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A New Test for Assessing Creative Flexibility of Perceptual Interpretation: The Figural Interpretation Quest

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Perceptual flexibility—adopting varied construals and perspectives of ambiguous shapes or forms—has long been recognized by artists and designers as a source of creative inspiration. Despite this, the ways in which perceptual flexibility contributes to creative thought and making has only sporadically been empirically examined by researchers. To address this gap, this study offers a schematic framework that integrates apparently disparate concepts such as representational restructuring ("seeing as"), conceptual connectivity, and openness to experience as interrelated constructs that collectively shape the flexibility of perceptual interpretation. Guided by this framework, a new measure of perceptual flexibility (the Figural Interpretation Quest, or FIQ) is systematically assessed to evaluate its relations to creative ideation and innovative problem solving. Across six experiments, ambiguous irregular shapes of various colors were visually presented to more than 550 participants, and the originality and flexibility of participants' interpretations of those shapes were compared with their performance on creative thinking, design, and individual difference measures. As hypothesized, originality scores on the FIQ significantly positively correlated with originality on lab-based assessments of divergent thinking—encompassing several predominantly conceptual tasks and a predominantly perceptual task. Further demonstrating construct validity, FIQ originality and FIQ flexibility significantly positively correlated with multiple measures of openness to experience, and with creative performance on two open-ended product ideation tasks. The FIQ offers a novel assessment of perceptual flexibility, opening new opportunities for systematically deepening our empirical and theoretical understanding of how ambiguity stimulates creative ideation at the dynamic intersections of perceptual and conceptual exploration.

Keywords: perceptual flexibility, ambiguity, representational restructuring, openness to experience, creative ideation

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> Look into the stains of walls, or the ashes of a fire, or clouds, or mud, or like things, in which, if you consider them well, you will find really marvelous ideas. The mind of the painter is stimulated to new discoveries … because the mind is stimulated to new inventions by obscure [indistinct, uncertain, incompletely defined] things….[1] (Leonardo da Vinci)

The flexibility with which we can interpret ambiguous visual stimuli has been the object of both intensive and enduring empirical examination—and of comparative neglect. Beginning with the former, perceptual flexibility has been intensively examined in the context of neurocognitive studies of perception using ambiguous bistable images such as the duck–rabbit image (Jastrow, 1899), Rubin's vase–faces, and the Necker cube (for reviews, see Long & Toppino, 2004; Rodríguez & Parra, 2018; Scocchia et al., 2014). With such images at one moment, the stimulus seems, for example, to be a duck, at another moment it is a rabbit that one sees—yet the visual stimulus itself has not changed, only one's semantic interpretation (duck–rabbit), or what one treats as the figure versus background (vase–faces), or the orientation in depth from which one assumes one is viewing the object (Necker cube). Such bistable stimuli provide considerable experimental control by holding the visually presented ambiguous stimulus constant, while only the observer's subjective interpretation of the stimulus changes. Thus, these studies often aim to evaluate the relative influence of bottom-up versus top-down processes in creating an individual's subjective interpretative experience. The precise cognitive and neural mechanisms that contribute to the fluctuating interpretation of different types of ambiguous bistable images continue to be investigated (Cao et al., 2018) and may differ depending on whether what is emphasized is perceptual ambiguity itself (i.e., the same physical stimulus can be cognitively or perceptually interpreted in more than a single way), or reversibility (i.e., the observer's interpretation

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[1] Leonardo da Vinci, *Treatise on Painting*, trans. A. Philip McMahon (Princeton University Press, 1956), 51. The phrases in parentheses are those offered in commenting on the da Vinci quotation by Kauffman (2019) or in alternative translations, such as that of Janson (2016, p. 44).

changes over time, with one interpretation abandoned for another even though it is "same" retinal pattern that is present; Long & Toppino, 2004). Nonetheless, there is general agreement that there is room for both comparatively bottom-up sensory-neural processes (e.g., mutual inhibition of competing cortical neural representations) and top-down cognitive processes (e.g., effects deriving from an observer's knowledge that alternative interpretations are possible), in shaping how such bistable images are subjectively perceived (e.g., Kornmeier & Bach, 2012; Strüber & Stadler, 1999).

In marked contrast, the question of how and why one's ability to flexibly and variedly perceptually interpret ambiguous images is associated with creative thinking and imagination has been less extensively and only more sporadically explored. Despite clear historical claims and evolving practices of artists and designers (da Vinci, 1956/1651; Kauffman, 2019; Robert, 2008) and some early empirical intimations linking flexibility of perceptual interpretation to a corresponding flexibility and exploratory reach in the processes of creative ideation (Bergum & Bergum, 1979; Klintman, 1984), only a handful of empirical studies have examined this connection (e.g., Blake & Palmisano, 2021; Doherty & Mair, 2012; Taranu & Loesche, 2017; Wiseman et al., 2011), and have not always found support for a positive correlation (e.g., Denham et al., 2018). Additionally, these studies have often relied on bistable stimuli that allow for only two or a few alternative interpretations (Blake & Palmisano, 2021; Riquelme, 2002; Wiseman et al., 2011; X. Wu et al., 2019), and thus differ from the provocatively ambiguous clouds or wall stains alluded to by artists such as Leonardo da Vinci, that can invite a wide array of richly varied readings.

Nonetheless, a few suggestive empirical observations directly linking perceptual flexibility and creativity have emerged. Notable amongst these are studies that used the abstract line-drawn "pattern meanings test" (PMT) stimuli created by developmental researchers Wallach and Kogan (1965). These line-drawn black-and-white stimuli do allow for multiple interpretations. For instance, one stimulus, depicting a single vertical line surrounded at the top by five circularly arrayed small open dots might be imaginatively construed as a tree, a pinwheel, a lollipop—or, changing visual perspective—a cluster of five viewing platforms or picnic tables at the head of a hiking trail as seen from above. Comparing the ability of secondary school students to generate novel interpretations of the PMT stimuli with the frequency with which they reported perceptual reversals for three ambiguous figures, Doherty and Mair (2012) found significant positive correlations between the number of PMT interpretations that participants generated and the frequency of their reported bistable image reversals for the vase–faces stimulus (Spearman's $\rho = .39$), the Necker cube ($\rho = .49$), and a numerically similar though weaker pattern for the duck–rabbit stimulus ($\rho = .20$). Furthermore, for all three stimulus types, students classified as falling into a high creativity group ($n = 21$, producing between 17 and 32 interpretations of the PMT stimuli) reported more frequent perceptual reversals than did students classified as being in a low creativity group ($n = 17$, producing 16 or fewer PMT interpretations).

The experience of suddenly restructuring or reconfiguring how one is conceptually approaching a problem is commonly taken to be a key aspect of the phenomenon of insight problem solving (Debarnot et al., 2019; Kounios & Beeman, 2014) or of problem solving generally (Fleck & Weisberg, 2004; Weisberg, 2015)—and shifts in how one construes a perceptually presented object seem analogous to such alternative perspectives. This might be characterized as "an absence of perceptual rigidity" (Riquelme, 2002, p. 107). Developing alternative interpretations of ambiguous images may draw on an individual's abilities for perceptually noticing or becoming visually attuned to specific aspects of a visual stimulus (e.g., an especially unevenly shaped or jagged portion of an outline, or a certain concavity, or an elongation) that could point to different interpretations (Tsal & Kolbet, 1985), and such flexibility of endogenous visual attention may be elevated in artists and art students compared with nonart students (Chamberlain et al., 2018).

