***

Successful treatment of DID is associated with increased feelings of integration<sup>1</sup> (e.g., Ellason & Ross, 1997; Kluft, 1984), which could influence self bias effects. Broadly speaking, integration is a process experienced at multiple levels by everyone. In the most general sense, it is a "process

involving ongoing mental actions that help both to differentiate and link experiences over time within a personality” (Van der Hart et al., 2006, p. 11). Van der Hart and colleagues (2006) propose that integration includes two main cognitive processes: synthesis and realization. Synthesis is the process of categorizing interoceptive and exteroceptive experience on a moment-by-moment basis and across time (see also situated conceptualization, conceptual act, Barrett, Wilson-Mendenhall, & Barsalou, 2014; Barsalou, 2009). This can occur at the level of, for example, sensorimotor experience, affect, action, or one’s sense of self. In this way, synthesis helps produce an experience of a cohesive consciousness and personal history. At a higher level, realization is a process of perceiving, accepting, and making meaning of reality as it is. It includes present centered awareness and personal ownership and agency over experience (i.e., presentification and personification, respectively; e.g., Van der Hart et al., 2006). Integration is a capacity that develops across the lifetime as different cognitive abilities emerge, and individuals can also experience variation in integration throughout a single day (e.g., sleeping vs. waking; Van der Hart et al., 2006).

Integration is often disrupted in DID at many of these levels, and of particular interest to this study, specifically in the context of an integrated sense of self. A major goal of therapy for individuals with DID is to promote a sense of integration at all these levels (Van der Hart et al., 2006). Markers of identity state integration in DID may include increased awareness of internal states, increased awareness across aspects of one’s sense of self that feel separate, and a subjective sense of cohesiveness in memory and sense of self (Greaves, 1989; Kluff, 1984, 1993a). Few empirical treatment studies have been conducted on identity state integration in DID, but some research has found identity state integration to be associated with reductions in symptoms of depression, amnesia, and trauma-generated dissociation (e.g., Ellason & Ross, 1997; Kluff, 1984). Given this, as an individual with DID begins to experience successful synthesis and realization within a moment and across time, seeing one’s own facial image may produce feelings of familiarity, positive valence, reward processing and/or embodiment, just like it would for someone without DID.

### **Experiment overview**

Given errors in visual self-recognition may signal dysfunction in one’s sense of self, we sought to examine whether individuals with DID and those with clinical presentations similar to DID (e.g., DSM-IV dissociative disorder not otherwise specified type 1, hereafter referred to as DDNOS) would demonstrate a distinct lack of self biasing effects in face perception. We designed a novel self bias paradigm, the Face Familiarity Paradigm, to test this hypothesis through covert (masked) face processing. We chose covert rather than overt face processing for

three reasons: 1) to avoid discomfort – individuals with DID sometimes report that it is very aversive to see images of their own face, 2) to capture self-related neural activity that occurs within milliseconds after initial presentation of a self face (Adler, Schabinger, Michal, Beutel, & Gillmeister, 2016), and 3) to avoid demand characteristics in which the participant might infer the hypotheses of the experiment and consciously or unconsciously alter their responses to fit experimental hypotheses.

In a backwards masking paradigm (Breitmeyer & Ogmen, 2000), both nonclinical controls and participants with DID/DDNOS were overtly shown a series of unfamiliar strangers' faces and asked to rate their feeling of familiarity with the faces. Unbeknownst to participants, on different sets of trials, prior to the overt appearance of stranger's faces, they were covertly shown their own face, an unfamiliar stranger's face, and a familiar famous person's face. We anticipated that control participants' familiarity ratings would demonstrate a self bias effect, which we termed the self familiarity bias. That is, they would rate overtly perceived strangers' faces as more familiar if their own face covertly preceded them. In contrast, we hypothesized individuals with DID/DDNOS would not show this effect. We predicted both groups, however, would show a famous familiarity bias. That is, covert presentation of a famous face would increase associated familiarity ratings in the task.

Finally, we were also interested in whether the severity of dissociative symptoms was related to familiarity ratings. We hypothesized that participants with DID/DDNOS who had a greater sense of awareness of other identity states, communication between identity states, shared executive control, and less amnesia between identity states (i.e., higher identity state integration; Barlow & Chu, 2014) would have higher ratings of familiarity after the covert presentation of their own face compared to individuals who reported less identity state integration.

## Method

We sought both to validate a new self bias task, the Face Familiarity Paradigm in a control sample of individuals without trauma-generated dissociation, and also to test for differences between our control and DID/DDNOS sample. See the Electronic Supplementary Materials (ESM) for further characterization of the participants, design, materials, procedures, and data analysis. All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments. Informed consent was obtained from all participants. All participants were compensated \$15 for the Face Familiarity Paradigm and related procedures.

