Current Psychology
https://doi.org/10.1007/s12144-023-04670-6

Absorption relates to individual differences in visual face pareidolia

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Accepted: 11 April 2023

Abstract
Visual face pareidolia is the experience of perceiving illusory faces in inanimate objects (e.g., rocks, buildings, appliances); however, the individual differences that relate to these pareidolia experiences remain unclear. The present set of studies assessed individual differences in face pareidolia, with a particular emphasis on personality factors previously associated with changes in perceptual experiences (openness and absorption). Study 1 measured face pareidolia in two novel ways: an implicit, speeded visual categorization task, and a self-report measure. Study 2 measured face pareidolia using more explicit categorization tasks and a slightly modified version of the self-report measure from Study 1. Across both studies, we also measured the Big Five personality dimensions, absorption, and a performance-based measure of divergent association formation, a proxy for creativity. We found that absorption was positively associated with individual differences in face pareidolia. The association between absorption and face pareidolia remained significant when controlling for factors that also positively correlated with absorption (openness, extraversion, and positive mood). Taken together, these results suggest that individual differences in face pareidolia experiences are consistently associated with absorption, which represents an especially promising construct to investigate in future pareidolia research.

Keywords Personality · Absorption · Face Perception · Pareidolia

Attending to faces is a key aspect of social behaviour and interaction. As a result, face perception has been found to represent a specialized instance of visual perception, with significant neural resources dedicated to face processing (e.g., see Grill-Spector et al., 2017 for a review). Although the extent to which face perception represents a highly practiced skill as opposed to an innate ability has been debated (see Gauthier et al., 1999; Kanwisher et al., 1997), it is clear that, among most individuals, faces are processed differently than most other visual objects. For example, faces tend to be perceived holistically, rather than in a feature-based manner (Farah et al., 1998). Faces also capture attention more robustly (Eimer & Kiss, 2007; Gluckman & Johnson, 2013; Sato & Kawahara, 2015) and are better held in short-term memory than non-face objects (Curby & Gauthier, 2007).

One consequence of having highly sensitive and developed face processing mechanisms is that individuals may erroneously see faces in inanimate objects – a phenomenon known as *face pareidolia* (e.g., Wardle et al., 2022). Pareidolia is defined as the imposition of structure on ambiguous perceptual input, in a manner where the observer perceives a meaningful pattern (e.g., a face) where there is none (Abo Hamza et al., 2021). Recent research has suggested that face pareidolia is a robust phenomenon, observed not only in human adults (e.g., Proverbio & Galli 2016), but also infants (Kato & Mugitani, 2015) and non-human primates (Taubert et al., 2017). The robustness of this illusion across the lifespan and in various species likely reflects highly specialized face-perception mechanisms at work in both humans and non-human primates. Although some isolated instances of pareidolia have received widespread attention, such as seeing religious figures on grilled cheese sandwiches (Taubert et al., 2017), the question of *why* some individuals are more

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Published online: 22 April 2023

prone to these experiences is a relatively understudied topic. Thus, the goal of this study is to further explore individual differences that potentially give rise to experiences of face pareidolia.

Most of the prior research investigating individual differences in face pareidolia experiences has approached this question from a clinical perspective, using cases in which perceptual processing is known to be altered. Pareidolia experiences have been documented in Lewy body dementia (Yokoi et al., 2014) and Parkinson's disease (Göbel et al., 2021), suggesting that these experiences might represent subclinical hallucinations or a propensity to experience hallucinations (e.g., Uchiyama et al., 2015). Recent studies have also shown conflicting findings for pareidolia experiences among patients with schizophrenia. In one instance, these patients experienced pareidolia significantly more than healthy controls or patients with bipolar disorder (Abo Hamza et al., 2021), while another recent study found individuals with schizophrenia have lower hit rates for identifying pareidolias (Mavrogiorgou et al., 2021). Furthermore, Mavrogiorgou et al. (2021) explored the contribution of specific personality traits (e.g., extraversion and conscientiousness) to pareidolia experiences, and found these associations were supported by collapsing across clinical participants (schizophrenia, affective disorder) and healthy controls, though the generalizability of these findings to non-clinical samples remains unclear.

Further studies have begun to characterize the mechanisms that underlie pareidolia experiences (e.g., see Zhou & Meng 2020 for a review). Although the initial neural signatures of both real faces and illusory pareidolia faces are highly similar, including representational similarity at the subcortical level (Leadner et al., 2021), pareidolia objects undergo a relatively rapid transformation within a few hundred milliseconds to become more object-like rather than face-like (Wardle et al., 2020). Past studies have suggested that these pareidolia experiences result from an imbalance of top-down factors (e.g., perceptual expectation, prior knowledge, imagery) and bottom-up sensory input (Aleman et al., 2003; de Boer et al., 2019; Hall et al., 2019; Hugdahl, 2009), which has been referred to as the *perceptual imbalance hypothesis*. This perspective, however, does not necessarily mean that face pareidolia reflects an atypically functioning perceptual system. On the contrary, given the social salience of face information, face pareidolia may be a natural consequence of a detection system that prioritizes sensitivity over accuracy (e.g., Wardle et al., 2020). In other words, borrowing from signal detection theory (Macmillan & Creelman, 2004), face pareidolia may reflect inevitable "false alarms" in a perceptual system that is designed to minimize "misses" in terms of perceiving faces. However, other studies have provided evidence that face detection for pareidolic objects is unrelated to the ability to recognize and differentiate between unfamiliar faces among neurotypicals (Robertson et al., 2017) and individuals with developmental prosopagnosia, a known face recognition deficit (Epihova et al., 2022). Thus, the individual differences that might account for variability in visual face pareidolic experiences are still in need of investigation.

There are several promising constructs that have been previously linked to differences in perceptual experience (although not face pareidolia specifically), which are the primary focus of the present research. First, prior work has found intriguing associations between the personality construct of *openness to experience* and the processing of perceptual ambiguity (Antinori et al., 2017). Openness to experience generally refers to an individual's tendency to seek out and appreciate novel situations, as well as adopt a higher tolerance for ambiguity (e.g., McCrae 1993). Although openness to experience is not typically discussed in terms of strictly perceptual experiences, Antinori et al. (2017) found evidence that individuals who scored higher on openness to experience might literally perceive the world differently. Using a binocular rivalry task, a classic visual paradigm in which separate images are presented to each eye and typical perceptual experience alternates between the two images (e.g., Frassle et al., 2014), Antinori and colleagues found that openness to experience was positively associated with fused percepts – that is, simultaneously experiencing both images. These findings suggest that individuals who score higher on openness to experience measures may treat perceptual ambiguity in a fundamentally different manner than individuals who score low on openness to experience measures. Although this prior research did not investigate pareidolia specifically, such findings might extend to the realm of face pareidolia given that face pareidolia images definitionally have multiple perceptual interpretations.

The present research additionally includes measures that have been found to strongly relate to openness to experience – namely, *absorption* and *creativity*. The inclusion of these associated measures will provide a better sense of the specific contributions of openness to experience to face pareidolia. Absorption, which is conceptually linked to openness to experience (e.g., Glisky et al., 1991) is defined as the tendency to become deeply immersed in sensory experiences and to experience altered states of consciousness (e.g., Tellegen & Atkinson 1974; Watson et al., 1988; Witthöft et al., 2008). Although there has not been any published association between face pareidolia and absorption to our knowledge, there are strong reasons to expect a positive association between these constructs. The capacity to become deeply engaged in perceptual experiences may allow individuals to recognize, understand, and appreciate different interpretations of the same perceptual stimulus.

This is reflected in the construction of some items from the Tellegen Absorption Scale (TAS; Watson et al., 1988), which assess the ease with which an individual can see object shapes in forms such as clouds. In comparison, creativity is an immensely broad construct that can be generally defined as generating and implementing novel approaches to a particular problem or domain (Kaufman & Glăveanu, 2019). Importantly for the purposes of the present research, creativity has recently been associated with pareidolia experiences (Diana et al., 2021; Mavrogiorgou et al., 2021). As such, given the consistently reported associations between creativity and openness to experience (e.g., Tan et al., 2019), as well as creativity and absorption (e.g., Manmiller et al., 2005), the current study aims to further elucidate how these factors interrelate in the context of explaining variability in face pareidolia experiences.

