Title
Externalizing Imagery: Exploring the Phenomenology of Outsight

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 47(0)

Authors
Vallee-Tourangeau, Frederic
Ross, Wendy

Publication Date
2025

Externalizing Imagery: Exploring the Phenomenology of Outsight

Frédéric Vallée-Tourangeau (f.vallee-tourangeau@kingston.ac.uk)
Department of Psychology, Kingston University
Penrhyn Road, Kingston-upon-Thames, UNITED KINGDOM, KT1 2EE

Wendy Ross (w.ross@londonmet.ac.uk)
Department of Psychology, London Metropolitan University
166-220 Holloway Rd, London, UNITED KINGDOM, N7 8DB

Abstract

We adapted Irving's (2014) Image Control and Recognition Task (ICRT) to explore a phenomenon we term *outsight*. The ICRT is a visual synthesis task: Participants construct a mental image of an object following stepwise instructions. They are then asked to name and subsequently draw the imagined object. We focus on trials when participants after having failed to name their mental image, could do so after having drawn it. In this exploratory study, such outsight recognition occurred on 29% of the ICRT trials. In addition, outsight recognition was accompanied by some of the phenomenological markers associated with aha! experiences. We offer some reflections on the importance of reified imagery for creativity.

Keywords: Guided Synthesis Task; Mental Imagery; Creativity; Outsight.

Introduction

Imagination and creativity are commonly associated. Afterall, creativity is often defined as resulting in something new, something that hitherto did not exist or was unknown, which is exactly the stuff that imagination can conjure up. Retrospective—and invariably anecdotal—accounts of creatives' thought processes often refer to mental imagery, a rich internal theatre where new entities engage in new behaviour, take on new shapes, and the resulting imagined scenography guides and inspires creatives' work and discoveries (LeBoutillier & Marks, 2003). Pidgeon et al. (2015, p. 1) write: "visual creativity refers to the generation of novel and useful mental imagery, which may lead to the production of novel and useful forms". Pearson (2023, p. 182) puts it this way: "(…) creative insight appears linked to the active manipulation and transformation of mental images"; whether these manipulations and transformations are strictly mental will be addressed in this paper.

Efforts to go beyond plausible but anecdotal accounts of the association between mental imagery and creativity involve standard psychometric tools to measure, in turn, mental imagery skills and creativity (usually in samples of psychology undergraduates). Mental imagery skills are sometimes measured with self-report scales or actual visual imagery performance tests (e.g., mental rotation). Creativity, in turn, is commonly operationalized with performance on divergent or convergent thinking tasks. In LeBoutillier and Marks's (2003) meta-analysis, the average correlation coefficient between mental imagery and creativity was .15, 95%CI [.10 - .20]. Mental imagery, thus, explains anywhere between 1 to 4% of the variance in creativity.

Image Generation and Creative Visualization

Other efforts to cash in on the plausible association between imagery and creativity have placed a bet on image synthesis or generation tasks. In Finke and Slayton (1988), participants were familiarised with a set of 15 shapes and forms composed of letters (e.g., J), numbers (e.g., 8) and geometric figures (e.g., circle). The experimenter would then name, at random (with some selection constraints), three of these shapes and invite participants to imagine (synthesize) a composite nameable figure configured from these three shapes (see the top panel of Figure 1 for an example). In the two experiments reported in Finke and Slayton, participants could name and draw recognizable patterns on approximately 40% of the trials, and of these about 15% were independently judged to be highly creative.

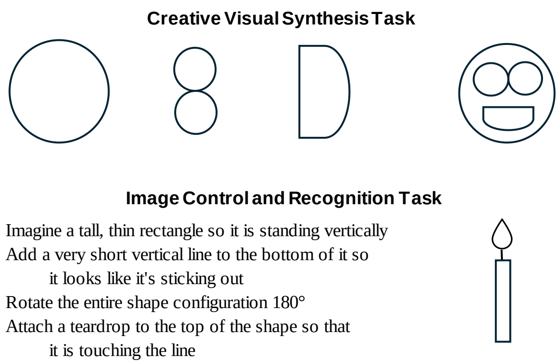

Figure 1. Elements sampled in a trial from Finke and Slayton's (1988) creative visual synthesis task, top panel; a four-stage trial from Irving's (2014) Image Control and Recognition Task, bottom panel.