## Participants

For the control sample, a convenience sample of 21 females ages 18 to 60 ( $M = 28.10$ ) was drawn from the greater Boston area. 76% were Caucasian, 14% Asian, 5% African American, 5% identified as “other,” and 1 individual also identified as Hispanic/Latino. Control participants were of unknown education level, household monthly income, medication status, and trauma-exposure. Exclusion criteria were reports of clinical levels of trauma-generated dissociation.

The DID/DDNOS sample was a combination of two cohorts: A) individuals seeking treatment at a psychiatric hospital, and B) individuals attending the annual international Healing Together Conference – an educational and support conference for individuals with DID in Orlando, FL. At the time of data collection (February 2017), this conference hosted 240 attendees from across the United States, Canada, and Europe. Attendees included 65 mental health professionals, 73 supporters, and 102 individuals with DID or related dissociative disorders.

Cohort A hospital sample was a convenience sample of 12 female participants ages 23 to 61 ( $M = 45.58$ ) recruited as part of a larger study on trauma-generated dissociation not reported here. Expert clinicians used the gold standard Structured Clinical Interview for DSM-IV Dissociative Disorders to diagnosis dissociative disorders (SCID D, Steinberg et al., 1993). All 12 individuals met criteria for DID ( $N = 10$ ) or DDNOS type 1 ( $N = 2$ ). All individuals also endorsed a history of childhood trauma, and met criteria for posttraumatic stress disorder (PTSD). One individual was dropped for exhibiting symptoms of psychosis. This left a final  $N$  of 11 in this cohort.

Cohort B conference sample was a convenience sample of 19 female participants ages 18 to 62 ( $M = 46.47$ ). Given time constraints at a 2-day conference, we relied on self-reported diagnoses and self-report questionnaires to assess trauma exposure, and diagnoses of DID/DDNOS and PTSD. All participants endorsed a history of childhood and adulthood trauma. All individuals also stated they had a diagnosis of DID ( $N = 18$ ) or DDNOS ( $N = 1$ ), and furthermore all but one individual had an Identity Dissociation subscale score of 15 or higher on the Multiscale Dissociation Inventory, a score which has been shown to identify 93% of those with a diagnosis of DID (Briere, 2002). All but one individual stated they had a diagnosis of PTSD, and 89% of the sample met PTSD criteria on the PTSD Checklist for DSM-5 (Weathers et al., 2013). One individual did not complete the Face Familiarity Paradigm. This left a final  $N$  of 18 for the Face Familiarity Paradigm analyses. Combining both cohorts provided a final  $N$  of 29 for self-reports and 28 for the Face Familiarity Paradigm analysis for the DID/DDNOS sample.

## **Design**

Both the control and DID/DDNOS sample had a within subjects factor of target type (famous, self, stranger). Control participants and Cohort A of the DID/DDNOS group included an additional within subjects factor, mask type (female, male). The male mask condition did not demonstrate the hypothesized self bias effect in control participants (see ESM), and these trials were dropped from the analysis presented here. Given this, the male mask condition was dropped from the design used for Cohort B of the DID/DDNOS group, and replaced with all female masks.

The backwards masking design and event timing were adapted from two backwards masking paradigms (Chen, Whalen, Freeman, Taylor, & Heatherton, 2015; Whalen et al., 1998). Visual backwards masking is a technique used to decrease the visibility of a target stimulus by quickly presenting another stimulus, that is, a “mask” directly after the target (Breitmeyer & Ogmen, 2000). How the mask disrupts visibility of the target is still theoretically debated. Intriguingly, even though participants are not aware of seeing the target stimulus, it can still influence cognition and behavior (e.g., response times and ratings).

Trials were organized in a block design. One block was made up of 1 target type and 10 novel masks. Masks never repeated. The Face Familiarity Paradigm was divided into three 4 min 2 sec runs. Each run contained 6 blocks (Controls/Cohort A DID/DDNOS: 1 for each of the 6 critical conditions; Cohort B DID/DDNOS: 2 for each of the 3 critical conditions). Each participant made a total of 180 familiarity ratings. This task design was optimized for neuroimaging and also included 6 blocks of an active baseline task not reported here.