In sum, the present studies were designed to assess how individual differences in personality traits relate to experiences of face pareidolia among non-clinical participants. In Study 1, face pareidolia was assessed through two measures – a performance-based visual categorization task and a self-report questionnaire. In Study 2, face pareidolia was assessed through three measures – two performance-based visual categorization tasks, and a slightly modified version of the self-report questionnaire used in Study 1. Across both studies, the five-factor model of personality (openness to experience, agreeableness, conscientiousness, extraversion, and emotional stability) and absorption were assessed through previously validated survey measures (Gosling et al., 2003; Watson et al., 1988). Creativity was assessed through both a performance-based measure: the Divergent Associations Test (DAT; Olson et al., 2021) as well as a self-report measure.

These studies were designed to test several hypotheses. First, based on prior research, we predicted a positive association between experiences of face pareidolia and measures of creativity (Diana et al., 2021; Mavrogiorgou et al., 2021). Second, given the reported associations between openness to experience, absorption, and tolerance of perceptual ambiguity, we predicted positive associations between face pareidolia experiences and both openness to experience and absorption. Third, based on Mavrogiorgou et al. (2021), we predicted positive associations between extraversion, conscientiousness, and face pareidolia, although this prediction was more qualified given the use of both clinical and non-clinical participants in this prior work (compared to an exclusively non-clinical sample in the present research). Finally, given the expected intercorrelation between our individual difference measures, we planned to assess potential mediating relationships between personality traits and face pareidolia – assuming preconditions of mediation were met - with exploratory analyses.

Study 1

Method

Participants

We recruited 100 participants from Amazon Mechanical Turk, a large-scale crowdsourcing marketplace that allows "workers" (participants) to complete tasks that are posted by requesters (researchers) for payment. Amazon Mechanical Turk has a large worker pool, estimated to be around 250,000 as of 2019 (Robinson et al., 2019), and over the past decade has become increasingly popular in conducting psychology studies (e.g., Crump et al., 2013). We used the CloudResearch participant management platform (Litman et al., 2017) to interface with Mechanical Turk and provide additional constraints with respect to participant recruitment. Specifically, participants were only eligible for the study if they (1) resided in North America, (2) had a minimum 90% approval on prior Mechanical Turk assignments, and (3) passed internal attention checks administered by CloudResearch (i.e., limiting recruitment to "CloudResearch Approved" participants). The third constraint in particular has been shown to result in significantly improved online data collection when using Mechanical Turk as a participant pool (Hauser et al., 2021). Of the 100 recruited participants, 23 were excluded for the following reasons: (1) incorrectly describing a task they had completed ($n = 13$), failing to answer some of the questions ($n = 9$), and (3) completing the questionnaire in an unrealistic amount of time – i.e., responding to each question in an average of just 1.85 s ($n = 1$). As such, 77 participants were retained for the primary analyses (Age: $M = 42.57$ years old, $SD = 10.76$, range = 21–70; 41 men, 35 women, one preferred not to answer). All participants provided informed consent and were treated in accordance with the Declaration of Helsinki.

Procedure

Upon accessing the study link, participants viewed a Letter of Information and consent form and clicked a check box on the screen acknowledging that they agreed to participate in the study. The Letter of Information provided a general description of the study flow, but did not make specific references to visual pareidolia, as we did not want this framing to influence participant responses.

After providing consent, participants were introduced to the *visual categorization task*. The visual categorization task was designed as an implicit measure of pareidolia, and it required participants to simply categorize images as either "animal" or "non-animal" and made no mention that some non-animal images would have face-like features.

Participants were instructed to press one designated key if the image was of an animal (humans included) and a second designated key if the image was of a non-animal. The mapping of the designated keys (z, m) to category (animal, non-animal) was randomly determined upon the loading of the study. The visual categorization task consisted of 160 images, consisting of four trial types (40 images each): (1) animal image: face visible, (2) animal image: face not visible, (3) non-animal image: pareidolia, and (4) non-animal image: control. The pareidolia images were selected by the authors from online searches and consisted of a variety of objects (e.g., buildings, household objects). The non-animal control images were matched with each pareidolia image (see examples in Fig. 1), and images were presented to each participant in a randomized order. Prior to each image, a central fixation cross was presented for 1 s. Following the fixation cross, the image appeared on the screen and the participant had 3 s to make their response, otherwise the trial was marked as incorrect and the script automatically advanced. Following each response, participants received feedback ("Correct" or "Incorrect."), which was visually displayed for 500 milliseconds. In total, the visual categorization task took around 15 min to complete.

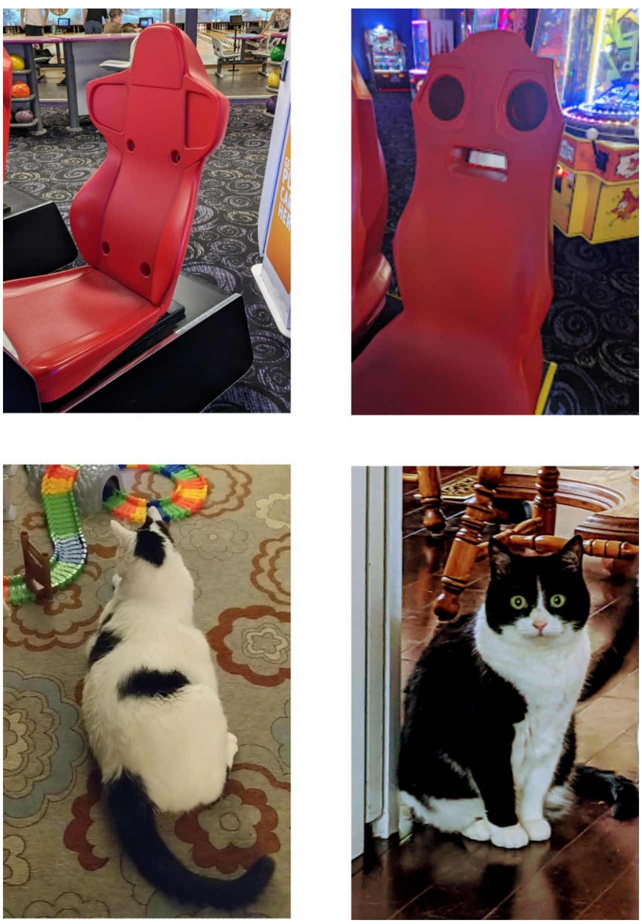

Fig. 1 Illustration of the different categories in the visual categorization task

Note: *These images are representative of the different categories found within the visual categorization task (pareidolia image: top right, control image: top left, animal-face visible: bottom right, animal-face not visible: bottom left). Actual images used in the categorization task could not be reprinted due to copyright. These illustrative images were taken by one of the authors (SVH)*

Following the visual categorization task participants completed a self-reported visual pareidolia measure, the Ten-Item Personality Inventory (TIPI; Gosling et al., 2003), the Divergent Associations Task (DAT; Olson et al., 2021), the Tellegen Absorption Scale (TAS; Tellegen & Atkinson 1974), and a short demographic questionnaire (age, gender). These measures were presented in a randomized order. Afterward participants answered questions about the initial visual categorization task including whether they noticed anything unusual about the images used in the categorization task (yes/no). If participants responded in the affirmative, they were provided with a free-response text box to elaborate on their answer. Just over half of the participants (55.84%) reported noticing something unusual about the images, and all these participants then specified that they had noticed that some of the non-animal objects contained faces. Finally participants were shown a debriefing screen, which explained the purpose of the study, and were given a unique completion code, which they entered to receive payment ($4.00 USD).