The process of flexibly finding alternative visual interpretations or construals of an image is also closely related to the concept of "seeing-as," or of what the philosopher Ludwig Wittgenstein further describes as the experience of "noticing an aspect" (Wittgenstein, 1958, p. 193). "Seeing as" has been identified as an important aspect of visual thinking and creative design cognition (Goldschmidt, 1991) and involves the process of proposing (trying out) properties or attributes of an image based on what is provided in the image and how those properties mesh or match with one's mental representations via metaphors, analogies, semantic concepts, and past experiences (Hay et al., 2017a, 2017b). In the case of more complex visuospatial arrangements of elements or textures, such as the clouds and wall-stains considered by Leonardo da Vinci, the proclivity for the human visual system to attempt to extract meaningful patterns may lead individuals to "see" human faces, animals, or other forms in perceptually ambiguous stimuli. This phenomenon, termed "pareidolia," has recently been shown to be related to the fluency (although not originality) of divergent thinking as assessed by the alternative uses task (AUT; Diana et al., 2021; see also Gregory, 2000), and also to self-reported creativity and to semantic flexibility (Pepin et al., 2022) as assessed by the verbal divergent association task (Olson et al., 2021).

A related discovery has arisen at the intersection of design and engineering (Olteţeanu & Shu, 2018) specifically in the context of efforts to combat the pervasive creative ideation generation roadblock of "functional fixedness"—that is, the cognitive bias to unduly restrict construals of how an object might be used to ways the object has been used in the past, or to its currently demonstrated use (Ye et al., 2009). Olteţeanu and Shu (2018) sought to assess if, and how, altering the typical visual–spatial orientation of an object—thereby allowing for its perceptual rerepresentation from a different perspective—might help to overcome functional fixedness. They found strong positive correlations between the frequency with which participants altered their visual–spatial orientation in construing stimuli, and the number (fluency) and variety (flexibility) of their alternative uses responses to photographs of real-world objects and their responses to a subset of the abstract PMT stimuli of Wallach and Kogan (1965).

A few further empirical and theoretically integrative connections between flexibility of perceptual interpretation and creative ideation have derived from the investigation of individual differences, particularly openness to experience. Of the five broad personality domains in the five-factor model (Costa & McCrae, 1995), openness to experience is the trait most consistently found to be associated with creativity (e.g., Feist, 1998; McCrae, 1987; Puryear et al., 2017), and is typified by tendencies to seek out new and varied experiences, to be aesthetically sensitive, curious, and to actively explore different knowledge domains (Ackerman & Heggestad, 1997). Notable here is a binocular rivalry study by Antinori et al. (2017), in which contrasting stimuli are presented simultaneously to each eye. They assessed both how often different individuals reported that their perception of the two stimuli flipped, or alternated, and whether participants sometimes experienced a blending or fusing of the two stimuli, leading to a "mixed percept." Individuals higher in openness to experience showed higher rates of mixed percepts (times when the stimuli appeared as a grid or patchwork combination of two different gratings presented to each eye). This finding was observed in both an initial study and a replication, and more recently was further conceptually replicated using not different gratings, but images of houses versus faces presented to each eye (Kovisto et al., 2023). Mixed percepts were also more frequent after a positive mood induction, particularly in individuals higher in the openness facet of openness to experience (Antinori et al., 2017).

These findings were interpreted as congruent with other evidence relating to increased flexible cognition and inclusive perception in individuals higher in openness to experience, such as their "being able to 'see' more opportunities when presented with familiar objects" (Antinori et al., 2017, p. 20)—as when generating nontypical ways to use a common object in the AUT (Guilford, 1967). In turn, this flexibility in imaginatively construing/reconstruing a given perceptual stimulus may, perhaps, be due to the broader general knowledge or more interconnected semantic memory networks found to characterize individuals who are higher compared with lower in openness to experience (Christensen et al., 2018). Speculatively, the elevated frequency of experiencing mixed percepts might perhaps also be related to a greater tolerance of ambiguity that may characterize both individuals higher in openness to experience (Jach & Smillie, 2019) and higher in creativity (Zenasni et al., 2008).

A schematic summary of several of these known or proposed cognitive-motivational contributors to the flexibility of perceptual interpretation is provided in Figure 1. Although alternative conceptual groupings and adjacencies are possible, the varied contributors are broadly grouped into those comparatively more directly related to the formation and adaptation of mental representations (e.g., bistable perception), memory and conceptual knowledge search and connectivity (e.g., conceptual knowledge breadth and connectivity), and cognitive-motivational individual differences or predispositions (e.g., openness to experience). The lower panel of Figure 1 provides representative sources for each contributor, particularly sources that further link to aspects of creative thought, design, or artistic practice.

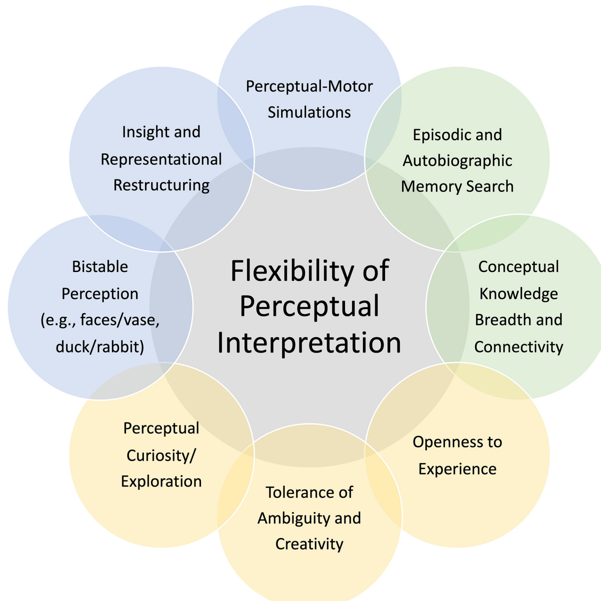
Despite these varied findings and converging cognitive-motivational constructs pointing to the potential contributions of perceptual flexibility to creative ideation, there are a number of still unaddressed theoretical and empirical questions. Prior research is nearly entirely based either on a comparatively small set of stimuli that allow only two or a few "reversing" interpretations (bistable images) or on a small subset of ambiguous abstract but highly geometric, symbol-like forms: there are only eight PMT stimuli and all are comprised of black-and-white straight or curved lines. This leaves unanswered the question of how perceptual flexibility that is prompted by more irregular, ambiguous, or organic-like forms—irregular forms more similar to the cloud or wall-stain formations mentioned by Leonardo—relates to creative or design cognition. Additionally, although irregular lines do comprise a part of the comparatively more often-assessed figural subtests of the Torrance tests of creative thinking (Torrance, 1974) and the abbreviated Torrance test for adults (ATTA; Goff & Torrance, 2002), the Torrance figural tasks require participants to actually draw their own images, incorporating the shapes or lines that are provided into a participant-produced drawing—thus calling on perceptual-motor abilities different from those required for flexibly perceptually interpreting a complete but ambiguous image. Moreover, the requirement for participants to physically draw their responses renders the Torrance figural subtests less amenable to cognitive neuroscience or neuroimaging studies, with such studies showing perhaps disproportionate reliance on tasks such as the AUT, which allows for covert interpretative responding, but does not call on in-the-moment flexible perceptually based creative interpretation, and relies on familiar common objects for which alternative uses may be recalled from memory, rather than newly generated on the fly (Gilhooly et al., 2007). Equally important, from a broader scientific and methodological point of view, if our understanding of the process of creative flexibility of perceptual interpretation relies on only a single test, such as the PMT, then it is not possible to determine whether our inferences are related to creative flexibility of perceptual interpretation generally, or to a single measure specifically. There is a clear need for varied measures to permit valid generalizations of creative and divergent thinking (e.g., Reiter-Palmon et al., 2019; Snyder et al., 2019), and also to enable neurocognitive differentiation between the multiple component processes that contribute to creative ideation of all forms (Dietrich & Kanso, 2010)—including creative flexibility of perceptual interpretation.