## **Materials and measures**

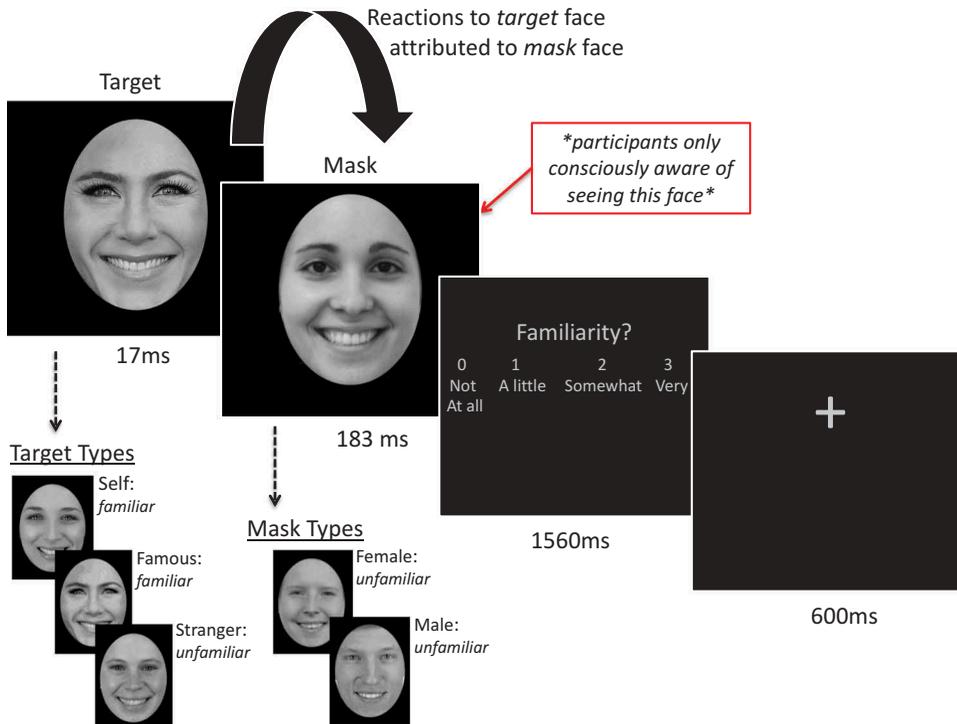
Controls/Cohort A DID/DDNOS: The face stimuli included 180 critical (90 female) and 30 practice masks (20 female) that were all of unfamiliar strangers' faces, hereafter referred to as “masks.” The face stimuli set also included 1 practice and 8 critical target female faces: 1 self face, 1 famous face, and 7 stranger faces, hereafter referred to as “stranger.” The self face was a picture of the participant. The famous face was a stock photo of Jennifer Aniston. The 7 target stranger faces and the 210 mask faces were drawn from nine face databases. 7 different target female faces, one for each block of the experiment, were used to avoid the stranger condition becoming covertly familiar as the experiment went on. The face stimuli for Cohort B DID/DDNOS were the same as those used for Controls/Cohort A DID/DDNOS except the male masks were replaced with new female masks.

For Controls/Cohort A DID/DDNOS we used the state portion of the State Trait Anxiety Inventory (STAI) to measure anxiety in the present moment (Spielberger, 2010). To measure present moment anxiety for Cohort B DID/DDNOS, participants rated the statement, “I feel anxious,” on a scale of 1 (not at all), 2 (somewhat), 3 (moderately so) to 4 (very much so). We used the Integration Measure (IM) to assess subjective feelings of “not me” vs. agency and cohesion in sense of self or identity for individuals with DID/DDNOS (Barlow & Chu, 2014). This scale captures a number of elements hypothesized to be components of identity state integration in DID including, awareness of other identity states, communication between identity states, shared executive control, and no longer experiencing amnesia between identity states (Barlow & Chu, 2014; Greaves, 1989). Possible scores range from 0, indicating, “little or no communication or awareness among identities” to 20, indicating, “all parts are aware of and cooperating with each other” (Barlow & Chu, 2014).

### **Procedure**

Participants were told we were interested in individual differences in anxiety surrounding having one’s photograph taken and how that was related to face perception. First, participants reported their present moment levels of anxiety as related to having their photograph taken using the state portion of the STAI or a single “I feel anxious” statement. Participants then had their photograph taken using a computer. After the photograph, participants completed the measure of anxiety again. Next, participants completed other self-report measures (see ESM), including the Integration Measure for participants with DID/DDNOS. Unbeknownst to the participant, the experimenter incorporated their photo into the Face Familiarity Paradigm during this time.

Subsequently, participants completed the Face Familiarity Paradigm. They were told they would see a series of faces. They were asked to rate how familiar each face felt to them on a scale of 0 (not at all) to 3 (very). Participants were instructed not to think too hard about their ratings, but instead to “go with their gut.” Participants practiced the task, and then completed the three 4 min runs of the real task. Participants received a 2360 ms cue “Familiarity Judgments” at the beginning of each 10-event block. As illustrated in [Figure 1](#), a trial consisted of the following: Unbeknownst to the participant, the target (famous, self, stranger) was presented for 17 ms on a black background. A novel mask face quickly covered the target for 183 ms. The mask was followed by the familiarity rating screen, “Familiarity?” in gray font on a black background. The rating screen also included a reminder of the rating options. Participants had 1560 ms to make their rating before the screen changed to a gray fixation cross for 600 ms. The use of



**Figure 1.** Face Familiarity Paradigm example trial. Target and mask types are also depicted. Familiar vs. unfamiliar designations are based on hypotheses for control participants.

backwards masking ensured that even though participants were unaware of perceiving the target stimulus (famous, self, stranger), these stimuli could still influence cognition and behavior – in this case, feelings of familiarity (or lack thereof) elicited by the targets would be misattributed to the mask stimuli and would influence participant familiarity ratings.