Materials

The visual categorization task was programmed in jsPsych 6 (de Leeuw, 2015). The 160 images used for the visual categorization task were selected by the first and last author through internet-based image searches. The images, along with their original access URL, are available on Open Science Framework ([blinded for peer review]). Face pareidolia images were selected first, and then control (non-face) images of the same objects were selected second. These images consisted of a variety of objects (e.g., buildings, appliances, vegetation, rocks). Similarly, animal images with clearly visible faces were selected first, and then matched images with non-visible faces were selected second. These images also consisted of a variety of animals (e.g., mammals, birds, fish, reptiles), including humans. Although each image varied in its dimensions, the experimental script presented all images with a fixed height of 500 pixels. The survey was programmed in Qualtrics (Provo, UT).

Visual pareidolia measure The *visual pareidolia measure* (VPM) was developed specifically for this study and contains two subcomponents. The first component (VPM1) consisted of questions related to the frequency of experiencing pareidolia in different contexts. Participants were given a list of ten objects (clouds, produce, trees, mountains/boulders, appliances, houses/buildings, fences, puddles, tiles/bricks, cars/vehicles) and rated on a 7-point Likert scale how easy it was to imagine things (e.g., faces) they knew were not actually there (1: *Incredibly difficult*, 7: *Incredibly easy*). The second subcomponent (VPM2) consisted of five questions related to participants' mental imagery and creativity. Responses were made on a 7-point Likert scale (1: *Strongly disagree*, 7: *Strongly agree*) and consisted of questions such as "I have difficulty imagining scenes" (reverse scored) and "I am often called a creative person." Both subcomponents displayed acceptable reliability (VPM1: $\alpha = .94$, VPM2: $\alpha = .78$), and the two subcomponents of the measure displayed a moderate positive correlation ($r = .47$), which is within the typical range of intercorrelation ($r = .30$-$.60$) reported for subscales (Vickers, 2004). For each subcomponent we calculated a mean rating score.

Ten-item personality inventory The Ten-Item Personality Inventory (TIPI; Gosling et al., 2003), is a state measure of the "Big Five" personality dimensions. Two questions assess each of the five dimensions (openness, conscientiousness, extraversion, agreeableness, neuroticism), with one of the two questions for each dimension being reverse scored. Each question consisted of two adjectives (e.g., "sympathetic, warm") that participants judge in relation to themselves on a 7-point Likert scale (1: *Strongly disagree*, 7: *Strongly agree*). Although the reliability of the TIPI is typically low because only two questions comprise each factor, in the present study the scale reliability of the TIPI was reasonable, apart from the agreeableness dimension (openness: $\alpha = .68$, conscientiousness: $\alpha = .72$, extraversion: $\alpha = .77$, agreeableness: $\alpha = .38$, neuroticism: $\alpha = .84$).

Divergent associations task The Divergent Associations Task (DAT; Olson et al., 2021) is designed as a performance-based measure of creativity (specifically, divergent thinking). The DAT requires participants to list ten nouns that are as unrelated as possible in all meanings and uses of the word. For example, the words "coffee" and "piano" would result in a higher score than the words "coffee" and "tea." Performance was operationalized in the same manner as reported by Olson et al. (2021), using the transformed average of the semantic distances between each pair of words. The scores can be intuitively interpreted in a similar manner as a grade, with possible scores theoretically ranging from 0 to 200 but most typically falling between 65 (low creativity) and 90 (high creativity). In the present study, the mean score was 76.55 ($SD = 7.15$), and the range was between 46.05 and 90.37.

Tellegen absorption scale The Tellegen Absorption Scale (TAS; Tellegen & Atkinson 1974) is a 34-item scale consisting of a series of statements with which participants either agreed or disagreed (yes/no). Example statements include "Sometimes I can change noise into music by the way I listen to it" and "Things that might seem meaningless to others often make sense to me." Scores were summed across the scale, with higher values representing higher levels of absorption. Given the binary response method of the TAS, we used the Kuder-Richardson formula (KR-20; Kuder & Richardson 1937) to calculate reliability. Overall, the TAS had excellent reliability (KR-20 = .92).

Data analysis

Data analyses were performed in R and JASP. To assess performance on the visual categorization task, we used a 2 (category: animal, non-animal) x 2 (face: present, absent) repeated-measures ANOVA. The dependent variable was response time, as overall accuracy was close to ceiling (96.7%). Only correct responses were analyzed. Given that this task was designed for the current study and has not been used in prior research, there is no standard means of operationalizing face pareidolia. Thus, the present approach was exploratory and examined the extent to which the presence of a face *inhibited* responses in the context of non-animal images and *facilitated* responses in the context of animal images – i.e., the category-by-face interaction term. We additionally included whether participants reported explicit awareness of the pareidolia features of the images as a between-participant factor.

In terms of assessing relationships among our survey measures, we first used Pearson bivariate correlations. Follow up mediation analyses, which examined the specific relationship among a subset of the personality measures and self-reported pareidolia experiences, were conducted using the "mediation" package in R (Tingley et al., 2014). Specifically, we used bootstrapping with 10,000 simulations to generate estimates and confidence intervals of the (1) average causal mediated effect, (2) average direct effect, (3) total effect, and (4) proportion mediated.

Results

Visual categorization task

Participants were overall faster to respond to images when a face or face-like features were present, represented by a main effect of face, $F(1, 75) = 51.78$, $p < .001$, $\eta^2_p = .41$. Overall, participants responded to "face present" images in 672ms (*SE*: 21ms) and responded to "face absent" images in 696ms (*SE*: 22ms). Participants were also overall faster to respond to animal images, represented by a main effect of category, $F(1, 75) = 15.03$, $p < .001$, $\eta^2_p = .17$. Overall, participants responded to animal images in 676ms (*SE*: 21ms) and responded to non-animal images in 692ms (*SE*: 22ms). However, the relative facilitation of response times for "face present" images was driven by the animal images, as evidenced by the significant interaction of face and category, $F(1, 75) = 56.70$, $p < .001$, $\eta^2_p = .43$. When animal images contained a face, participants made their responses on average 50ms faster (651ms versus 701ms). In contrast, the presence or absence of face-like features had no influence on response times for non-animal images (692ms when face-like features were present, 691ms when face-like features were absent).

Explicit awareness of the pareidolia features of some of the images influenced response times as well. Although there was no significant main effect of explicit awareness on response times, $F(1,75) = 2.87$, $p = .094$, $\eta^2_p = .04$, nor were there interactions of explicit awareness and face presence, $F(1,75) = 0.17$, $p = .682$, $\eta^2_p = .00$, or explicit awareness and category, $F(1,75) = 0.88$, $p = .350$, $\eta^2_p = .01$, there was a significant three-way interaction of explicit awareness, face presence, and category, $F(1,75) = 11.70$, $p = .001$, $\eta^2_p = .14$. This three-way interaction was unpacked by examining the simple main effect of face (i.e., present versus absent), moderated by both category (animal, non-animal) and explicit awareness. Participants with explicit awareness were significantly *slower* to respond to pareidolia images relative to non-pareidolia control images (664ms versus 650ms; $p = .024$), whereas participants without awareness were nominally *faster* to respond to pareidolia images, although this difference was not independently significant (721ms versus 732ms; $p = .108$). A follow-up independent samples *t*-test confirmed that participants with explicit awareness were significantly different in responding to pareidolia versus non-pareidolia control images compared to participants without explicit awareness, $t(75) = 2.41$, $p = .018$. For the animal images, participants with explicit awareness responded to face-present images significantly faster compared to face-absent images (607ms versus 667ms; $p < .001$). Although this same pattern was also observed among the participants without explicit awareness (695ms versus 734ms; $p < .001$), this "face advantage" was significantly attenuated compared to participants with explicit awareness, as evidenced by an independent samples *t*-test, $t(75) = -2.54$, $p = .013$).

In sum, participants who explicitly noticed the pareidolia images had a "face disadvantage" effect for non-animal images and a "face advantage" effect for animal images, whereas participants who did not explicitly notice the pareidolia images did not show a "face disadvantage" effect for non-animal images and displayed a relatively attenuated "face advantage" effect for animal images. The results from the visual categorization task across the included factors (face, category, and explicit awareness) are represented in Fig. 2A and B.