The aim of the present work is to provide empirical and theoretical grounding for adopting a new set of ambiguous visual stimuli for investigations of an individual's flexibility of perceptual interpretation in relation to creative ideation and problem solving, focusing particularly on flexibility of perceptual interpretation in relation to creativity, openness to experience, and prior experience—that is, constructs indicated on the right-hand side and the lower portion of Figure 1. The stimuli for the task, which is called the "Figural Interpretation Quest" or FIQ, are irregularly drawn, ambiguous-colored shapes that invite many different interpretations. The stimuli are shown, one at time, and participants are asked to indicate all of the various things the object might be. For example, a teal-colored shape that fans out at both ends with a thinner middle may be interpreted as a wine glass, a vase, a shovel, or the head and shoulders of a person looking away into the distance. The stimuli are a selected subset from a larger set of over 400 images originally developed to examine semantic contributions to episodic memory (Koutstaal et al., 2003), and adapted to provide a perceptually prompted measure of divergent creative thinking. Examples of the FIQ stimuli are presented in the Method section (Figure 2).

The present report synthesizes and summarizes findings from six separate studies, involving more than 550 participants that, together:

a. Provide evidence for the convergent construct validity of the FIQ stimuli as evocatively ambiguous perceptual prompts for divergent creative thinking by evaluating correlations of original and flexible ideation responses to the FIQ with responses to both more commonly and less-often used lab-based verbal and visually based assessments of divergent thinking. The lab-based measures include (among others) the AUT that asks participants to creatively generate nontypical ways to use a common object, and the Torrance "suppose" task (Torrance, 1974), a verbal subtest also included in the ATTA (Goff & Torrance, 2002), that invites participants to imaginatively generate all the different things that might happen if a given hypothetical scenario were to be true (see Alabbasi et al., 2022, for recent review). In Experiment 6, we also compare responses to the new hand-drawn, irregularly shaped colored FIQ stimuli to responses to the more

Figure 1
Cognitive-Motivational Contributors to Flexibility of Perceptual Interpretation



Bistable perception (e.g., faces/vase, duck/rabbit) -
Doherty & Mair (2012); Klintman (1984); Wiseman et al. (2011)
Insight and representational restructuring -
Knoblich et al. (1999); Olteţeanu et al. (2019)
Perceptual-motor simulations -
Olteţeanu & Shu (2018); Olteţeanu et al. (2019)
Episodic and autobiographic memory search -
Gilhooly et al. (2007); Hay et al. (2017a,b); Thakral et al. (2020)
Conceptual knowledge breadth and connectivity -
Benedek et al. (2012); Muth & Carbon (2019)
Openness to experience -
Christensen et al. (2019); Tan et al. (2016)
Tolerance of ambiguity and creativity -
Jach & Smillie (2019); Muth et al. (2015); Wu et al. (2019); Zenasni et al. (2008)
Perceptual curiosity/exploration -
Antinori et al. (2017); Blake & Palmisano (2021)

Note. See the online article for the color version of this figure.

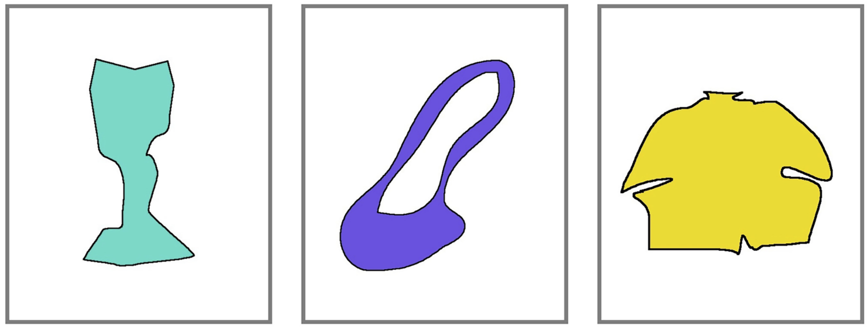
regularly drawn black-and-white line drawings from the less-often used PMT of Wallach and Kogan (1965).

b. Assess how an individual's originality on the FIQ correlates with their originality on two more open-ended design-based creative tasks: a garden design task adapted from Pringle and Sowden (2017), in which participants were asked to draw an initial plan for the design of a garden that is based on "a journey and the series of experiences those who walk around the garden will have on this journey," and participants' originality on two design product ideation tasks based on those that might be posed to individuals in the creative design industry.
c. Assess one of the strongest individual differences correlates of creativity, particularly openness to experience, as well as prior creativity-related training and activities, and control measures of verbal ability (vocabulary) and abstract fluid reasoning, to begin to build a nomological network from the FIQ to some of the key related cognitive-motivational factors depicted in Figure 1, including openness to experience and conceptual knowledge.

We hypothesized that there would be significant positive correlations between originality scores on the FIQ and originality scores on lab-based assessments of the AUT, Torrance suppose task, and the PMT. We also anticipated that participants' originality scores on the FIQ would be positively associated with their originality on the more complex garden design task and the product-ideation tasks, both of which called on participants to flexibly view a given problem from multiple perspectives. Given prior meta-analytic findings consistently associating creativity with openness to experience (Feist, 1998; Puryear et al., 2017), and the links between this multifaceted cognitive-motivational predisposition to both other

Figure 2

Three Illustrative Items From the FIQ



Note. FIQ = Figural Interpretation Quest. See the online article for the color version of this figure.

conceptually based measures of divergent thinking (McCrae, 1987) and to potentially "mixed" perceptual processing (Antinori et al., 2017; Kovisto et al., 2023), we predicted associations of FIQ originality and FIQ flexibility with this personality disposition, though whether the associations would be markedly stronger with one or more specific aspects of this multifaceted trait was unknown.

Method

Overview of Experiments and Participant Demographics

Experiment 1 was an initial experiment to assess the variety of interpretations provided to a range of different FIQ stimuli, and used to develop scoring rubrics for semantic/category flexibility and originality (see the online supplemental materials for scoring rubrics). Participants were tested individually, in-person, with a brief unrelated verbal filler task interposed between each item. In subsequent experiments, the FIQ stimuli were administered as part of larger research projects exploring cognitive-motivational contributors to creative cognition including evaluating: self-guided transitions between generating ideas for one versus two concurrently presented task items (Experiment 2; Y. Wu & Koutstaal, 2020); the effects of instruction in a creative design methods course (Experiment 3; Tran et al., 2022); a comparison of the predictive validity of four measures of divergent thinking for creative design ideation (Experiment 4; Erwin et al., 2022); the correlation of behavioral measures of creativity to behavioral measures of curiosity, including question-asking and autonomous information seeking (Experiment 5; this manuscript); and how the variety (diversity) of prior creative activity engagement influences creative responses to the FIQ and Wallach and Kogan's (1965) PMT (Experiment 6; Koutstaal et al., 2024). Thus, this report is a summary and across-study synthesis integrating findings from six experiments, with over 550 participants, that for the first time systematically and comprehensively focuses on the FIQ in relation to other creative and design tasks, openness to experience, and cognitive control variables.

An overview of the six experiments and participant demographic information is provided in Table 1. Participants in Experiments 1, 2, 5, and 6 were undergraduate students enrolled in psychology classes who took part for course participation credit. Participants in Experiments 3 and 4 were undergraduate students in an introductory course on creative methods in product design. All participants provided informed consent, and the studies were conducted in accordance with approved Institutional Review Board protocols from the University of Minnesota.