Irving (2014; Irving et al., 2011) developed another visual synthesis task, the Image Control and Recognition Task

In D. Barner, N.R. Bramley, A. Ruggeri and C.M. Walker (Eds.), *Proceedings of the 47th Annual Conference of the Cognitive Science Society*

(ICRT; an example of a trial in this task is illustrated in the bottom panel of Figure 1). This differs from Fink and Slayton's; participants are not required to generate novel or creative objects but rather to follow the instructions to find the correct answer. Participants listen to verbal instructions that describe shapes and their spatial arrangement or transformation; from these instructions participants aim to synthesize a mental image of the resulting combinations and transformations of the different elements and name it (some of the ICRT items are composed of elements employed by Finke & Slayton). They are invited then to draw the results of their synthesis. Irving (2014) reports that performance on the ICRT correlates positively with performance on Finke and Slayton's (1988) creative visualization task ($r(94) = .50$). In the final study of her dissertation, Irving reports a positive correlation between ICRT performance and divergent thinking ($r(90) = .36$) and scores on Carson et al.'s (2005) Creative Achievement Questionnaire ($r(90) = .25$).

Externalizing a Mental Representation

We wish to draw attention to an interesting measurement decision made by Irving and the serendipitous phenomenon that was revealed as a consequence. The correlations reported above are based on ICRT *total* scores: these total scores, in turn, are based on both correctly naming and *drawing* the intended object. Thus, in this procedure, it is possible for participants to carefully follow the instructions and then to be unable to name the object but still able draw it accurately (and score a point for doing so, adding to their total ICRT performance); the ICRT total measure is explicitly designed to capture this possibility by offering a score for both naming and drawing. It is this procedural/measurement decision, namely to invite participants to draw something they could not initially name, that revealed a particularly interesting phenomenon, one that manifests through the administration of the ICRT. As Irving (2014, pp. 151-152) remarked in her thesis, on some ICRT trials, participants can fail to name the object or shape mentally assembled, but can do so once they draw it: "Despite being able to complete the stages to perfect accuracy, a sizeable number of people apparently could not recognise the intended image until they had drawn it, *much to their own surprise*" (p. 152, our emphasis)[1]. Thus, a participant's internal (mental) representation of the object/shape is insufficiently clear, offers insufficient traction to cue the activation of an entry in her mental lexicon, yet is sufficiently detailed to guide its material reification[2].

The externalization is in turn sufficiently unambiguous that once completed it triggers a sudden recognition and may be accompanied by a phenomenology commonly associated with aha moments (Wiley & Danek, 2024). The feeling of aha arises when the answer to a problem initially deemed intractable comes suddenly to the mind of the problem-solver. It has a reliable and recognisable phenomenological profile marked by pleasantness, surprise, confidence and the feeling of overcoming a mental impasse (Danek et al., 2014). This feeling is commonly used to differentiate between cognitive processes; its presence is theorised to reflect the sudden restructuring of the unhelpful problem representation (Bowden et al., 2005; Danek et al., 2020). Like visual imagery, it has been associated with creative mental processes. Thagard and Stewart (2011, p. 10) call it the "ecstasy of discovery"

The feeling is commonly elicited by psychologists using "insight problems", that is, problems that are deliberately structured to induce an unhelpful initial mental representation. This starting representation leads to an impasse which may in turn trigger a change in the representation of the problem. The cognitive processes that underlie this representational change are still up for debate – either they are the same as those routinely deployed for everyday thinking (Fleck & Weisberg, 2013; MacGregor et al., 2001) or they are special non-routine processes kept in reserve for such a tricky moment (Danek et al., 2020; see also Weisberg, 2015 for an integrated account). The findings from Irving and observations from Vallée-Tourangeau et al. (2020) suggest that this same feeling and associated representational change can be elicited not by an internal mental reorganisation of a problematic or incomplete representation but the externalisation and subsequent recognition of the correct answer to a problem. This supports the proposal by Vallée-Tourangeau and March (2020; see also Ormerod & Ross, 2024) that creative insight can come from an interaction between internal and external sources of information – a phenomenon they call "outsight". This claim shifts the focus from the internal processes to the interaction between the mind and the world in idea generation.