In an exploratory analysis, we examined whether participants' "face advantage" for animal images (i.e., faster response times to animal images when a face was visible) was related to a potential "face disadvantage" for non-animals (i.e., slower response times for face pareidolia objects compared to control objects). For each participant, we calculated a "face advantage" score for animals – i.e., mean($RT_{\text{animal, face}}$) - mean($RT_{\text{animal, no face}}$) and correlated this with their "face disadvantage score" for non-animals – i.e., mean($RT_{\text{non-animal, face}}$) – mean($RT_{\text{non-animal, no face}}$). The results from this exploratory analysis suggested that the "face advantage" score for animal images was not significantly correlated with participants' "face disadvantage" score for non-animal images, $r(75) = -0.09$, $p = .437$, even when controlling for whether participants explicitly reported noticing faces in the non-animal images, $r(75) = -0.02$, $p = .893$. These results suggest that face advantages in processing animal images are not related to pareidolic inhibition in non-animal images.

Correlations of pareidolia with personality and creativity

Despite not finding evidence that pareidolia images influenced response times relative to non-pareidolia control objects, we included two measures related to the visual categorization task in our correlational analyses: (1) a pareidolia effect ($RT_{\text{non-animal, face}} - RT_{\text{non-animal, no face}}$) and (2) an interaction effect, summing the relative *advantage* of faces for animals and the relative *disadvantage* of faces for non-animals (($RT_{\text{animal, no face}} - RT_{\text{animal, face}}$) + ($RT_{\text{non-animal, face}} - RT_{\text{non-animal, no face}}$)). The reported correlational analyses also used partial correlations to control for whether participants had explicit awareness of the pareidolia images in the visual categorization task, as this factor influenced performance in the visual categorization task and may have also influenced how participants approached answering the survey questions.

The results from the correlational analyses are reported in Table 1. Overall, we did not find any evidence that the performance-based measures from the visual categorization task correlated with any of the self-report measures. We did, however, find that the visual pareidolia measure correlated with several additional variables. The VPM1 subcomponent, which assessed participants' self-reported ability to visualize imaginary things (e.g., faces) in different contexts,

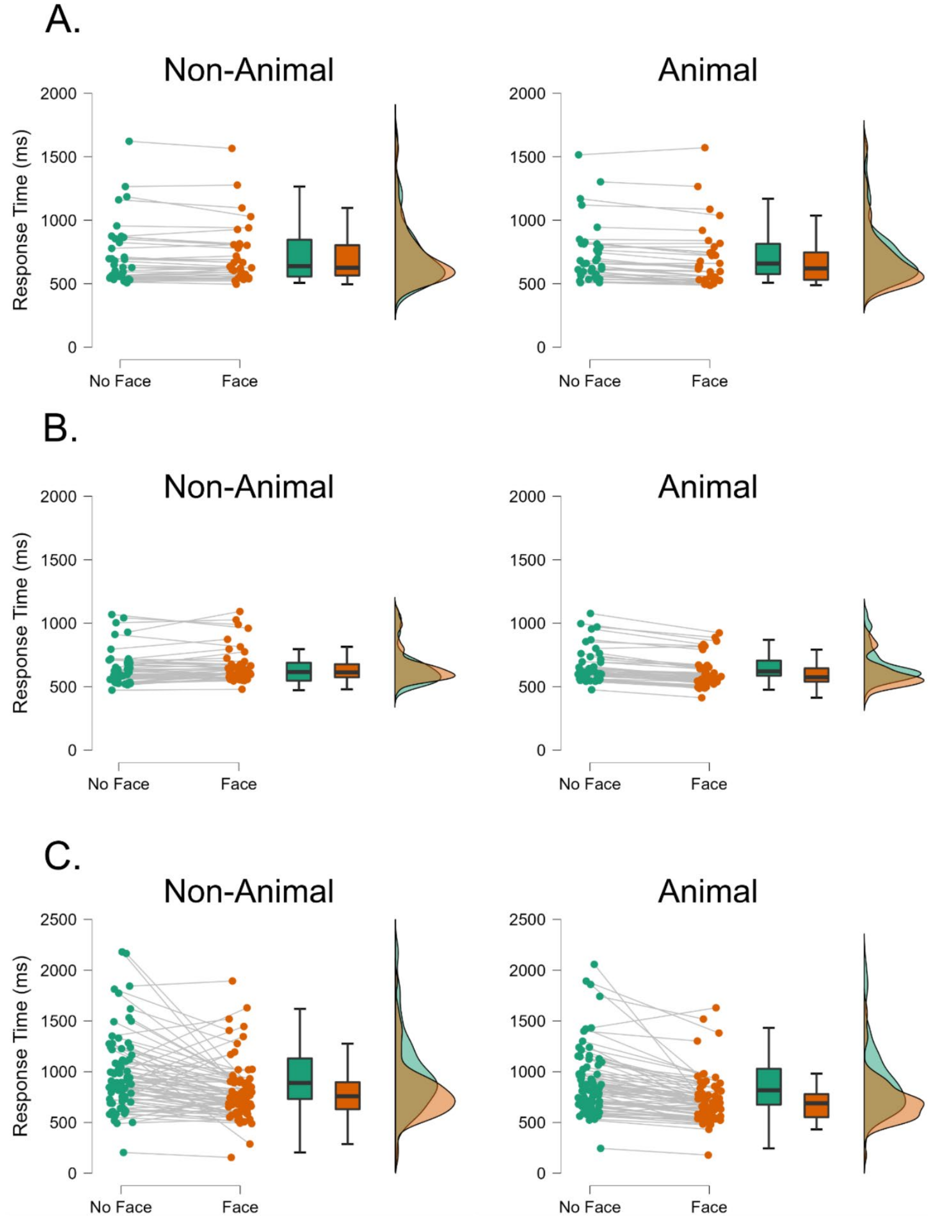

Fig. 2 Individual data points, boxplots, and raincloud plots for each factor of the visual categorization task in Study 1 (Panels A and B) and speeded visual categorization task in Study 2 (Panel C)
Note: *The top row (A) represents participants who did not report noticing anything unusual in the visual categorization task in Study 1. The second row (B) represents participants who noticed that some of the non-animal images contained face-like qualities in Study 1. The bottom row (C) reports the results from Study 2, in which all participants were instructed to attend to face information. Participants in Study 2 displayed more variability in response time and as such the y-axis is extended for these graphs*

was positively associated with openness, extraversion, and absorption, and was marginally associated with conscientiousness. The VPM2 subcomponent, which contained more general questions related to visual imagery and creativity, was positively associated with openness, extraversion, conscientiousness, agreeableness, and absorption. Notably, neither VPM1 nor VPM2 were significantly associated with the DAT – the performance-based measure of creativity (specifically, divergent thinking). Additionally, neither VPM1 nor VPM2 were associated with age or gender.

Mediation analyses of personality measures on pareidolia

The results of the correlation analyses suggest that both openness and extraversion were positively correlated with self-reported pareidolia ability (VPM1). However, absorption was also strongly positively associated with the VPM1, and both openness and extraversion were positively associated with absorption (openness and absorption: $r(75) = 0.57$, $p < .001$; extraversion and absorption: $r(75) = 0.27$, $p = .018$). Given these interrelationships among variables, we therefore tested whether absorption mediated the associations between openness/extraversion and visual pareidolia. We created separate models for openness and extraversion.