The trial sequence repeated itself for 10 trials, after which either another familiarity block occurred or an active baseline block of trials occurred. A final 7680 ms fixation cross occurred at the end of each run. After completing the Face Familiarity Paradigm, participants were asked if they saw their own face during the task. They were also shown the famous target face, and asked if they recognized her as a manipulation check.

### Data analysis

We used a linear mixed effect regression model (LMER; e.g., Snijders & Bosker, 2012) to assess the influence of the factors on familiarity ratings. Compared to more traditional ANOVA analyses using aggregate data and repeated-measures, LMER controls for random effects variance without data aggregation, providing greater statistical power (Baayen, Davidson, & Bates,

2008; Judd, Westfall, & Kenny, 2012). Using SPSS version 24 MIXED procedure (Heck, Thomas, & Tabata, 2014), the fixed effects were group (control, DID/DDNOS) and target type (famous, self, stranger). Subjects were specified as a random factor to account for individual differences in predicting familiarity (random intercept). The covariance structure for random effects was specified as orthogonal variance components, and the normal-deviate Wald test was used to test the significance of the random intercept.

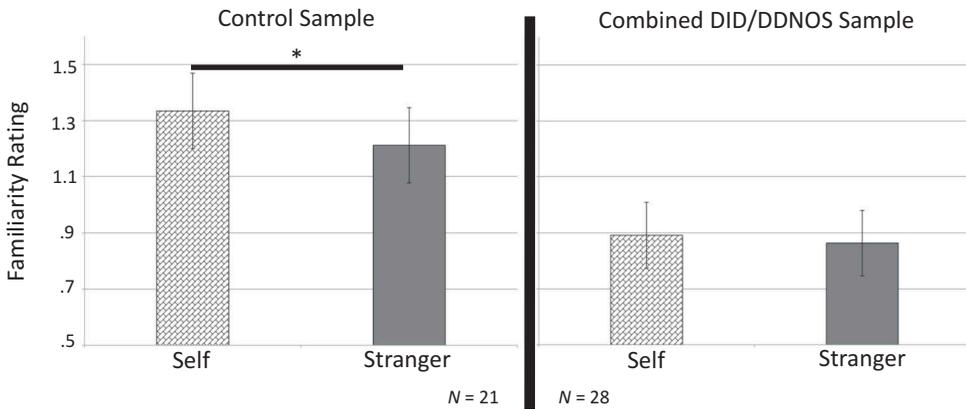
In a set of secondary analyses with only the DID/DDNOS sample, we assessed whether reported identity state integration was related to familiarity ratings. For these analyses, three average familiarity rating scores were computed for each participant with DID/DDNOS based on target type (famous, self, stranger). From these average ratings, two familiarity rating difference scores were computed: a) famous – stranger and b) self – stranger. These difference scores can be conceptualized as the magnitude of each participant's famous familiarity effect and self familiarity effect. Individuals who had a stronger familiarity reaction to the covert viewing of the famous face or their own face had larger positive scores. The two difference scores were entered into a correlation analysis. A repeated-measures ANOVA with continuous simple effects of identity state integration scores was also computed. For the ANOVA, we used the three average familiarity rating scores computed for each participant with DID/DDNOS based on target type (famous, self, stranger). Identity state integration scores were transformed into standardized z-scores before being entered into the ANOVA. The ANOVA examined whether there were significant differences in familiarity ratings based on individual's identity state integration levels. We then used pairwise comparisons of the estimated marginal means to test for differences between target conditions while holding identity state integration scores constant at one standard deviation below ("low integration") and above ("high integration") the mean.

As stated, the male mask trials were dropped from the analyses reported next. This meant that for control participants and the DID/DDNOS Cohort A 90 ratings were included for each person, while for DID/DDNOS Cohort B 180 ratings were included for each person. The two DID/DDNOS cohorts were combined into one group for these analyses, but see the ESM for additional results including each group analyzed separately for the LMER model, anxiety ratings, and famous manipulation check. Reported p-values for the LMER contrast analyses and the repeated-measures ANOVA pairwise comparisons are sidak corrected, and are 2-tailed unless otherwise specified as directional, hypothesis driven 1-tailed tests.