Alongside substantiating the claim of a different route to creative insight, it is possible that the ICRT will allow a closer examination of the relationship between the feeling of insight and the proposed restructuring that inspires it. In the ICRT, if participants can easily name the synthesised object then they are unlikely to have drawn on particularly special processes but instead will have relied on the everyday mental processes require to process information of this kind. On the other hand, the recognition after externalisation of the composite shape seems to require the rapid updating of the mental representation from ignorance to knowing and so we

[1] Vallée-Tourangeau et al. (2020, p. 735) report observing the same phenomenon when they employed the ICRT to profile their participants' visual imagery skills for an insight problem-solving experiment.

[2] One is reminded of Chambers and Reisberg's (1985) findings: a mentally imagined ambiguous figure (viz. duck/rabbit) cannot be inspected to reveal its alternative interpretation, which is readily made once the participants draw the imagined object (see their Table 1, p. 321).

would expect participants to experience something more akin to traditional insight.

In short, the primary objective of the exploratory study reported here was to better understand the phenomenological dimensions of two main types of ICRT trials: those in which the intended image was recognized and named based on its mental representation before drawing it and those in which the intended image was recognized only once drawn. We call the former *mental recognition* trials, and the latter *outsight recognition* trials. A secondary objective was to measure the rate of these two types of trials. For each type of trials, participants were invited to rate their experience along four dimensions: (i) the confidence in their answer, (ii) their surprise in doing so, (iii) the impasse they might have experienced before producing an answer, and (iv) the pleasure in recognizing the figure.

Method

Participants

Twenty-nine undergraduate and postgraduate students (24 females) in a research methods workshop volunteered for this study (M_{age} = 27.3, *SD* = 9.7). They were tested in groups.

Procedure

We used a reduced version of the adapted ICRT (Irving, 2011). The three objects we selected are described in Figure 2. Participants were given an answer booklet on which they recorded their age and gender and a page for each practice and test trial on which they could write the name of the imagined figure and a space to draw it.

Stage	**Umbrella**	**Heart**	**Candle**
1	Imagine a capital letter ‘D’	Imagine a capital letter ‘B’	Imagine a tall thin rectangle so it is standing vertically
2	Rotate it 90° to the left	Rotate it 90° to the LEFT/anti-clockwise	Add a very short vertical line to the bottom of it so it looks like it’s sticking out
3	Add a capital ‘J’ directly underneath it	Add a triangle pointing downwards so it lines up with the bottom of the shape and is touching	Rotate the entire shape 180°
4		Remove the horizontal line in the middle	Attach a teardrop to the top of the shape so that it is touching it

Figure 2. The three visual guided synthesis items (taken from Irving’s [2014] Image Control and Recognition Task.

As they listened to the instructions participants were not allowed to draw anything or even use gestures to anchor their mental imagery. For each synthesized item, participants were first asked to write down a name for it (they had 10s to do so); they were then invited to draw the imagined figure (and were given 30s to do so) and were asked a second time to name the figure, this time based on their drawing. Thus, for each trial, recognition of the object could be strictly mental (i.e., the object mentally synthesized was accurately named, or *mental recognition*), recognition of the object occurred once it was materially translated into an external drawing of the mental image (which we term *outsight recognition*); on some trials, recognition was not achieved, either mentally or once the image was drawn.

The instructions to participants read as follows:

> “You will be asked to mentally combine and manipulate sets of letters and shapes and then at the end of each set to draw the resultant image. The shapes will join to make a familiar object.
>
> As you hear the instructions, you should visualise the shapes in your mind. At no point may you draw or sketch anything apart from when instructed to do so. This includes sketching in the air with your hands. You may find this tricky and some people find it helps to hold their hands together in their lap.
>
> Once the instructions are finished, write the name of what you see in the space on the answer booklet. If you don’t see anything or if you can’t name, the object leave this space blank.
>
> After this you will have 30 seconds to draw whatever object has comes into your mind on the answer booklet. Please draw whatever is in your head even if you feel it may be incorrect.”

As a warmup, participants were given two practice trials, *diamond* (i. imagine a triangle pointing upwards; ii. imagine another downward pointing triangle so that it is directly underneath and the horizontal lines overlap; iii. remove the horizontal line) and *stickman* (i. imagine a plus sign; ii. add a circle to the bottom of the vertical line so it is touching; iii. add a capital ‘V’ to the top of the vertical line so it is touching; iv. rotate the entire shape 180°). Next participants were presented the three visual guided synthesis trials, corresponding to *umbrella*, *heart* and *candle* (see Figure 2); the trials were presented in the same order for all participants.