The openness model showed strong evidence that absorption mediated the relationship between openness and visual pareidolia ability. The *average causal mediation effect* from the bootstrapping was 0.27 and the 95% confidence interval did not include zero (95% CI: [0.13, 0.43]). The *average direct effect* was 0.06, with the 95% confidence

Table 1 Correlations between face pareidolia measures and additional variables in Study 1

	VPM1	VPM2	Pare-idolia effect	Inter-action effect
Absorption (TAS)	.49***	.71***	−.03	.03
Openness (TIPI)	.32**	.64***	−.05	−.04
Conscientiousness (TIPI)	.22	.25*	.08	.05
Extraversion (TIPI)	.25*	.37**	.14	.09
Agreeableness (TIPI)	.07	.23*	.13	.07
Neuroticism (TIPI)	.01	−.01	−.18	−.17
Creativity (DAT)	.04	−.11	.14	.15
Age	−.12	−.07	.10	.19
Gender	.06	.02	.12	−.02

*Note: The face pareidolia measures are represented as columns, and each additional measured variable is represented as rows. VPM1 = Visual Pareidolia Measure subcomponent 1; VPM2 = Visual Pareidolia Measure subcomponent 2; TAS = Tellegen Absorption Scale; TIPI = Ten-Item Personality Inventory; DAT = Divergent Associations Task. Gender is a treated in a binary fashion (woman / non-woman). ***p < .001 **p < .01 *p < .05*

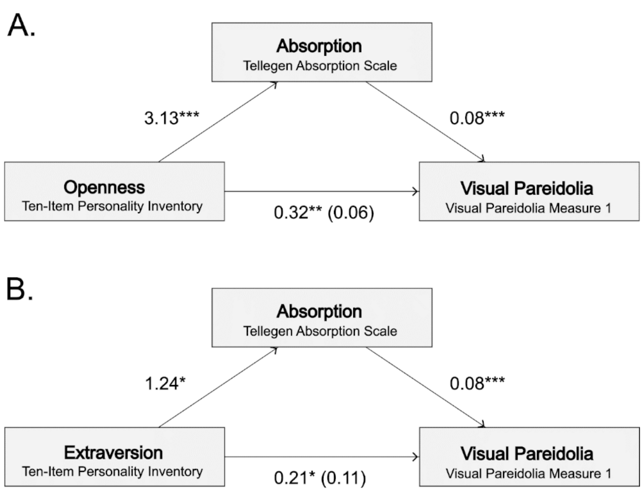

Fig. 3 Mediational analyses examining the effect of absorption on the relationship between personality traits and self-reported pareidolia ability

Note: *Panel A shows how absorption mediates the relationship between openness and visual pareidolia, whereas Panel B shows how absorption mediates the relationship between extraversion and visual pareidolia. Values represent unstandardized beta coefficients. The values in parentheses represent direct effects when including the mediator (absorption) in the model. * p < .05 ** p < .01 *** p < .001*

interval including zero (95% CI: [-0.21, 0.32]). The fact that the average direct effect overlapped with zero suggests that absorption fully mediates the relationship between openness and visual pareidolia. The *total effect* (which is the addition of the average causal mediation effect and the average direct effect) was 0.32, with the 95% confidence interval not including zero (95% CI: [0.09, 0.54]). Finally, the *proportion mediated* was 0.87 (95% CI: [0.32, 2.67]). Overall, these results suggest that the relationship between openness and visual pareidolia is entirely mediated by absorption. A visual representation of this mediation relationship is plotted in Fig. 3A.

The extraversion model similarly showed evidence that absorption mediated the relationship between extraversion and visual pareidolia ability. The *average causal mediation effect* from the bootstrapping was 0.11 and the 95% confidence interval did not include zero (95% CI: [0.02, 0.22]). The *average direct effect* was 0.11, with the 95% confidence interval including zero (95% CI: [-0.08, 0.29]). The fact that the average direct effect overlapped with zero suggests that absorption fully mediates the relationship between extraversion and visual pareidolia. The *total effect* (which is the addition of the average causal mediation effect and the average direct effect) was 0.21, with the 95% confidence interval not including zero (95% CI: [0.03, 0.38]). Finally, the *proportion mediated* was 0.49 (95% CI: [0.07, 2.11]). Thus, similar to openness, these results suggest that the relationship between extraversion and visual pareidolia is entirely mediated by absorption. A visual representation of this mediation relationship is plotted in Fig. 3B.

Discussion

Study 1 found associations between several personality measures and self-reported visual pareidolia. Conceptually aligning with previous work (Mavrogiorgou et al., 2021), we found a significant positive association between extraversion and pareidolia, as well as a marginal positive association between conscientiousness and pareidolia. The present results thus suggest that these earlier described associations generalize to a broader non-clinical sample. We additionally found an association between openness to experience and pareidolia. Although we are not aware of any prior reported associations between openness to experience and pareidolia, we had hypothesized this association might exist given that openness to experience has been related to variations in perceptual experiences, particularly in perceptually ambiguous contexts (Antinori et al., 2017). These findings therefore suggest that openness to experience might influence the interpretation of perceptual information beyond the specific context of binocular rivalry. Importantly, however, the associations between pareidolia and both openness and extraversion were completely mediated by absorption, highlighting the importance of absorption in explaining unique variance in self-reported pareidolia experiences.

Although Study 1 suggests that absorption relates to face pareidolia experiences, there are some limitations to acknowledge. First, Study 1 did not assess participants' current affective state. This is potentially important as previous work has found an association between positive affect and absorption (e.g., Pekala et al., 1985), meaning that the relationship between absorption and face pareidolia might no longer be significant when controlling for positive affect. Second, the VPM1 was worded in a manner that was not directly aligned with face pareidolia. Specifically, the preamble to the VPM1 asked participants to "rate how easily you are able to see things that you know are not actually there (for example, faces) in each object." Thus, although the preamble mentions faces as an example of an illusory percept, its wording allows participants to respond in a manner that potentially conflates face pareidolia with more general pareidolic experiences. Third, the visual categorization task did not show any pattern of results suggesting that participants were processing the face-like qualities of the pareidolia images (e.g., alterations in RT). Although a more detailed description of why this might have been the case is provided in the General Discussion, one possibility is that the task was not framed in terms of face perception.

These three limitations are directly addressed in Study 2. To address the first limitation, we included a measure of participants' current affective state – the Positive Affect Negative Affect Schedule (PANAS; Watson et al., 1988), which was administered at the beginning of the study. To address the second limitation, we slightly modified the wording of the VPM1 to more directly measure face pareidolia, with the preamble stating, "rate how easily you are able to see faces (that you know are not actually there) in each object." To address the third limitation, we designed two new visual categorization tasks, using a subset of the images from Study 1, which required participants to respond based on the presence or absence of a face (speeded categorization task) or the clarity with which they could see a face in images of inanimate objects (deliberate categorization task). Overall, Study 2 was designed to assess whether the observed association between absorption and face pareidolia would remain using this updated design.

Study 2

Method

Participants

We recruited 100 participants using identical recruitment parameters as Study (1) Participants who completed Study 1 were ineligible to complete Study (2) Of the 100 recruited participants, 26 were excluded for the following reasons: (1) failing to answer some of the questions ($n = 12$), and (2) task noncompliance in the speeded visual categorization task ($n = 14$). Task noncompliance was determined by examining participants' categorization accuracy to both animal images with faces present (for which participants should respond that a face is present) and non-animal, non-pareidolia images (for which participants should respond that a face is absent). The overall mean in accurately categorizing these classes of images was 84.3%; thus, if participants' mean accuracy for these two categories of images was at chance (50%) or below, we interpreted this as task noncompliance, either due to participant confusion or refusal to follow task directions (e.g., pressing the same response key regardless of the stimulus). As such, 76 participants were retained for the primary analyses (Age: $M = 39.47$ years old, $SD = 10.42$, range = 22–69; 46 men, 30 women). All participants provided informed consent and were treated in accordance with the Declaration of Helsinki.

Procedure

After providing informed consent, participants completed the PANAS as an initial measure of positive and negative affect. Following the PANAS, participants completed the (1) VPM, (2) TIPI, (3) TAS, (4) DAT, and (5) demographic questions, with block order randomized across participants, similar to Study 1. There was an additional question at the end of the demographic block that served as an attention check, which all participants passed ("For data quality purposes, please select 'Extremely' from the choices below"). All survey measures were presented in Qualtrics. After completing the survey measures, participants were redirected to another URL where they completed the speeded categorization task followed by the deliberate categorization task. The visual categorization tasks were programmed in jsPsych (de Leeuw, 2015). Following both the speeded and the deliberate visual categorization tasks, participants were provided with a debriefing form, explaining the purpose of the study, and were given a unique completion code, which they entered into Mechanical Turk to verify participation and receive compensation.