Stimuli and Materials

FIQ

As indicated in Table 1, across the six experiments, participants were shown between three and 12 FIQ stimuli. Each stimulus was presented individually, either in the lab (Experiments 1 and 2) or online (Experiments 3–6), and either under untimed/self-paced conditions (Experiments 1 and 5) or timed (40 s per item, Experiments 2, 3, 4, and 6). Figure 2 provides three examples of the FIQ stimuli. Illustrative participant-generated interpretations of the middle (purple) FIQ stimulus in Figure 2 are shoe, handbag, bib, and necklace.

For each experiment, responses to the FIQ were scored for fluency (the number of appropriate/relevant and complete responses, with

Table 1

Overview of Experiments and Participant Demographics

Experiment	Number of participants	Gender	Age	Education	Number of FIQ items	FIQ stimulus presentation[a]
Experiment 1	98	70 F, 28 M	19.70 (2.16)	13.69 (1.61)	12	Untimed, in lab
Experiment 2	81	58 F, 23 M	20.11 (2.29)	—	6	Timed, in lab
Experiment 3[b]	98	49 F, 49 M	20.11 (2.85)	13.85 (1.66)	8	Timed, online
Experiment 4[b]	99	45 F, 53 M	20.09 (3.61)	13.60 (2.28)	4	Timed, online
Experiment 5	67	52 F, 15 M	19.72 (2.06)	13.32 (1.31)	3	Untimed, online
Experiment 6	132	100 F, 32 M	20.07 (1.82)	13.89 (1.31)	8	Timed, online
Total	574					

Note. Age and total education in years; *SD* in parentheses; in Experiment 4, one person declined to indicate gender. FIQ = Figural Interpretation Quest.
[a] Timed FIQ stimulus presentation was 40 s/item. [b] In Experiment 3 and Experiment 4, participants were tested twice, separated by about 8 weeks; to maintain independence of observations, this report presents data from the first and earlier-administered assessments only.

each response scored 0 or 1), flexibility (the number of different semantic categories into which the responses belonged, based on a listing of 37 (Experiments 1–5) or 27 (Experiment 6) possible categories, with 1 point awarded for each unique category), and originality (the number of responses which were uncommon, novel, striking, fun, or otherwise original, scored as 0 for nonoriginal responses, 1 for somewhat original responses, or 2 for each response that was very original). We here report scores for the dimensions of flexibility and originality because flexibility serves as a measure of variation or diversity in an individual's ideational search for additional interpretive possibilities, and originality is an especially strong correlate of creativity and innovativeness (e.g., Acar et al., 2017; Runco & Charles, 1993; Ummar & Saleem, 2020); for comprehensiveness, fluency scores are reported in the online supplemental materials.

All responses were scored by two independent raters, blind to participant and to participant response order, using purpose-developed scoring rubrics (see the online supplemental materials for scoring rubrics). There was generally excellent interrater agreement for the three dimensions (e.g., correlations of .99, .87, and .83 for fluency, flexibility, and originality, respectively, in Experiment 1; see the online supplemental materials for interrater correlations for all of the experiments). All reported FIQ analyses are based on the average of two raters' scores.

Other Lab-Based Creativity Assessments

Across the experiments, in addition to the FIQ, to assess the convergent and discriminant validity of the FIQ, several different lab-based and design-related creativity assessments were administered. The lab-based tasks included:

a. the frequently used AUT (Guilford, 1967). Participants were given the name of a common object, together with a brief description of the object's typical use, and were asked to generate nontypical creative uses for the object ("cup" in Experiment 2; "paper clip" in Experiments 3 and 4; three items, including "cardboard box," "flashlight," and "wooden ruler" in Experiment 5); each item was presented for 3 min.
b. modified versions of the Torrance (Torrance, 1974) "suppose" task (given in Experiments 2, 3, 4, and 5). Participants were presented with an imaginary hypothetical situation (e.g., "Just suppose a great fog were to fall over the earth and all we could see of people would be their feet") and asked to list (in 5 min) all of the interesting things that might result.
c. modified versions of the Torrance (Torrance, 1974) product improvement task (given in Experiments 3 and 4). Participants were provided a brief written description of a child's stuffed toy (e.g., a toy elephant) with an accompanying gray-scale photograph of such a toy, and asked to "list the most interesting and unusual ways you can think of for changing this toy elephant so that it will be more fun to play with." Participants were given 5 min for this task.
d. a conceptual combination task (given in Experiment 2). Participants were presented with a pair of unrelated words and asked to list creative ideas to combine them. They were first provided an example item ("motorcycle–blanket") with four specific illustrations of how it might be interpreted (e.g., "a child's blanket that is printed with pictures of motorcycles," or "a bed that rumbles you to sleep"). Participants then were presented three conceptual combination items ("waterfall–jacket," "honesty–ladder," "frog–luck"), one at a time, with each pair of words presented for 3 min.
e. an analogy generation task (given in Experiment 6). Participants were presented with 28 incomplete analogies (i.e., potentially analogical word pairs but with one word missing) and were asked to generate a word to coherently complete the analogy. The analogies were adapted from various sources (e.g., Green et al., 2010) and included both near/within-domain analogies (e.g., foresight:future::hindsight: ____) and distant/across-domain analogies (e.g., bracelet:wrist::moat: ____).
f. the PMT, given in Experiment 6. This visually based task, developed by Wallach and Kogan (1965), included eight stimuli, plus a practice item (the set includes only eight items, so the practice item was created by the researchers). Each item (e.g., a single vertical line surrounded at the top by five circularly arrayed small open dots that might be seen as a tree or a pinwheel) was individually presented for 40 s, thus matching the presentation parameters for the FIQ stimuli. Additionally, across participants, the PMT stimuli were presented in one of two orders—either before or after the FIQ stimuli—with an unrelated written questionnaire task interposed between the FIQ and PMT. Responses to the PMT were scored for fluency, flexibility, and originality in the same manner as for the FIQ. One scoring adaptation, implemented in Experiment 6, involved slightly modifying the semantic categories used for scoring flexibility to be equally appropriate for both the PMT and FIQ (see online supplemental materials).
g. to contrast with the several predominantly divergent measures of creative thinking, we administered the comparatively convergent remote associates task (Experiments 3 and 5). In this task, participants are provided three words (e.g., boot, summer, ground) and are asked to generate a fourth word that connects or fits with all three words, such that each word pair makes a common compound word or phrase (in the current example, camp: bootcamp, summer camp, camp ground). The task included 30 items across a range of difficulty levels, based on the norms provided by Bowden and Jung-Beeman (2003).

Design-Related Creativity Assessments

We included two different design-related assessments.

a. A garden design task was given in Experiment 2. In this task, adapted from Pringle and Sowden (2017), participants were asked to draw an initial plan for the design of a garden that is based on "a journey and the series of experiences those who walk around the garden will have on this journey." Participants were allotted 15 min for this more complex task, during which they both sketched their garden ideas and engaged in a think-aloud protocol. The garden design task score is based on an average of 10 different aspects, including seven aspects relating to participants' sketches (e.g., originality, journey diversity, abstraction) and three aspects from their think-aloud transcript scores (e.g., idea unit count, idea category sum). Each of the 10 specific measures was first z-scored and then combined into a composite assessment of the overall quality on the garden design task, referred to as "Garden Quality10" (see Y. Wu & Koutstaal, 2020 for additional details).

b. A design product ideation task, in which participants were asked to generate ideas for urban gardening (Experiment 3; Tran et al., 2022) or ideas for picnics (Experiment 4; Erwin et al., 2022). The specific design product ideation tasks were as follows:

> A local company produces outdoor products that you may find at a hardware store. They are interested in breaking into the market of urban gardening. Urban gardening is essentially gardening in indoor or small spaces (a roof deck, a small yard, indoor areas, window sills, walls, ceiling, etc.). You are tasked with generating many new product ideas that can be used for urban gardening.