On all trials, once participants attempted to draw the shape, they were asked to rate their experience along four dimensions using a scale from 0 to 100: (i) confidence (*How confident do you feel that the answer you just gave above was correct?* where 0 meant ‘I’m certain my answer was not correct’ and 100 ‘I’m certain my answer was correct), (ii) surprise (*Did the answer surprise you?* where 0 meant ‘Not surprising at all’ and 100 ‘Very surprising’); (iii) impasse (*Before you realised the answer, did you feel stuck*? where 0 meant ‘I did not feel stuck at all’ and 100 ‘I felt very stuck’); (iv) pleasure (*When you found the solution, did it feel pleasant or unpleasant?* where 0 meant ‘Very unpleasant’ and 100 ‘Highly pleasant’).

The test session comprised of two final tasks. First, participants completed a simple mental arithmetic test, where they had to mentally calculate the result of 60 simple arithmetic questions (e.g., 6 x 7 = ?; 12 – 5 = ?) in 60 seconds; their basic arithmetic score (BAS) was simply the number of correctly answered questions. BAS is a proxy measure of working memory (e.g., Guthrie & Vallée-Tourangeau, 2018). Second, participants completed Runco et al.’s (2001) ‘creative ideation’ scale (Runco Ideational Behavior Scale or RIBS), a self-report measure composed of

23 items that include statements such as “I often get excited by my own new ideas” which participants rated on a scale ranging from 1 (‘Never’) to 5 (‘Very often’). Participants were then shown the answers to all three ICRT test trials and were debriefed.

Results

Participants’ performance on the ICRT was calculated in the same manner as Irving’s total ICRT score, that is participants could score a point for correctly naming the item and also a point for correctly drawing the intended object. Given there were three test trials, ICRT total scores could range from 0 to 6; the mean ICRT total was 3.55 (*SD* = 1.66). Participants’ mean BAS was 26.9 (*SD* = 12.5) and their mean total RIBS score was 79.4 (*SD* = 17.5). We note that none of the correlations among these measures were significant; the largest non-significant correlation was observed between ICRT scores and the BAS, $r(27) = .31$, $p = .098$.

With 29 participants and three visual synthesis trials, we could record the frequency of mental or outsight recognition or no recognition from 87 possible visual synthesis trials. Participants failed to name and draw the intended object on 25 (or 29%) of those trials; mental recognition (i.e., correctly naming the figure before drawing it) occurred on 37 trials (or 42%) while outsight recognition (i.e., correctly naming the figure once having drawn it) occurred on 25 trials (or 29%).

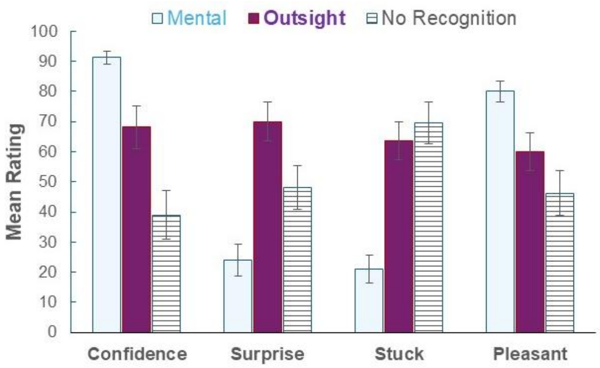

Figure 3. Mean ratings for confidence, surprise, impasse (or feeling stuck) and pleasantness following mental recognition (naming the object before drawing it), outsight recognition (naming the object after drawing it) and no recognition trials. Error bars are standard errors of the mean.

The Relationship Between Insight Phenomenology and Recognition Type

Figure 3 plots the mean ratings along the four phenomenological dimensions commonly associated with aha feelings, namely confidence, surprise, impasse (or feeling stuck), and pleasantness for mental recognition and outsight recognition trials. Looking at the pattern of data, participants’ confidence in their answer was higher following mental than outsight recognition; participants were more surprised and experienced more impasse on outsight recognition trials than on mental recognition trials; finally, pleasantness ratings were higher for mental recognition than outsight recognition trials.

As we could not predict the type of recognition prior to participants undertaking the study, we analysed the data at the trial level but we took clustered variance into account by building linear mixed models with the participant and stimuli as random intercepts (formula = (1|participant) + (1|stimuli). These models were then compared to a null model using likelihood ratio testing (LRT) from the afex package (Singmann et al., 2023), as recommended by Brown (2021). We tested whether there were differences between the experience of the four main insight measures – pleasantness, confidence, surprise and the feeling of being stuck - across the three possible outcomes: internal recognition (mental), external recognition (outsight) or lack of success.