Materials

Identical survey measures as study 1 The TAS, DAT, TIPI, and VPM2 were identical to Study 1. The reliability of the TAS was high and identical to Study 1 (KS-20 = .92). The DAT had a mean of 75.74 ($SD = 7.55$, range of 45.38 to 87.90) which was comparable to Study 1 ($M = 76.55$, $SD = 7.15$, range of 46.05 to 90.37). The reliability of the TIPI was more variable, as expected given that only two items are used to calculate each factor (openness: $\alpha = .53$; conscientiousness: $\alpha = .69$; extraversion: $\alpha = .79$; agreeableness: $\alpha = .53$; neuroticism: $\alpha = .84$). These reliability estimates were generally comparable to Study 1 (openness: $\alpha = .68$; conscientiousness: $\alpha = .72$; extraversion: $\alpha = .77$; agreeableness: $\alpha = .38$; neuroticism: $\alpha = .84$), although it should be noted that openness was lower in the present study and agreeableness was higher in the present study. The VPM2 had very good reliability ($\alpha = .78$), which was identical to Study 1.

Modified and new survey measures The VPM1 had a slightly modified preamble, in which participants were instructed to rate how well they were able to see faces, that they knew were not there, in a variety of objects. This differed from Study 1, in which the preamble was more generic - instructing participants to rate how well they were able to see *things*, that they knew were not there, (for example faces) in a variety of objects. Despite this slight wording change, the reliability of the VPM1 remained high ($\alpha = 0.91$) and comparable to Study 1 ($\alpha = .94$). Additionally, similar to Study 1, the relative correlation between the VPM1 and VPM2 was moderate (r (74) = .43, $p < .001$) and in an appropriate range for subscales (Vickers, 2004).

The PANAS is a 20-item measure for assessing positive and negative affect (Watson et al., 1988). Participants rated the extent to which they felt specific terms (e.g., attentive, jittery) on a 5-point Likert scale (1: *Very slightly or not at all*, 5: *Extremely*). The scale consists of 10 terms corresponding to positive affect and 10 terms corresponding to negative affect. We calculated both positive affect (PANAS-P) and negative (PANAS-N) affect scores for each participant. Both the PANAS-P ($\alpha = .92$) and the PANAS-N ($\alpha = .85$) had excellent reliability.

We additionally included a demographic question on participants' highest level of education, in response to a suggestion by an anonymous reviewer. Choices were arranged in terms of the amount of formal education (1 = *No formal schooling, 2 = Elementary School, 3 = Middle School, 4 = Some High School (No Degree), 5 = High School or GED, 6 = Some College/University (No Degree), 7 = Vocational School or Skilled Trade Training, 8 = Associate Degree, 9 = Bachelor Degree, 10 = Master's Degree, 11 = Professional Doctoral Degree (e.g., JD, MD), 12 = Academic Doctoral Degree (PhD))*. As such, this was treated as an ordinal variable in our analyses. The modal response was 6, which corresponds to participants completing some college/university courses with no degree, and the median response was 5.5, which falls between a High School diploma or GED (5) and some college or university courses with no degree (6).

Visual categorization tasks The visual categorization tasks in Study 2 used a subset of the images from the visual categorization task in Study 1 but were specifically designed to be more directly aligned with face pareidolia. The first task (speeded categorization task) presented participants with pictures and instructed them to press a designated key on the keyboard as quickly as possible if they were able to see a face in the picture ("z"). If participants were unable to see a face in the picture, they were instructed to press a second designated key as quickly as possible ("m"). Similar to Study 1, there were four categories of pictures: (1) images of animals (humans included) in which faces were clearly visible, (2) images of animals (humans included) in which faces were not visible, (3) images of non-animal objects in which an illusory (pareidolia) face was ostensibly visible, and (4) control images of non-animal objects in which an illusory (pareidolia) face was not expected to be visible. There were 20 pictures in each category, and the ordering of the pictures was randomized. Overall accuracy was high, and thus analyses focused on response times. Participants were given a break halfway through the speeded categorization task – i.e., after responding to 40 pictures.

The second task (the deliberate categorization task) required participants to make explicit judgments about the extent to which the non-animal images used in the speeded categorization task evoked a face percept. In this non-speeded task, participants were presented with all 40 non-animal images from the speeded categorization task (randomized order) and rated each on a 5-point Likert scale (1: *Not at all*, 5: *Extremely*) in terms of how clearly they were able to see a face. The deliberate categorization task was designed to serve as a manipulation check – i.e., that the pictures preselected to evoke face pareidolia would be rated higher than the non-pareidolia pictures.

Data analyses

Data analyses were performed in R and JASP. In terms of assessing relationships among our pareidolia measures and our other variables, we first used Pearson bivariate correlations. Unlike Study 1, preconditions for mediation were not observed, and thus mediation models were not constructed. Rather, in order to get a clearer sense of whether absorption was a significant predictor of face pareidolia, we constructed multiple regression models in which we assessed how well absorption predicted variance in face pareidolia while also controlling for all other measured variables.

To assess performance in the speeded visual categorization task, we used a 2 (category: animal, non-animal) x 2 (face: present, absent) repeated-measures ANOVA. The dependent variable was response time, as the task was framed as a speeded measure and overall accuracy was close to ceiling (89.0%). Only correct responses were analyzed. Given that this task was designed for the current study and has not been used in prior research, there is no standard means of operationalizing face pareidolia. However, based on the predicted "face advantage" (cf. Horowitz, 2018) in categorizing pictures, we operationalized face pareidolia in terms of the relative response time facilitation for pareidolia pictures compared to control (non-animal) pictures as an exploratory measure.

To assess performance in the deliberate visual categorization task, we calculated mean ratings for both the face pareidolia images and the control images, and assessed the difference between these two categories using a paired-samples *t*-test. Given that this task was also designed for the current study and was meant to serve more as a manipulation check, there was no standard means of operationalizing face pareidolia. Thus, we decided to use participants' difference scores (i.e., how much higher they rated the pareidolia images compared to the control images) as an exploratory measure of face pareidolia.

Results

Visual categorization task

Speeded visual categorization task Participants were faster in responding to pictures of animals versus non-animals, reflected by a main effect of category, $F(1, 75) = 37.81$, $p < .001$, $\eta^2_p = .335$. Participants' marginal mean response time to animal pictures was 805ms and participants' mean response time to non-animal pictures was 893ms ($SE = 32$ms). Participants were also faster in responding to pictures with faces present versus faces absent, reflected by a main effect of face, $F(1, 75) = 37.58$, $p < .001$, $\eta^2_p = .334$. Participants' marginal mean response time to pictures with faces present was 759ms and participants' mean response time to non-face pictures was 939ms ($SE = 34$ms). There was no significant interaction, $F(1, 75) = 0.06$, $p = .810$, $\eta^2_p < .001$, suggesting that the relative response time advantage for pictures containing faces did not depend on whether the picture was from the animal versus non-animal category. Put another way, the notable lack of an interaction suggests that the relative "face advantage" is statistically comparable for animal and non-animal (i.e., face pareidolia) images. The results from the speeded visual categorization task are plotted in Fig. 2C.

Deliberate visual categorization task Pictures preselected by the authors to exhibit pareidolia elicited significantly clearer face percepts than the control pictures, $t(75) = 24.97$, $p < .001$, Cohen's d = 2.87. The mean rating for the pareidolia pictures was 3.98 ($SD = 0.71$) and the mean rating for the control pictures was 1.50 ($SD = 0.74$). Thus, both the pareidolia and control images were essentially rated near the ceiling and floor of the rating scale, respectively, providing strong evidence that the pictures in the set differed on face pareidolia percepts, as expected.