## Results

### *Predicting familiarity ratings with LMER modeling*

We hypothesized control participants would have higher familiarity ratings in the self and famous conditions compared to stranger conditions, whereas



**Figure 2.** Familiarity rating estimated marginal means from the linear mixed effect regression model. Familiarity ratings of the mask are broken out by target stimulus (self, stranger). These are only results for the female masks. The graph on the left is control participants and the graph on the right is a combined sample of all participants with DID/DDNOS. \* indicates  $p < .05$ , 1 tailed. Error bars are  $\pm 1$  standard error of the mean.

individuals with DID/DDNOS would only have higher familiarity ratings in the famous condition – that is, they would be missing a self bias effect. To test whether control participant findings were significantly different from patterns observed in individuals with DID/DDNOS, we were interested in whether there was a group  $\times$  target type interaction. As hypothesized, the group  $\times$  target type interaction was significant,  $F(2, 5555.59) = 6.72$ ,  $p = .001$ .

For the control sample, contrast analyses supported our hypothesized differences between famous, self, and stranger target conditions. Female masks of the self target were rated as significantly more familiar than female masks of the stranger target,  $M$  diff = .12, 95% CI [.02, .22],  $t(5555.63) = 2.98$ ,  $SE = .04$ ,  $p = .005$  1 tailed, Figure 2. Female masks of the famous target were rated as significantly more familiar than female masks of the stranger target,  $M$  diff = .18, 95% CI [.09, .28],  $t(5555.64) = 4.46$ ,  $SE = .04$ ,  $p < .001$  1 tailed. Female masks of the famous and self targets were not significantly different from one another,  $M$  diff = .06, 95% CI [-.04, .16],  $t(5555.41) = 1.49$ ,  $SE = .04$ ,  $p = .355$ .

For the DID/DDNOS sample, our hypotheses were partially supported. As expected, female masks of the self target and stranger target were not significantly different,  $M$  diff = .03, 95% CI [-.04, .10],  $t(5555.89) = .97$ ,  $SE = .03$ ,  $p = .706$ , Figure 2. Also, female masks of the self target were rated as significantly more familiar in the control group compared to the DID/DDNOS sample,  $M$  diff = .44, 95% CI [.13, .76],  $t(118.12) = 2.76$ ,  $SE = .16$ ,  $p = .004$  1 tailed.

Unexpectedly, however, in the DID/DDNOS sample, female masks of the famous and stranger target were not significantly different from one another,  $M$  diff =  $-.001$ , 95% CI [-.07, .07],  $t(5555.54) = -.03$ ,  $SE = .03$ ,

$p > .05$ . And female masks of the famous and self targets were not significantly different from one another,  $M \text{ diff} = -.03$ , 95%  $CI [-.10, .04]$ ,  $t(5555.86) = -1.00$ ,  $SE = .03$ ,  $p > .05$ . This is likely because only 13 of the 28 participants reported that they recognized the famous face during the manipulation check, making the famous face equivalent to the stranger target condition.

Interestingly, there was also a main effect of group,  $F(110.70) = 7.82$ ,  $p = .006$ . Collapsing across condition (self, famous, stranger), control participants were more likely than participants with DID/DDNOS to rate mask faces as familiar. This was likely largely driven by higher familiarity ratings to the self and famous targets in the control sample. However, familiarity ratings of the stranger target were also higher in the control sample compared to participants with DID/DDNOS,  $M \text{ diff} = .35$ , 95%  $CI [.03, .67]$ ,  $t(118.32) = 2.18$ ,  $SE = .16$ ,  $p = .032$ .

In summary, the control sample demonstrated the hypothesized familiarity effects for self and famous targets, indicating that covert presentation of their own or a famous face elicited feelings of familiarity. In contrast, individuals with DID/DDNOS did not demonstrate familiarity effects for self or famous targets. This suggests that for participants with DID/DDNOS their own face did not elicit feelings of familiarity in the same way as it did for control participants. The lack of effects with the famous target is likely because the majority of the DID/DDNOS sample did not recognize the famous face.

### ***Evaluating the relationship between identity state integration and the self familiarity bias***

To assess how participants' reported identity state integration was related to familiarity ratings, we computed a series of correlation analyses and an ANOVA. Overall, we hypothesized that participants with DID/DDNOS who had higher identity state integration scores would have higher ratings of familiarity after the covert presentation of their own face vs. the stranger faces compared to individuals who had lower identity state integration scores.

In our sample, identity state integration scores ranged from 3 to 17 out of a total possible score of 20 ( $M = 11.43$ ,  $SD = 3.58$ ). As hypothesized, the correlation between the self – stranger difference score (the magnitude of the self familiarity effect) and identity state integration scores was significant,  $r(27) = .52$ ,  $p = .002$  1 tailed, indicating the higher their identity state integration scores, the greater the magnitude of their self familiarity effect (Fig S4). The correlation between the famous – stranger difference score (the magnitude of the famous familiarity effect) and identity state integration scores was not significant,  $r(27) = .23$ ,  $p = .119$ , indicating identity state integration was not related to the magnitude of the famous familiarity effect (Fig S4). This suggests reported identity state integration was specifically related to self-face processing not just face processing in general.