> A local retail store is interested in creating new products for next summer related to picnics. A picnic, in the most general sense, is an occasion involving taking a packed meal to eat outdoors. You are tasked with generating many new product ideas that can enhance a picnic experience.

Similarly to the FIQ, the originality of participants' ideas on the product ideation tasks was evaluated by two independent raters, using a 2-point scale, with 0 assigned for responses that were not at all original, 1 for responses that were somewhat original, and 2 for very original responses. For the product ideation task, we also evaluated the "value" of the ideas that participants suggested. Value concerned whether the proposed ideas would be useful or likely to be adopted by someone (e.g., to solve existing problems with picnics or urban gardening, or to make these experiences more enjoyable), and was determined by, but not limited to, the degree to which the product ideas were assessed as impactful, useful, meaningful, fun, pleasant, marketable or represent trends/personal preferences or styles, etc. For instance, a response to the urban gardening prompt that focused on "artificial light for the plants" is both meaningful and valuable; however, the product is not original at all; in contrast, for the picnic prompt, the suggestion to include a blue tooth speaker as part of a picnic basket or blanket is both original and valuable.

Openness to Experience, Cognitive Ability, and Creative Training

Across the experiments, several assessments of openness to experience, cognitive ability, and creative training were administered.

a. Measures of openness to experience, with alternative assessments providing convergent evidence for the relationship of this key creativity-related personality dimension to the new FIQ measure. Three of the experiments (Experiments 2, 3, and 4) included the 100-item Big Five Aspect Scales (BFAS; DeYoung et al., 2007), which incorporates assessments of the aspect of openness (sometimes variously referred to as "culture" and characterized by such descriptors as artistic and imaginative) and intellect (characterized by adjectives such as intellectual and intelligent); each aspect was assessed by 10 items. Three of the experiments (Experiments 2, 5, and 6) included the 54-item openness to experience questionnaire developed by Woo et al. (2014), a more comprehensive assessment of this complex personality trait (Christensen et al., 2019) that includes six subscales, each assessed with nine items, that can be considered separately or combined as an overall intellect/culture score. Additionally, in Experiment 4, we administered the HEXACO-60 questionnaire (Ashton & Lee, 2009), which included 10 items for the openness to experience facet, and encompassed items relating to creativity, aesthetic appreciation, inquisitiveness, and unconventionality.

b. Measures of prior creative experience or training, including the Inventory of Creative Activities and Achievements (Diedrich et al., 2018) in Experiment 5, and an assessment of creative training, activities, and unrealized creative ideas developed for the creative design methods research (Erwin et al., 2022; Tran et al., 2022) in Experiments 4 and 6.

c. Additionally, although not itself a measure of creative ability, given the known positive brain and behavioral association of fluid and crystallized intelligence with creativity and divergent thinking (e.g., Frith et al., 2021; Sligh et al., 2005), we administered a standardized assessment of general mental ability, the Shipley-2 (Shipley et al., 2009), with subtests of vocabulary (Experiments 4 and 5) and abstract fluid reasoning (Experiments 4 and 5) as control variables. In Experiment 3, we also obtained participants' college grade point average (GPA).

d. Finally, to assess the relation between perceptual reorientation and FIQ performance, Experiment 6 also included a visual–spatial orientation match/mismatch judgment task. In this task, participants were presented with 20 image pairs of three-dimensional objects constructed of cubes, selected from the Peters and Battista (2008) mental rotation stimulus library. Participants were asked to determine if the second of two presented objects could be rotated to entirely match a target object, such that the two objects were perfectly superimposable. Image pairs were chosen to represent a range of difficulty levels and required different degrees of rotation around either the horizontal or vertical axis. Images were presented on a light background as a wire-frame figure or with alternating black-and-white cubes. Participants were provided examples of matching and nonmatching objects with accompanying explanatory instructions, and were asked to respond to 20 items in 5 min.

Results

Overview

We first examined the results from (a) Experiment 1, an initial experiment to assess the variety of interpretations provided to a range of different FIQ stimuli, and used to develop scoring rubrics for semantic/category flexibility and originality. Next, for Experiments 2 through 6, we present correlations between the FIQ measures and (b) other performance-based measures of divergent and design-based creative thinking, (c) the varied measures of openness-to-experience, and (d) assessments of convergent thinking, including the remote associates task, additional cognitive ability (e.g., vocabulary) and creativity training/experience measures. (The corresponding descriptive statistics for each of the measures from Experiments 2 through 6 are provided in the online supplemental materials.)

Experiment 1

Table 2 presents the average fluency, flexibility, and originality for each of the 12 different FIQ items presented in Experiment 1, together with the means across items, and 95% confidence intervals (CIs) for all. From Table 2, it can be seen that, on average, participants generated slightly more than four responses to each FIQ stimulus; those responses were drawn from about 3.5 different semantic categories, and earned an average originality score (on the 0, 1, or 2-point rating scale) that was slightly above 1.

Scale analyses based on the 12 different FIQ items revealed that there was good reliability across items for each creativity dimension (Cronbach's $\alpha = .95$, .87, and .69 for fluency, flexibility, and originality, respectively). Correlations based on each participant's mean scores for each dimension revealed that scores on each of the three creativity dimensions significantly positively correlated with the others: fluency–flexibility, $r = .90$ [0.85, 0.93], $p < .001$; fluency–originality, $r = .49$ [0.32, 0.63], $p < .001$; flexibility–originality, $r = .56$ [0.41, 0.69], $p < .001$. Notably, however, the correlation of fluency with originality although positive, is not exceedingly high ($r = .49$ [0.32, 0.63]), indicating that the scoring approach we used for originality (with each response awarded a score of 0, 1, or 2) was assessing both something partially overlapping with, but also independent of, the sheer number of ideas that participants generated. Additionally, as noted earlier, we here focus on the results for flexibility and originality because flexibility serves as a measure of the semantic or categorical variation or diversity in an individual's ideational search and originality is an especially strong correlate of creativity and innovativeness (e.g., Acar et al., 2017; Runco & Charles, 1993; Ummar & Saleem, 2020).

The outcomes of Experiment 1 provide a clear initial demonstration of the viability of the FIQ as a new perceptually prompted measure of creative ideation. They provide firm grounding for further clarification of the interrelations between how individuals respond to the perceptually ambiguous stimuli of the FIQ task and other creative performance and individual difference measures. We next examined how participants' creative performance on the FIQ related to their performance on the other creative and design tasks assessed in Experiment 2 and the subsequent experiments.

Correlations of FIQ Performance With Other Creative and Design Tasks

Table 3 presents the correlations of FIQ flexibility and FIQ originality with the other creative and design tasks for the five experiments.