Confidence. Participants were most confident when they mentally recognised the answer (*M* = 90.9, 95% CI [78.50, 103.20]) then when they recognised it through outsight (*M* =68.4, 95% CI [55.5, 81.3]) and, unsurprisingly, were less confident when they failed to solve (*M* = 39.5, 95% CI [26.1, 52.90]). The model predicting confidence by outcome was a significantly better fit for the data than the null model, $\chi^2(2) = 37.81$, $p < .001$. Post hoc tests with a Bonferroni correction suggested that this significant difference was between mental recognition and both the lack of success ($p < .001$) and outsight recognition ($p = .019$) and also between the failure to solve and experiencing outsight ($p = .001$).

Surprise. Those who experienced outsight had the highest ratings of surprise (*M* = 70.3, 95% CI [49.92, 90.70] followed by those who failed to solve (*M* =52.4, 95% CI [31.62, 73.30]) and finally there were low levels of surprise in those who mentally rearranged the parts of the problem (*M* = 20.4, 95% CI [-0.06, 40.9]). The model predicting surprise by outcome was a significantly better fit for the data than the null model, $\chi^2(2) = 31.75$, $p < .001$. Post hoc tests with a Bonferroni correction suggested that this significant difference was between mental recognition and the lack of success ($p = .001$) and outsight recognition ($p < .001$) but not between the failure to solve and experiencing outsight ($p = .094$).

Feeling Stuck. Participants felt most stuck when they did not get the answer correct (*M* = 71.4, 95% CI [55.68, 87.00), followed closely by when they experienced outsight (*M* = 62.8, 95% CI [47.76, 77.90]) but experienced lower levels when they answered the problem through mental recognition (*M* = 20.1, 95% CI [5.26, 34.90]). The model predicting feeling of being stuck by outcome was a significantly better fit for the data than the null model, $\chi^2(2) = 44.58$, $p < .001$. Post hoc tests with a Bonferroni correction suggested that this significant difference was between mental recognition and both the lack of success ($p < .001$) and outsight recognition ($p < .001$) but not between the failure to solve and experiencing outsight, $p = .671$.

Pleasantness. Those who experienced mental recognition found the experience more pleasant (*M* = 79.0, 95% CI [65.8, 92.2]) than those who experienced outsight (*M* =59.4, 95% CI [45.7, 73.1]) and those who failed to solve (*M*=49.0, 95% CI [34.5, 63.5]). The model predicting pleasantness by outcome was a significantly better fit for the data than the null model, χ^2 (2) = 6.84, p <.001. Post hoc tests with a Bonferroni correction suggested that this significant difference was between both mental recognition and both failure (p = .002) and outsight recognition (p = .039) but not between the failure to solve and experiencing outsight (p = .551).

Exploratory Analyses

We tested whether the pleasantness of the experience was related to the feelings of surprise, levels of feeling stuck or confidence; some have remarked in the past that the pleasant dimension of aha phenomenology might be explained by the confidence in the correct answer, most often established with insight problems that have a unique, normative, correct answer (Ross & Vallée-Tourangeau, 2022). We fitted a linear mixed model (estimated using REML and nloptwrap optimizer) to predict pleasantness with stuck, surprise, confidence and outcome with mental recognition as the reference class. The model's explanatory power related to the fixed effects alone (marginal R^2) was 0.59: the only significant predictor was the effect of confidence (β = 0.65, 95% CI [0.48, 0.82], $t(75)$ = 7.70, p < .001; Std. β = 0.74, 95% CI [0.55, 0.93]); the largest non-significant predictor was the effect of being stuck β = 0.18, 95% CI [-2.20e-03, 0.37], $t(75)$ = 1.97, p = .053; Std. β = 0.22, 95% CI [-2.60e-03, 0.44]).

Discussion

On the basis of the anecdotal reports of outsight recognition with the Image Control and Recognition Task in Irving (2011) and Vallée-Tourangeau et al. (2020), we wanted to get a better sense of its rate of occurrence and its associated phenomenology. In this exploratory study, outsight recognition was observed on 30% of the ICRT trials. Outsight recognition shares a strong similarity with aha phenomenology with its emphatic surprise element following an inability to name the target shape based on mental imagery alone, supporting Irving's initial observation. The feelings of surprise and of resolving the feeling of being stuck (due to the inability to name the intended object based on mental imagery) were experienced to a significantly greater degree than when recognition was solely based on mental recognition as indexed by participants' ability to name the synthesized object before drawing it. In turn, mental recognition elicited significantly greater feelings of confidence and pleasantness than outsight recognition.