Table 2 Correlations between face pareidolia measures and additional variables in Study 2

	VPM1	VPM2	Pareidolia effect (speeded)	Pareidolia effect (deliberate)
Absorption (TAS)	.54***	.57***	.17	−.16
Openness (TIPI)	.08	.57***	.19	.14
Conscientiousness (TIPI)	−.18	.04	−.14	.06
Extraversion (TIPI)	.14	.24*	.08	−.06
Agreeableness (TIPI)	−.23*	.11	.25*	.32**
Neuroticism (TIPI)	.12	−.12	.14	.06
Positive Affect (PANAS)	.17	.10	−.13	−.30**
Negative Affect (PANAS)	.31**	−.12	−.13	−.30**
Creativity (DAT)	−.09	−.01	−.09	.19
Age	−.16	−.10	.30**	.11
Gender	.11	.00	.28*	.07
Education	−.04	.00	.09	−.17

*Note: The face pareidolia measures are represented as columns, and each additional variable is represented as a row. VPM1 = Visual Pareidolia Measure subcomponent 1; VPM2 = Visual Pareidolia Measure subcomponent 2; TAS = Tellegen Absorption Scale; TIPI = Ten-Item Personality Inventory; PANAS = Positive Affect Negative Affect Schedule; DAT = Divergent Associations Task. Gender is a treated in a binary fashion (woman / non-woman). ***p < .001 **p < .01 *p < .05*

Correlations of pareidolia with personality, creativity, and affect

Correlations between pareidolia measures and measures of personality, creativity, and affect are reported in Table 2. Notably, absorption (TAS) was positively correlated with self-reported face pareidolia (VPM1) and the imagery/creativity subscale (VPM2), replicating Study 1. However, we did not find evidence that openness was associated with either the VPM1 or VPM2. Extraversion was not associated with the VPM1, although it was positively correlated with the VPM2. Positive affect (PANAS-P) was not associated with the VPM1; however, it was positively correlated with the TAS, $r(74) = .44$, $p < .001$. Interestingly, although negative affect (PANAS-N) was not significantly associated with the TAS, $r(74) = .18$, $p = .121$, the PANAS-N was positively associated with the VPM1. These findings thus replicate the findings from Study 1 and extend them by pointing to a potential role of affect in both absorption and face pareidolia. Given these observed relationships, the next section assesses whether the relationship between absorption and face pareidolia (VPM1) is still significant when controlling for the other measured variables in the present study, most notably affect. The visual categorization measures (the

"Face Advantage" score in the speeded task and the "Rating Difference" score in the deliberate task) were not associated with absorption and were thus not included in subsequent analyses.

Multiple regression to assess relationship between absorption and pareidolia

Absorption was a significant predictor of self-reported face pareidolia even when controlling for all other measured variables (PANAS-P, PANAS-N, TIPI-O, TIPI-C, TIPI-E, TIPI-A, TIPI-N, DAT, Age, Gender, Education), $B = 0.09$, $SE = 0.02$, $p < .001$. The only additional variable that was significantly related to face pareidolia was agreeableness, with lower agreeableness relating to higher reported levels of face pareidolia, $B = -0.26$, $SE = 0.12$, $p = .026$.

Discussion

There were three main goals of Study 2. First, by including additional measures (affect and education level), we aimed to further contextualize the relationship between absorption and face pareidolia. Second, by modifying the language of the VPM1, we aimed to ensure that the scale unambiguously referenced *face* pareidolia. Third, by redesigning the performance-based categorization component of the study to be about face perception explicitly, we aligned the categorization tasks more closely with the construct of face pareidolia and provided a manipulation check that our pareidolia images were reliably evoking face percepts relative to our control images.

Importantly, Study 2 replicated the primary findings of Study 1 – that is, absorption was again found to be a significant predictor of self-reported face pareidolia. This association was observed even when controlling for affect, the Big Five personality factors, creativity, and demographic variables. As such, the results from Study 2 continue to suggest that absorption is a promising construct in further explorations of face pareidolia.

Additionally, the modification of the visual categorization tasks in Study 2 yielded some intriguing results that might help inform the development of performance-based face pareidolia measures. First, the large main effect of face (present, absent) in the speeded categorization task suggests that performance was facilitated by the presence of a face, similar to the animal images from Study 1 and similar to prior research findings (Horowitz, 2018). However, the fact that this "face advantage" was statistically comparable for animal images and non-animal images (in which the "face" was illusory) suggests that the processing of pareidolic faces is statistically comparable to the processing of real faces, conceptually aligning with prior work (e.g., Wardle et al., 2020). Second, the deliberate categorization task demonstrated that participants robustly differentiated pareidolia images from control images (i.e., images of the same objects that were not selected based on their pareidolia features), providing a clear validation of our image set.

General discussion

Taken together, the present results suggest that absorption is an important factor in explaining individual differences in face pareidolia. Across both studies, we found a positive association of a similar magnitude between absorption and self-reported face pareidolia (see Fig. 4 for a scatterplot integrating results from both studies). Moreover, this positive association between absorption and self-reported face pareidolia (1) fully mediated the relationship between openness and pareidolia, as well as extraversion and pareidolia (Study 1), and (2) was still observed when controlling for participants' current affective state (Study 2), which has been previously associated with absorption scores (Pekala et al., 1985).

There are several prior findings that conceptually support the role of absorption in pareidolia-like experiences. A core characteristic of absorption is to become immersed in sensory experiences and to experience an altered state of consciousness as a result (e.g., Tellegen & Atkinson 1974; Witthöft et al., 2008). Although absorption is commonly associated with hypnotic suggestibility (e.g., Crawford 1982; although see Milling et al., 2000), more broadly absorption can be characterized in terms of heightened sensitivity and imposition of meaning towards sensory signals. For example, in the context of bodily sensations, higher absorption scores have been associated with both medically unexplained symptoms and hypochondriacal behavior (Brown, 2004; Kirmayer et al., 1994), presumably because of a heightened attention to these bodily sensations as well as a tendency to see a larger pattern in their interpretation. Thus, the present findings suggest that absorption is a particularly promising construct to examine in future research on pareidolia experiences.

Across both studies, we did not find any associations between our performance-based measure of creativity (the DAT) and any other measures of personality or pareidolia. This was somewhat unexpected given the previous associations between creativity and openness to experience (e.g., Tan et al., 2019), absorption (e.g., Manmiller et al., 2005), and even pareidolia experiences (Diana et al., 2021). However, the present results may reflect the multidimensional nature of creativity (Hee Kim, 2006). More specifically, although naming unrelated words in the DAT is correlated with other standard measures of creative thinking, such as