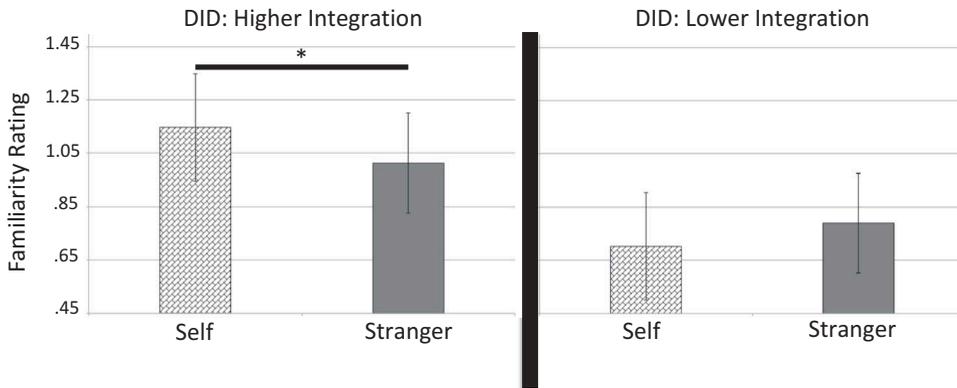
To further test the relationship between identity state integration and familiarity ratings, we conducted a repeated-measures ANOVA with a within-subjects factor of target type (famous, self, stranger) and the continuous simple effects of standardized identity state integration scores. We hypothesized individuals with higher identity state integration scores would have a self familiarity effect similar to control participants, and individuals with lower identity state integration scores would not. This would be indicated in a significant interaction between target type familiarity ratings and identity state integration scores.

As hypothesized, the target x identity state integration interaction was significant,  $F(2, 26) = 5.22$ ,  $p = .012$ ,  $\eta_p^2 = .286$ . Please see [Figure 3](#) for the results that follow. For individuals one standard deviation above the mean on identity state integration scores (“high integration”), participants’ familiarity rating patterns between target types resembled control participants. That is, female masks of the self target were rated as significantly more familiar than female masks of the stranger target,  $M$  diff = .13, 95% CI [.01, .26],  $t(28) = 2.71$ ,  $SE = .05$ ,  $p = .016$  1 tailed,  $d_z = .50$ . For individuals one standard deviation below the mean on identity state integration scores (“low integration”), participants’ familiarity rating patterns between target types had no significant differences, female masks: self vs. stranger target,  $M$  diff =  $-.09$ , 95% CI  $[-.21, .04]$ ,  $t(28) = 1.82$ ,  $SE = .05$ ,  $p = .220$ ,  $d_z = .33$ . For both individuals with high and low integration scores, the famous condition did not affect familiarity ratings, high integration famous vs. stranger:  $M$  diff = .07, 95% CI  $[-.07, .21]$ ,  $t(28) = 1.33$ ,  $SE = .06$ ,  $p > .05$ ,  $d_z = .25$ , low integration:  $M$  diff =  $-.02$ , 95% CI  $[-.16, .12]$ ,  $t(28) = -.40$ ,  $SE = .06$ ,  $p > .05$ ,  $d_z = .07$ . This is likely because only some of the individuals reported recognizing the famous face during the manipulation check and/or because familiarity of famous faces is unrelated to identity state integration scores. Unrelated to our hypotheses, the target type main effect was not significant,  $F(2, 26) = .26$ ,  $p = .772$ ,  $\eta_p^2 = .020$ .

In summary, individuals with DID/DDNOS and higher identity state integration scores more closely resembled control participants. For these individuals, covert presentations of their own face elicited feelings of familiarity, whereas for those who scored lower in identity state integration, covert presentations of their own face did not elicit feelings of familiarity.

## Discussion

Individuals with DID often report they do not recognize themselves in the mirror. Persistent failures in mirror recognition may signal an aberration in one’s sense of self. One way to test visual self-recognition and possibly tap into one’s current experience of “self” is to leverage the self bias effect. The self bias effect is enhanced processing of self-related stimuli (Sui & Humphreys, 2015). Furthermore, individuals with DID experience



**Figure 3.** Estimated marginal means of familiarity ratings from the traditional repeated-measures ANOVA with continuous simple effects of identity state integration. Familiarity ratings of the mask are broken out by target stimulus (self, stranger). These are only results for the female masks. The left panel is the estimated marginal means while holding identity state integration scores constant at one standard deviation above the mean (“high integration”) while the right panel is the model holding identity state integration scores constant at one standard deviation below the mean (“low integration”). \* indicates  $p < .05$ , 1 tailed.  $N = 28$ , and error bars are  $\pm 1$  standard error of the mean.

a number of symptoms that could disrupt self bias effects and impact both the predictions made by the brain and sensory inputs received by the brain when looking at one’s reflection or thinking about one’s self. Based on these points, we predicted that in a novel paradigm, control participants would exhibit self bias effects when covertly processing their own face, but individuals with DID/DDNOS would not. We also predicted both groups would show a familiarity bias for famous faces. Finally, we hypothesized self bias effects would interact with symptom severity in our DID/DDNOS group. These predictions were partially confirmed.