One explanation for the difference in experience between mental recognition and outsight recognition is that the pleasant feelings traditionally associated with the experience of insight are actually a reflection of the feeling of success rather than indicating a different cognitive process. This would fit with findings that the levels of aha do not differ reliably between problem types but are regularly more associated with a correct answer (Webb et al., 2016). Our exploratory analyses go some way to supporting this interpretation; there was a relationship between the pleasantness of the experience and overall confidence, and this was not related to the relief of a feeling of impasse or surprise in the answer.

Given the exploratory nature of this study, and the small sample size, it remains difficult to interpret the correlations between ICRT scores and our proxy measure of working memory and the self-report measure of creative ideation. Replicating this study with a more robust sample, and possibly profiling participants along a number of other measures of individual differences would likely yield more interpretable data concerning the predictors of performance on the ICRT. Similarly, a more systematic manipulation of the working memory load of the internal rotations required could inform our understanding of what is being externalised. Finally, it would be interesting to see if the externalisation of visual imagery varies in line with artistic expertise.

What Does Outsight Recognition Mean?

Outsight recognition offers an interesting window onto the interactive and enacted nature of creativity. In essence, a hunch or an embryonic idea guides its initial development through material reification, akin perhaps to the process of physical prototyping (Sass & Oxman, 2006). The very process of materializing the idea gives shape or form to the idea. Once materialized, sense making kicks in. Recall Irving's (2011) more encouraging findings concerning the association between visual imagery—operationalized in terms of *total* ICRT scores—and measures of creative visualization, divergent thinking, and creative behaviour inventories. ICRT total scores were calculated on the basis of mental recognition *plus* the ability to draw the synthesized object (although we don't know the rate of outsight recognition in her study). It may be that the stronger associations with measures of creativity are partly driven by participants' ability to materially translate a mental image into a nameable external representation.

Imagery, and imagining, is not mental imagery, or not just mental imagery. Once externalized (e.g., sketched), a representation shifts from mental to physical: it can be perceived, analysed, interrogated, the physical representation lends itself to inferences and new ideas (e.g., Chalmers & Reisberg, 1985). Pearson and Logie (2015) also illustrate the importance of externalization in a guided synthesis task. In creative work, a hunch, visual or otherwise, is quickly and inevitably materialized through a sketch, maquette, or draft. Creativity *accrues* in the very process of material reification (to adapt Perez-Breva, 2018). And what's more, the material object created can be perceptually inspected, can cue new ideas, trigger new actions, and recursively the object qua physical representation, is modified still in an iterative manner. The initial idea, and that's the territory of creative cognition, is not the *cause* that threads the ensuing contingent developmental process of creativity. Rather, the explanation of creativity finds purchase in the evolving and unpredictable dialogue between creator and thing created; the explanation describes a double process of becoming: creator and thing co-evolve through their co-constitution.

References

Brown, V. A. (2021). An introduction to linear mixed-effects modeling in R. *Advances in Methods and Practices in Psychological Science*, *4*(1), 1-19. https://doi.org/10.1177/2515245920960351

Bowden, E. M., Jung-Beeman, M., Fleck, J., & Kounios, J. (2005). New approaches to demystifying insight. *Trends in Cognitive Sciences*, *9*(7), 322–328. https://doi.org/10.1016/j.tics.2005.05.012

Carson, S. H., Peterson, J. B., & Higgins, D. M. (2005). Reliability, validity, and factor structure of the creative achievement questionnaire. *Creativity Research Journal*, *17*(1), 37-50. https://doi.org/10.1207/s15326934crj1701_4

Chambers, D., & Reisberg, D. (1985). Can mental images be ambiguous? *Journal of Experimental Psychology: Human Perception and Performance*, *11*(3), 317-328. https://doi.org/10.1037/0096-1523.11.3.317

Danek, A. H., Fraps, T., von Müller, A., Grothe, B., & Öllinger, M. (2014). It's a kind of magic—what self-reports can reveal about the phenomenology of insight problem solving. *Frontiers in Psychology*, *5*, 1408. https://doi.org/10.3389/fpsyg.2014.01408