Looking first at the results for FIQ originality, and focusing first on the creative and design assessments that were administered in two or more separate experiments (providing conceptual replication and thereby protection against Type I error), it can be seen that originality scores on the FIQ consistently positively and significantly correlated with originality scores on the AUT (4/4 tested correlations significant, correlations of .30, .43, .21, and .55, Experiments 2, 3, 4, and 5, respectively, average Fisher Z_r of .40) and also with flexibility scores on the AUT (2/2 tested correlations significant, correlations of .25, and .53, Experiments 2 and 5, average Fisher Z_r of .42). FIQ originality also consistently significantly positively correlated with originality scores on the Torrance "just suppose" task (4/4 tested correlations significant, correlations of .28, .27, .32, and .38, Experiments 2, 3, 4, and 5, respectively, average Fisher Z_r of .32) and with both the originality of ideas generated during the more ecologically valid design product task (2/2 tested correlations significant, correlations of .32 and .34, Experiments 4 and 5, average Z_r of .34), and the value of the generated design product ideas (2/2 tested correlations significant, correlations of .30 and .37, Experiments 4 and 5, average Z_r of .35). Additional creative and design measures, but administered only on one occasion (and so considered promising, in need of further replication), included positive correlations of FIQ originality with originality and also flexibility on the Pattern Meanings Task ($r = .76$ and $r = .72$, respectively, Experiment 6), originality on the conceptual combination task ($r = .40$, Experiment 2) and distant analogy generation ($r = .22$, Experiment 6). FIQ originality also positively correlated with the overall quality measure of the complex multifaceted garden design task ($r = .29$, Experiment 2), in which participants sketched and verbally described their design for a garden that would generate "a journey and the series of experiences those who walk around the garden will have on this journey" (15 min). In contrast, FIQ originality did not appear to be as consistently correlated with originality or flexibility on the Torrance product task.

Looking next at the results for FIQ flexibility, largely the same patterns are found: there are strong and across-experiment replications of significant positive correlations of FIQ flexibility with

Table 2
FIQ Creative Performance Measures in Experiment 1

FIQ item	FIQ fluency	95% CI	FIQ flexibility	95% CI	FIQ originality	95% CI
FIQ-1	4.23	[4.04, 4.43]	3.20	[3.00, 3.40]	1.62	[1.30, 1.95]
FIQ-2	4.41	[4.25, 4.57]	3.60	[3.42, 3.77]	1.90	[1.56, 2.24]
FIQ-3	4.30	[4.10, 4.49]	3.67	[3.49, 3.85]	0.99	[0.81, 1.17]
FIQ-4	4.31	[4.13, 4.49]	3.53	[3.35, 3.70]	1.06	[0.82, 1.31]
FIQ-5	4.21	[4.01, 4.41]	3.79	[3.58, 3.99]	1.54	[1.27, 1.81]
FIQ-6	4.21	[4.02, 4.41]	3.28	[3.08, 3.48]	1.20	[0.98, 1.42]
FIQ-7	4.02	[3.80, 4.25]	3.55	[3.34, 3.76]	1.87	[1.54, 2.20]
FIQ-8	4.01	[3.79, 4.23]	3.21	[3.01, 3.43]	1.72	[1.44, 2.00]
FIQ-9	4.21	[4.02, 4.41]	3.28	[3.09, 3.47]	0.95	[0.72, 1.19]
FIQ-10	4.47	[4.28, 4.66]	3.94	[3.75, 4.13]	0.51	[0.37, 0.65]
FIQ-11	4.15	[3.95, 4.35]	3.56	[3.38, 3.75]	0.74	[0.52, 0.96]
FIQ-12	4.24	[4.05, 4.43]	3.72	[3.54, 3.91]	0.55	[0.37, 0.72]
Mean	4.23	[4.07, 4.39]	3.53	[3.41, 3.65]	1.22	[1.10, 1.34]

Note. FIQ = Figural Interpretation Quest; CI = confidence interval.

Table 3
Correlations of the FIQ Creativity Measures (Flexibility and Originality) With Divergent and Design-Based Creative Thinking Measures

Creativity measure	FIQ flexibility	95% CI	FIQ originality	95% CI
Experiment 2 ($N = 81$)				
AUT flexibility ("cup")	0.41***	[0.21, 0.58]	0.25*	[0.03, 0.44]
AUT originality ("cup")	0.35**	[0.14, 0.52]	0.30**	[0.08, 0.48]
Torrance suppose originality	0.39***	[0.18, 0.56]	0.28*	[0.06, 0.47]
Concept. comb. originality	0.39***	[0.18, 0.56]	0.40***	[0.20, 0.57]
Garden design—Quality10	0.22*	[0.004, 0.42]	0.29**	[0.08, 0.48]
Experiment 3 ($N = 98$)				
AUT originality ("paper clip")	0.44***	[0.27, 0.59]	0.43***	[0.26, 0.58]
Torrance suppose originality	0.26**	[0.07, 0.44]	0.27**	[0.07, 0.44]
Torrance product flexibility	0.34***	[0.16, 0.51]	0.14	[−0.06, 0.33]
Torrance product originality	0.16	[−0.04, 0.35]	0.16	[−0.04, 0.35]
Design ideation originality	0.32**	[0.13, 0.49]	0.32**	[0.13, 0.48]
Design ideation value	0.33***	[0.15, 0.50]	0.30**	[0.10, 0.47]
Experiment 4 ($N = 99$)				
AUT originality ("paper clip")	0.41***	[0.23, 0.57]	0.21*	[0.01, 0.39]
Torrance suppose originality	0.46***	[0.29, 0.60]	0.32**	[0.13, 0.49]
Torrance product flexibility	0.23*	[0.03, 0.41]	0.11	[−0.09, 0.30]
Torrance product originality	0.37***	[0.19, 0.53]	0.20*	[0.006, 0.39]
Design ideation originality	0.45***	[0.27, 0.59]	0.34***	[0.16, 0.51]
Design ideation value	0.33**	[0.14, 0.50]	0.37***	[0.19, 0.53]
Experiment 5 ($N = 67$)				
AUT flexibility (three items)[a]	0.61***	[0.43, 0.74]	0.53***	[0.34, 0.69]
AUT originality three items)[a]	0.66***	[0.50, 0.78]	0.55***	[0.35, 0.70]
Suppose flexibility	0.35**	[0.12, 0.54]	0.28*	[0.04, 0.49]
Suppose originality	0.36**	[0.13, 0.55]	0.38**	[0.16, 0.57]
Experiment 6 ($N = 132$)				
Pattern meanings flexibility	0.75***	[0.66, 0.81]	0.72***	[0.62, 0.79]
Pattern meanings originality	0.65***	[0.54, 0.74]	0.76***	[0.68, 0.82]
Analogy generation—total	0.21*	[0.042, 0.37]	0.17*	[0.002, 0.33]
Analogy generation—distant	0.23**	[0.060, 0.38]	0.22*	[0.049, 0.38]

Note. All p values are two-tailed. FIQ = Figural Interpretation Quest; AUT = alternative uses task; Concept. Comb. = conceptual combination; CI = confidence interval.
[a] In Experiment 5, the AUT was based on three items: cardboard box, flashlight, wooden ruler.
* $p < .05$. ** $p < .01$. *** $p < .001$.

AUT originality (correlations of .35, .44, .41, and .66, Experiments 2, 3, 4, and 5, respectively, average Z_r of .52), with AUT flexibility (correlations of .41 and .61, Experiments 2 and 5, average Z_r of .57), originality on the Torrance just suppose task (correlations of .39, .26, .46, and .36, Experiments 2, 3, 4, and 5, respectively, average Z_r of .39), originality on the design product ideation task (correlations of .32 and .45, Experiments 3 and 4, average Z_r of .41) and the value of generated ideas during the design product ideation task (correlations of .33 and .33, Experiments 3 and 4, average Z_r of .34). Likewise, for the other creative and design tasks, that were each administered once across the different experiments, there are (promising) positive correlations of FIQ flexibility with both flexibility and originality on the Pattern Meanings Task ($r = .75$ and $r = .65$, respectively), originality of conceptual combination ($r = .39$), distant analogy generation ($r = .23$), as well as with the overall quality of idea-generation on the multifaceted garden design task ($r = .22$).