### ***Covertly processed self and famous faces produce a bias in familiarity ratings for controls***

In a sample of female control participants without trauma-generated dissociation, covert exposure to their own face and a famous face produced feelings of familiarity. These feelings were misattributed to the mask faces, and participants rated masks that followed self and famous faces as feeling more familiar compared to masks that followed stranger faces. Interestingly, these effects were only evident for female mask conditions. Male masks blocked the effect. There is some evidence to suggest masking paradigm effects can be gender specific (Jiang, Costello, Fang, Huang, & He, 2006), but the direct mechanism at play in our paradigm is unclear. Perhaps target and mask gender need to be matched for self bias effects to take place in this

paradigm. Given abuse by male perpetrators is commonly reported by individuals with DID, perhaps just viewing male faces is threatening enough to block familiarity effects. However, male masks blocked the effects for our control sample as well. A separate study including only males with both female and male mask conditions is warranted to examine this question.

### ***Individuals with DID/DDNOS fail to display a self bias, but identity state integration is associated with a recovered self bias***

In our paradigm, we found a distinct lack of self bias effects for individuals with DID/DDNOS, in particular for those reporting lower identity state integration scores. This suggests that covertly processed self faces did not elicit feelings of familiarity for these individuals, and this was reflected in their behavioral ratings.

Clinical reports suggest these findings may be specific to self faces, but this conclusion cannot be definitively drawn in relation to our findings because the famous face manipulation was unsuccessful in our DID/DDNOS group. That is, covert presentation of the famous face did not increase familiarity ratings. This may have occurred for two reasons: 1) our chosen famous person, Jennifer Aniston, was less widely known in our DID/DDNOS sample as evidenced by the famous manipulation check at the end of the experiment, or 2) it could be reflective of more general, non-self specific aberrations in face processing for individuals with DID/DDNOS. In both body dysmorphic disorder and anorexia nervosa, disorders that include irregularities in self-referential processing and visual perception of self, the literature also points to the existence of general irregularities in face processing (e.g., Beilharz, Castle, Grace, & Rossell, 2017; Moody et al., 2015). This may also be the case for individuals with DID. Further research is necessary to test this hypothesis.

Familiarity ratings elicited by stranger target faces were also significantly lower in our DID/DDNOS sample compared to our control sample. This may be because individuals with DID/DDNOS were just less likely to endorse faces as familiar. Future research could address this question by testing participant's recognition memory for novel and previously presented faces, and measuring discriminability and bias in responding. Differences in accuracy of face identity perception between the two groups may also have contributed to this result. Anecdotally, most control participants reported after the experiment that they thought the (mask) faces were repeating. Reflective of this, their familiarity ratings across all conditions increased throughout the experiment. No participants with DID/DDNOS reported this. Perhaps these individuals were more discerning in their face identity perception compared to control participants as in reality none of the mask faces repeated across the experiment.

Finally, individuals with DID/DDNOS who had higher identity state integration scores displayed a self bias pattern similar to control participants. That is, covert processing of their own face elicited feelings of familiarity that were attributed to the mask faces. Individuals who had lower identity state integration scores exhibited no self bias effect in their familiarity ratings. Identity state integration scores correlated with the magnitude of self bias effects, but they did not correlate with the magnitude of familiarity elicited by the famous face. Because famous familiarity was not associated with identity state integration, this could point toward self-specific processing differences in DID/DDNOS and our paradigm.

### ***Limitations and future directions***

Across three cohorts, we used different self-report measures of dissociation, trauma exposure, data collection environments, and ways of establishing diagnoses. However, this allowed us to validate our paradigm with different measures, across different sites, and within different samples of individuals with DID/DDNOS, enhancing the generalizability of our findings. Additionally, we relied on the MDI cutoffs and self-disclosure of a DID/DDNOS diagnosis for Cohort B, instead of a SCID-D based diagnosis. The risk of false or inflated diagnoses is possible. Also, Cohort B was made up of individuals willing and able to attend a DID-related conference, who then self-selected to participate in research. With these points in mind, the next iteration of this paradigm will seek to replicate findings in a larger sample with more controlled measures and environment.

During the famous face manipulation check very few individuals with DID/DDNOS recognized the famous face. This prevented us from making strong conclusions about the self-specificity of our results. Future work should personalize the famous face condition to each individual to ensure it is acting as a familiarity control. Individuals with DID may have more general differences in how they perceive faces or process information. Domain general differences cannot yet be ruled out.