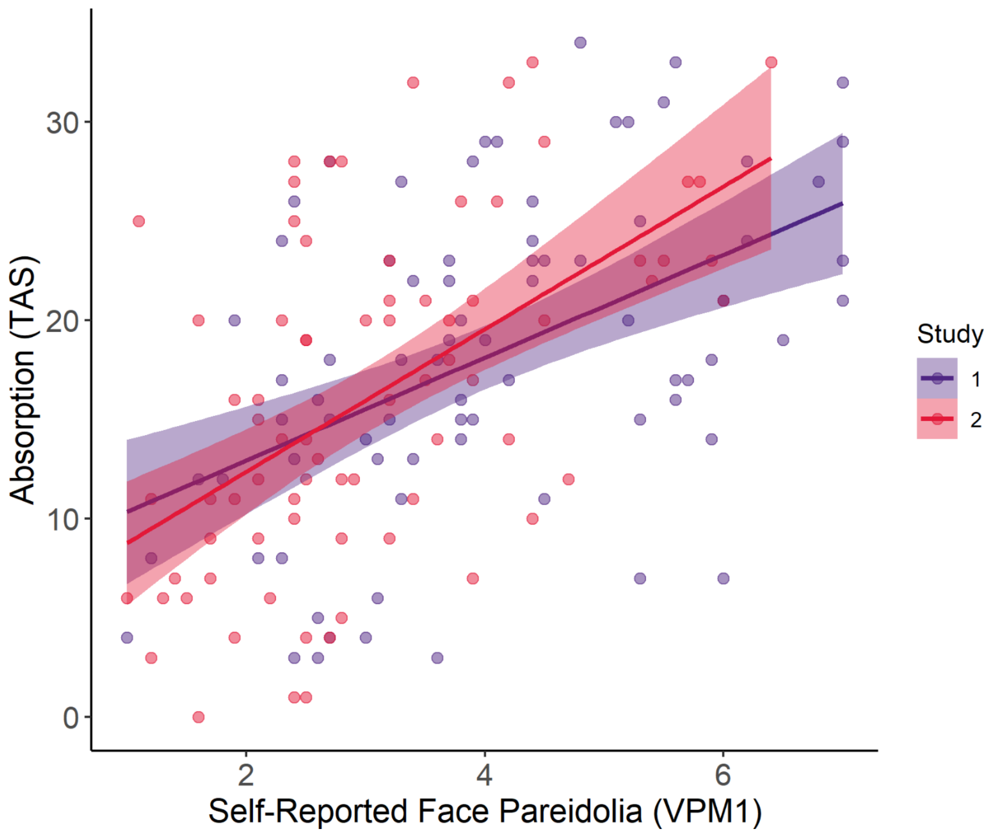

Fig. 4 Scatterplot with linear fit lines demonstrating the positive association between absorption and self-reported face pareidolia across both Study 1 and Study 2 Note: *Ribbons around the linear fits represent 95% confidence intervals. TAS = Tellegen Absorption Scale; VPM1 = Visual Pareidolia Measure Subscale 1*

the Alternative Uses Task (Olson et al., 2021), the specific construct of *divergent thinking* may not be associated with individual differences in pareidolia experiences. A second possibility is that self-report and performance-based measures, in some contexts, may be measuring different aspects of a construct (e.g., Brackett et al., 2006; Pretz & McCollum, 2014). Indeed, in the present study we found no association between DAT performance and scores on the VPM2 ($r = -.11$ in Study 1; $r = -.01$ in Study 2), which contained questions related to self-reported creativity (e.g., "I am often called a creative person"). To further explore the relationship between creativity and pareidolia, future research should include a more comprehensive assessment of both self-report and performance-based creativity and pareidolia measures.

Developing a performance-based face pareidolia measures

Although both studies used "performance-based" measures (speeded judgments in a visual categorization paradigm) to assess face pareidolia, the extracted pareidolia measures from these tasks did not correlate with the self-reported pareidolia questionnaire (VPM1), nor did they correlate with absorption. Given that one of the goals of the present study was to develop a performance-based measure of face pareidolia, the following paragraphs explore the limitations of the tasks used in the present studies and offer possible paths forward in developing sensitive performance-based face pareidolia measures.

The approach taken in the visual categorization task in Study 1 was to make the pareidolic features of the images *irrelevant* for categorization. By designing a categorization task in which participants did not need to attend to facial information in each image, we had predicted that facial information would nevertheless influence category performance (cf. Algom & Fitousi, 2016). Although this prediction was partly supported, as participants were significantly faster to respond to animal images if a face was visible, we only found evidence that pareidolia faces influenced responses to non-animal images for participants who explicitly noticed the face-like qualities of the images, calling into question the utility of the task as an implicit measure of pareidolia sensitivity.

In Study 2, the speeded categorization task was aligned more directly with the construct of face pareidolia, as participants categorized images based on the perceived presence or absence of a face. Despite finding strong evidence that responses were faster when a face was present versus absent – even when faces were illusory (i.e., pareidolia images) – the relative processing advantage for face pareidolia images was not related to the VPM1, nor was it related to absorption.

Additionally, the calculated measure of face pareidolia from the deliberate categorization task in Study 2 (the relative difference in clarity of face percept ratings for pareidolia versus control images) was not related to absorption.

How, then, can these findings across the self-report and performance-based measures of face pareidolia be reconciled? The first possibility is that we received low-quality responses in the performance-based tasks. However, we find this possibility unlikely for several reasons. First, across both studies, we found evidence that the presence of faces (or illusory faces, in the case of Study 2) *facilitated* response times, consistent with prior work (Horowitz, 2018) and suggesting that participants were processing facial information in both studies. Second, categorization accuracy was high in both studies, suggesting that participants understood the parameters of the task. Third, the use of timing-sensitive paradigms using jsPsych has been shown to have acceptable levels of jitter for response-time paradigms (Bridges et al., 2020), suggesting that problems due to variability in data recording were not a factor (and indeed, the "face advantage" effect found across studies highlights the sensitivity of the task to detecting response time differences as a function of condition).

A second possibility, which we view as much more likely, is that the tasks themselves were not well designed to measure *individual differences* in face pareidolia. If individual differences in visual pareidolia represents the propensity to see objects such as faces in everyday objects, then presenting images that very clearly depict illusory faces (as evidenced by the ratings from the deliberate categorization task in Study 2) might not adequately capture variability along this dimension. The strength with which the pareidolia images elicited face percepts was shown in Study 1, as roughly half of the participants spontaneously noticed the face-like qualities of the non-animal objects, despite the task not mentioning anything about faces. In further support of this idea, in Study 2 we observed essentially non-overlapping distributions of face ratings for the pareidolia and control image sets. Although this suggests that the images used in the present set of studies strongly evoked face pareidolia, these images may have compressed any individual variability in face pareidolia percepts (as *all* participants rated the pareidolia images as clearly depicting faces). In other words, the selection of pareidolia images in the present research might have been akin to *forced perspective* images, in which the composition of the image compels a viewer to interpret the scene in a constrained manner (thus minimizing the ways in which the image could be interpreted).

Based on these observations, one potentially promising future direction is to generate and validate an image set with greater ambiguity in terms of depicting face pareidolia. In support of this approach, an exploratory analysis from the deliberate categorization task in Study 2 showed that participants' ability to clearly see faces in the *control* images was correlated with both self-reported face pareidolia and absorption (see Electronic Supplementary Material). Although this finding was not predicted and should be interpreted cautiously given its exploratory nature, it has face validity in terms of explaining individual variability in face pareidolia. Essentially, reporting stronger face percepts across images represents a promising counterpart to the VPM1, in which participants are more abstractly asked to report how easily they can see faces in common objects.

Limitations and conclusion

Although the positive association between face pareidolia and absorption was observed across two studies, there are several limitations to consider in the present work. Perhaps most notably, the primary results are based on self-report measures (for both face pareidolia and absorption). The TAS is the standard way of measuring absorption, and it displayed excellent internal consistency in the present studies. It has also been shown to have excellent test-retest reliability in prior research (Kihlstrom et al., 1989; Tellegen, 1982); however, future work might consider implementing performance-based measures of absorption, or possibly manipulating absorption and then assessing if subsequent changes in face pareidolia are observed. Similarly, as previously discussed, future work would benefit from continuing to refine and implement performance-based measures of face pareidolia. These approaches will provide a clearer sense of the generalizability of the relationship between absorption and face pareidolia.

Despite its limitations, the present study offers a novel approach for examining the relationships between personality and individual difference measures and visual pareidolia in a non-clinical sample. By using a mix of self-reported and performance-based measures we examined difference operationalizations of visual pareidolia and explored the nuances of the relationship between personality metrics and self-reported pareidolia by including the construct of absorption. Future research should assess whether the relationship between absorption and pareidolia generalizes to other performance-based measure of pareidolia. Overall, this study highlights the influence of individual differences on categorical perception, and together with other recent studies of visual pareidolia represents an exciting avenue for further inquiry.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12144-023-04670-6.

Authors Contribution This study was designed by Stephen Van Hedger and Kathryne Van Hedger. Material preparation and data collection were performed by Katherine Hull, data analyses were performed by Stephen Van Hedger. The first draft of the manuscript was written by Katherine Hull and all authors contributed to editing and revising the manuscript.

Funding This project was funded by an internal grant to SVH from Huron University College at Western.

Data Availability All data and materials associated with this manuscript are available on Open Science Framework (https://osf.io/akh7g/).

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Ethics approval This study was approved by the Research Ethics Board at Huron University College at Western.

Consent to Participate All participants provided informed consent and were treated in accordance with the Declaration of Helsinki.

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