Correlations of FIQ Performance With Openness to Experience

Table 4 presents the correlations of FIQ flexibility and FIQ originality with the measures of openness to experience, including the combined aspects of intellect/openness (for the BFAS), openness/culture (for the measure of Woo et al., 2014), and openness (for the HEXACO).

As can be seen from Table 4, there were uniformly positive correlations between FIQ originality across these different assessments of openness to experience, with six of the seven correlations statistically significant, with an average Fisher $Z_r = .28$ for BFAS openness/intellect, and an average Fisher $Z_r = .29$ for Woo intellect/culture. (See the online supplemental materials for analyses of the aspects separately.) For all but Experiment 2, there were also uniformly positive correlations of the different assessments of openness with FIQ flexibility.

Correlations of FIQ Performance With Cognitive Ability and Creative Training

Table 5 presents correlations of FIQ flexibility and FIQ originality with additional measures such as cognitive ability (e.g., Shipley-2 Vocabulary and Abstraction/Fluid Reasoning) and previous creativity-related training and experiences.

From Table 5, it can be seen that most of the remaining measures (e.g., Shipley-2 Vocabulary scores) were not consistently positively

Table 4

Correlations of the FIQ Creativity Measures (Flexibility and Originality) With Openness-to-Experience

Experiment/openness-to-experience measure	FIQ flexibility	95% CI	FIQ originality	95% CI
Experiment 2 ($N = 81$)				
BFAS—openness/intellect	0.06	[−0.16, 0.28]	0.24*	[0.024, 0.44]
Woo—intellect/culture	0.14	[−0.08, 0.35]	0.23*	[0.009, 0.43]
Experiment 3 ($N = 98$)				
BFAS—openness/intellect	0.31**	[0.12, 0.48]	0.38***	[0.19, 0.53]
Experiment 4 ($N = 99$)				
BFAS—openness/intellect	0.34***	[0.15, 0.50]	0.20	[−0.001, 0.38]
HEXACO—openness	0.33**	[0.14, 0.50]	0.26*	[0.057, 0.43]
Experiment 5 ($N = 67$)				
Woo—intellect/culture	0.37**	[0.14, 0.56]	0.32**	[0.09, 0.52]
Experiment 6 ($N = 132$)				
Woo—intellect/culture	0.29***	[0.12, 0.43]	0.29***	[0.12, 0.44]

Note. All p values are two-tailed. FIQ = Figural Interpretation Quest; CI = confidence interval; BFAS = Big Five aspect scales.
* $p < .05$. ** $p < .01$. *** $p < .001$.

associated with FIQ originality or FIQ flexibility. FIQ performance also was unrelated to grade point average (correlations of .15 and .04 for originality and flexibility, respectively), and the visual–spatial orientation match/mismatch judgment task (correlations of .06 and −.07 for originality and flexibility, respectively). However, particularly in Experiment 6, greater frequency of engagement in more general forms of creative activities emerged as a significant positive correlate of both more flexible (diverse) and original FIQ interpretative responses.

Discussion

A primary aim of this work—anchored in a consideration of the multiple cognitive-motivational contributors to flexibility of perceptual interpretation—is to offer both empirical and theoretical grounding for adopting a new set of ambiguous visual stimuli to assess an individual's flexibility of perceptual interpretation in relation to creative ideation and problem solving. Across six experiments, the irregularly drawn, ambiguous colored shapes of the FIQ were presented to more than 550 participants, and the originality and flexibility of participants' varied interpretations of those shapes was compared with their performance on multiple creative thinking, design, and individual difference measures.

As hypothesized, we observed significant positive correlations between originality scores on the FIQ and originality scores on several lab-based assessments of divergent thinking, showing convergent validity of the perceptually prompted FIQ with both predominantly conceptual tasks (especially the AUT, and Torrance suppose) and initial support for convergence with the more abstract predominantly perceptual PMT. Also, as hypothesized, we found that the degree of originality that participants demonstrated in

Table 5

Correlations of FIQ Creativity Measures (Flexibility and Originality) With Cognitive Ability, Remote Associates, and Creative Training/Experience Measures

Experiment/individual differences measure	FIQ flexibility	95% CI	FIQ originality	95% CI
Experiment 3 ($N = 98$)				
Grade point average	0.04	[−0.16, 0.23]	0.15	[−0.05, 0.34]
Remote associates task	0.09	[−0.12, 0.28]	0.02	[−0.18, 0.22]
Experiment 4 ($N = 99$)				
Shipley-2 vocabulary	0.11	[−0.09, 0.30]	0.16	[−0.05, 0.35]
Shipley-2 abstraction	0.29**	[0.097, 0.47]	0.06	[−0.14, 0.26]
Creativity training	0.05	[−0.15, 0.25]	0.20	[−0.001, 0.38]
Creative activities	−0.04	[−0.23, 0.16]	0.06	[−0.14, 0.26]
Creative unrealized ideas	−0.02	[−0.22, 0.18]	−0.01	[−0.21, 0.19]
Experiment 5 ($N = 67$)				
Shipley-2 vocabulary	0.33**	[0.096, 0.53]	0.25*	[0.013, 0.47]
Shipley-2 abstraction	0.16	[−0.085, 0.38]	0.17	[−0.071, 0.40]
Remote associates task	0.45***	[0.24, 0.63]	0.39**	[0.16, 0.57]
Creative activities-ICAA	0.23	[−0.009, 0.45]	0.16	[−0.085, 0.38]
Creative achievements-ICAA	0.12	[−0.12, 0.35]	0.04	[−0.21, 0.27]
Experiment 6 ($N = 132$)				
Visual-spatial orientation	−0.07	[−0.24, 0.11]	0.06	[−0.11, 0.23]
Creativity training	0.14	[−0.03, 0.31]	0.15	[−0.02, 0.31]
Creative activities	0.34***	[0.18, 0.48]	0.29***	[0.13, 0.44]
Creative unrealized ideas	0.37***	[0.21, 0.50]	0.33***	[0.17, 0.47]

Note. All p values are two-tailed. FIQ = Figural Interpretation Quest; CI = confidence interval; ICAA = inventory of creative activities and achievements.
* $p < .05$. ** $p < .01$. *** $p < .001$.

responding to the FIQ was significantly positively associated with the two open-ended product-ideation tasks similar to those that might be required in innovative design or creative industry (generating product ideas to improve the experience of urban gardening, and of outdoor picnics). Collectively, the current findings provide convergent support to recent emphases on the important contribution of perceptual flexibility (and ambiguity) to creative ideation, but notably also extend findings such as those of Pepin et al. (2022) beyond self-reported creativity and semantic flexibility, to performance-based assessments of the originality of ideas generated during multiple creative and design-related tasks.

From a theoretical perspective, the present research has begun to more specifically identify some of the varied cognitive-motivational contributors to flexibility of perceptual interpretation that were schematically summarized in Figure 1. Of those constructs, beyond positive associations with both lab-based and more complex creative design challenges, the current investigation has focused particularly on the contributions of openness to experience, and prior knowledge/training. The consistent association of FIQ originality with openness to experience is especially notable—significant positive correlations between FIQ originality and openness were observed for three different operationalizations of this construct, including the BFAS, the 54-item Woo et al. (2014) measure, and the HEXACO-60. These positive links between originality on the FIQ and individual differences measures of openness point to the construct validity of the FIQ and bode well for the possible adoption of the FIQ in research examining contributors to innovative design thinking (e.g., Toh & Miller, 2016). For example, given the recent work of Olteţeanu and Shu (2018) exploring the interrelations between design fixation and visual–spatial flexibility and perspective taking for the abstract and regular line-drawn stimuli of the PMT, future research might examine if individuals who show greater innovation or ideational divergence on constructive tasks (e.g., design tasks) also show higher levels of both perceptual flexibility and originality for the more irregularly shaped, organic-like, and concrete yet still ambiguous FIQ stimuli (cf., Berlyne, 1958; Sun & Firestone, 2021). Interestingly, and in contrast to the findings reported by Olteţeanu and Shu (2018), original ideation on the FIQ was largely uncorrelated with participants' performance on a visual–spatial orientation matching task. This suggests that the FIQ may be calling on somewhat different aspects of mental rerepresentation or construal than are assessed by judgments of visual–spatial rotation.