We relied on a nonclinical control sample. This limits us from making strong claims about the specificity of our findings to DID. For example, depersonalization symptoms could be one potential underlying mechanism in our DID/DDNOS findings. As depersonalization is a transdiagnostic psychiatric symptom, we may find similar results in other clinical samples. Future work should include clinical comparison groups to test the specificity of findings to DID vs. psychopathology more generally.

Nearly all individuals in our DID/DDNOS Cohort A were taking various psychiatric medications, and it is unknown what medications (if any) Cohort B was taking. These medications could have interfered with our results. The reported medications, however, were taken to reduce psychiatric symptoms,

which could potentially bias against our hypothesized lack of self bias effects in DID/DDNOS, yet we still found no self bias effects.

Finally, this set of studies demonstrated a lack of self bias effects in covert behavioral recognition and feelings of familiarity elicited by perceiving one's own face for individuals with DID/DDNOS. It could be possible that individuals with DID/DDNOS may still demonstrate autonomic nervous system (e.g., skin conductance) "recognition" of their own face similar to covert recognition of personally familiar faces sometimes reported in prosopagnosia (Bruyer, 1991). In addition, an important goal of future work is to investigate the neural correlates of missing self bias effects and more generally, the experience of "not me" associated with self in DID. Foundational work by Reinders and colleagues has demonstrated distinct neural activity associated with different identity states in DID, markedly similar to patterns in PTSD and the dissociative subtype of PTSD (Reinders et al., 2003, 2006; Schlumpf et al., 2014), but as of yet, no one has examined the feeling, specifically, that one's own image is nonautobiographical.

### ***Clinical meaning and implications***

Viewing one's own face did not elicit feelings of familiarity for individuals with DID/DDNOS as demonstrated in their behavioral responses compared to individuals without trauma-generated dissociation symptoms. This provides empirical evidence of aberrant self-referential processing in DID that can be seen in a behavioral paradigm. Internal intrusion symptoms (see also 'positive dissociative symptoms,' Van der Hart et al., 2006) related to self-referential processing represent the majority of symptoms in DID, and thus, it is key that the field develop ways to measure them (Dell, 2009).

Presumably, subjective feelings of "not me," strangeness, and unfamiliarity reported by individuals with DID when viewing their own face have a brain basis. Identifying neurological intermediate phenotypes linked to this subjective experience will increase the likelihood of detecting biological markers of dysfunction or recovery in DID (Admon, Milad, & Hendler, 2013; Meyer-Lindenberg & Weinberger, 2006). It may also expose emerging physiological consequences of DID before they are perceptible in observable behavior (Pohlack et al., 2015). Detecting neurological intermediate phenotypes of DID may also help to distinguish between biological sequelae of DID and vulnerabilities toward developing DID given the necessary environmental circumstances (Admon et al., 2013; Meyer-Lindenberg & Weinberger, 2006).

Furthermore, these self-referential processing differences in our paradigm occurred outside conscious awareness. The covert nature of the paradigm would have prevented individuals from molding their responses to preconceived notions about, for example, what the "right" responses for someone with DID would be based on media representations, therapist cueing, and

sociocultural expectations about the symptoms of DID. This suggests that these influences were not at play in response patterns for individuals with DID.

Finally, these findings demonstrate that variation in identity state integration is associated with objective, measurable behavioral differences. While a longitudinal study would be necessary to definitively test within-person changes in identity state integration over time, our results suggest that as an individual with DID/DDNOS becomes more integrated, a self bias effect is recovered – akin to that experienced by individuals without symptoms of trauma-generated dissociation. This finding provides preliminary, empirically-derived evidence in support of the current expert-consensus treatment recommendations regarding identity integration as the therapeutic goal for patients with DID (International Society for the Study of Trauma and Dissociation, 2011; Kluft, 1986, 1993b).

## Note

1. Our use of the term integration is not to be confused with the use of the term “cognitive integration” proposed by Menary (2007), in which he describes a theoretical framework by which cognitive tasks are accomplished by integrated, dynamical interactions of neural, bodily, and environmental processes.

## Authorship

LAML, JDW, SW, KJR and MLK developed the study concept and design. LAML, JDW, CEB, and SBH performed data collection. MLK and SW performed diagnostic interviews. LAML, JDW, and SBH performed the data analysis and interpretation under the supervision of MLK and KJR. LAML drafted the paper, and all authors provided critical revisions. All authors approved the final version of the paper for submission.

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## Conflict of Interest

The authors declared no conflicts of interest with respect to the authorship or the publication of this article.

## Clinical Trial Registration

NCT02757339 Evaluating the Neurobiological Basis of Traumatic Dissociation in Women With Histories of Abuse and Neglect

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