The research presented here has also taken some initial steps to establish discriminant validity of the FIQ. For instance, the current (multimethod) observation of minimal correlation between FIQ originality and participants' GPA ($r = .15$ 95% CI [−0.05, 0.34]) is quite similar to that reported by Runco et al. (2001) for the discriminant validity of the self-report measure of creative ideation (the Runco Ideational Behavior Scale) in university students ($r = .106$, $n = 90$). The discriminant validity of the FIQ is further supported by the generally minimal correlations of FIQ performance with the Shipley-2 measure of abstraction (fluid reasoning).

To empirically evaluate the cognitive processes involved in the generation of original responses to the FIQ, future research might adopt think-aloud procedures, such as those that have been used to illuminate the ideational search processes involved in the AUT (Gilhooly et al., 2007) and earlier for art, creative writing and different problem-solving tasks (Khandwalla, 1993; Ruscio et al., 1998). It may also be informative to examine the time course of idea generation, as in the serial order effect (e.g., Beaty & Silvia, 2012), or the temporal-spatial clustering of semantically or thematically related ideas (e.g., Mastria et al., 2021). Also, it may be fruitful to explore how participants' responses to the FIQ relate to the four different variants of semantic instability (integrative blend, multistability, indeterminancy, and contradiction to habits) identified by Muth et al. (2018) in individuals' sense making of artworks that allow for a plurality of meaning (see also Wang et al., 2025). Comparisons of alternative methods of establishing the originality of particular responses, such as may be provided by psycholinguistic, computationally based assessments of semantic distance (e.g., Beaty & Johnson, 2021), are likewise promising directions and have recently been successfully implemented to assess both perceptually prompted FIQ and PMT responses (Koutstaal et al., 2024).

In this context, it might be noted that there is ongoing discussion of the best approaches to assessing originality (e.g., Forthmann et al., 2020) and different methods have both merits and demerits. Although some researchers have advocated for a method of frequency-based scoring to assess originality, infrequency-based metrics may be unreliable for typical sample sizes of between 100 and 200 participants, and particularly so for highly original responses (Forthmann et al., 2020). We here adopted a more holistic qualitative rater-based approach that encompassed response rarity as one of several possible qualities associated with original ideation such as surprisingness or playfulness. The uniformly strong interrater reliabilities that we found for this approach may, in part, be attributable to our adoption of several guidelines that can bolster the consistency with which raters make judgments, such as encouraging raters to take sufficient time to provide their evaluations and emphasizing openness and receptivity to multiple perspectives in making their ratings (Ceh et al., 2022).

This study has primarily focused on the correlations between FIQ originality scores (and also flexibility scores) with creativity, design, and individual difference measures. Although, as briefly noted earlier, the concurrent incremental validity of originality scores on the FIQ—over and above that provided by originality scores on the AUT or Torrance suppose tasks—has been demonstrated for the product ideation tasks that we tested here (Erwin et al., 2022), it will be important to assess the incremental concurrent predictive value of FIQ originality for a wider range of complex design tasks, both in combination with alternative assessments of divergent thinking, and with individual differences measures such as openness to experience. Additionally, the current work has primarily considered constructs on the right-hand side and lower portion of the schematic conceptual map of flexibility of perceptual interpretation shown in Figure 1. Future research might explore, for instance, the originality and variety of FIQ responses in relation to the roles of insight, representational restructuring, perceptual-motor simulations, and individuals' experience with sketching or drawing, including on drawing completion tasks such as the Torrance figural tasks (e.g., Goff & Torrance, 2002) and including with younger children (e.g., Allen et al., 2016) or adolescents. Nonetheless, the consistency (essentially conceptual replication) of several of the findings reported here, particularly the correlations of FIQ originality and flexibility with original ideation on the AUT and Torrance suppose, and with varied measures of openness to experience, are marked strengths.

Finally, the patterns of convergent and divergent validity that we report here for the FIQ task is important in offering a wider array of stimuli for cognitive and cognitive-neuroscience investigations of creativity in general, and the flexibility of perceptual interpretation in particular. The FIQ offers a novel opportunity for assessing creative ideation based on changing perspectives, altered attentional focus, and perceptual attunement that is not dependent on subjective reports such as the timing or frequency of perceptual reversals with bistable images (e.g., the duck–rabbit or Necker cube).

To consider one specific point: Across the studies reported here, the FIQ stimuli were presented under both timed and untimed conditions. From a methodological and practical perspective, the similarity between findings using timed and untimed presentation is important and points to the feasibility of using FIQ in neuroimaging contexts. Additionally, the FIQ and PMT can both readily be administered during neuroimaging, providing the opportunity to extend the generalizability of findings relating to divergent thinking to more perceptually based, less verbal, and more novel stimuli, beyond the largely conceptually based and frequently used AUT—which is also often already familiar to participants, and thus may elicit "old" (i.e., remembered) responses that are judged to be less original both by participants themselves, and by raters, than are newly generated ideas (Benedek et al., 2018; Silvia et al., 2017). It also could be valuable to contrast cognitive-neural responses to the perceptually ambiguous FIQ stimuli, which are all single continuously enclosed "object-like" stimuli with responses to other forms of perceptually ambiguous stimuli, such as the distributed fractal "pattern-like" images recently developed by Pepin et al. (2022), the landscape-like photographs used by Diana et al. (2021) in the context of pareidolias, or some of the multielement "scene-like" line-drawn stimuli of the PMT (Wallach & Kogan, 1965). For instance, in Experiment 6, we found that, unlike for any of the FIQ stimuli, some multielement PMT stimuli were often interpreted in human and social-emotional terms (e.g., three smaller circles arrayed around each of the sides of a larger triangle were often construed as three people sitting at a table at a meeting or eating lunch; four smaller circles arrayed at the top of a larger rectangle was often seen as people watching a movie, collaborating, or even as a jury). Developing larger and more varied sets of ambiguous stimuli will both tend to enhance participant engagement (by avoiding the presentation of multiple similar-appearing items), and help ensure generalizability. This aligns with key methodological points underscored by Reiter-Palmon et al. (2019) regarding the importance of relying on a range of divergent thinking tasks so as to avoid misinterpretation of findings or overgeneralizing findings from a single task to divergent thinking in general, or, indeed, to creative ideation as a whole. To facilitate such further comparisons, the 12 FIQ stimuli used in the current series of studies, together with the more than 400 additional potential FIQ stimuli from the earlier study from which those stimuli are drawn (Koutstaal et al., 2003), can be requested from the author. Such research might also be a step toward integrating the already extensive neurocognitive findings on perceptual flexibility as revealed in our perception of ambiguous bistable images such as the duck–rabbit (Jastrow, 1899), Rubin's vase–faces, and the Necker cube (Long & Toppino, 2004; Rodríguez & Parra, 2018; Scocchia et al., 2014), with the smaller—but steadily growing—set of empirical observations directly linking perceptual flexibility and creative thought because (to return to where we began…) "the mind is (sometimes) stimulated to new inventions by obscure [indistinct, uncertain, incompletely defined] things…."

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