Danek, A. H., Williams, J., & Wiley, J. (2020). Closing the gap: Connecting sudden representational change to the subjective Aha! experience in insightful problem solving. *Psychological Research*, *84*(1), 111–119. https://doi.org/10.1007/s00426-018-0977-8

Finke, R.A., & Slayton, K. (1988). Explorations of creative visual synthesis in mental imagery. *Memory & Cognition*, *16*(3), 252–257. https://doi.org/10.3758/BF03197758

Fleck, J. I., & Weisberg, R. W. (2013). Insight versus analysis: Evidence for diverse methods in problem solving. *Journal of Cognitive Psychology*, *25*(4), 436–463. https://doi.org/10.1080/20445911.2013.779248

Guthrie, L.G., & Vallée-Tourangeau, F. (2018). Numbers in action: individual differences and interactivity in mental arithmetic. *Cognitive Process*ing, 19, 317–326. https://doi.org/10.1007/s10339-018-0856-7

Irving, L. (2014). *Creativity, imagery and schizotypy: An exploration of similarities in cognitive processing*. Unpublished doctoral dissertation, Middlesex University.

Irving, L., Barry, R., LeBoutillier, N., & Westley, D. (2011). The image control and recognition task: A performance-based measure of imagery control. *Journal of Mental Imagery, 35*, 67–80. https://psycnet.apa.org/record/2012-04055-008

LeBoutillier, N., & Marks, D. F. (2003). Mental imagery and creativity: A meta-analytic review study. *British Journal of Psychology, 94*(1), 29-44. https://doi.org/10.1348/000712603762842084

MacGregor, J. N., Ormerod, T. C., & Chronicle, E. P. (2001). Information processing and insight: A process model of performance on the nine-dot and related problems. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *27*(1), 176–201. https://doi.org/10.1037/0278-7393.27.1.176

Ormerod, T. C., & Ross, W. (2024). *Modelling insight: Process or phenomenology*. in E. Ippoliti et al. (Eds.): MBR 2023, SAPERE 70, pp. 415–432.

Pearson, D. G. (2023). Mental imagery and creative cognition. In L. J. Ball and F. Vallée-Tourangeau (Eds.), *The Routledge international handbook of creative cognition* (pp. 180-198). Routledge.

Pearson, D. G. & Logie, R. H. (2015). A sketch is not enough: Dynamic external support increases insight on a guided synthesis task. *Thinking and Reasoning, 21*(1), 97–112. https://doi.org/10.1080/13546783.2014.897255

Perez-Breva, L. (2018). *Innovating: A doer's manifesto for starting from a hunch, prototyping problems, scaling up, and learning to be productively wrong*. MIT Press.

Pidgeon, L. M., Grealy, M., Duffy, A. H., Hay, L., McTeague, C., Vuletic, T., ... & Gilbert, S. J. (2016). Functional neuroimaging of visual creativity: A systematic review and m eta-analysis. *Brain and Behavior, 6*(10), e00540. https://doi.org/10.1002/brb3.540

Ross, W., & Vallée-Tourangeau, F. (2022). Insight with stumpers: normative solution data for 25 stumpers and a fresh perspective on the accuracy effect. *Thinking Skills and Creativity*, *46*, 101114.
https://doi.org/10.1016/j.tsc.2022.101114

Runco, M.A., Plucker, J.A., & Lim, W. (2001). Development and psychometric integrity of a measure of ideational behavior. *Creativity Research Journal, 13*(3-4), 393–400. https://doi.org/10.1207/S15326934CRJ1334_16

Sass, L., & Oxman, R. (2006). Materializing design: the implications of rapid prototyping in digital design. *Design Studies*, *27*(3), 325-355. https://doi.org/10.1016/j.destud.2005.11.009

Singmann, H., Bolker, B., Westfall, J., Aust, F., & Ben-Shachar, M. (2023). *afex: Analysis of Factorial Experiments* (Version R package version 1.3-0) [Computer software]. https://CRAN.R-project.org/package=afex

Thagard, P., & Stewart, T. C. (2011). The AHA! experience: Creativity through emergent binding in neural networks. *Cognitive Science*, *35*(1), 1–33. https://doi.org/10.1111/j.1551-6709.2010.01142.x

Vallée-Tourangeau, F., & March, P. L. (2020). Insight out: Making creativity visible. *The Journal of Creative Behavior, 54*(4), 824-842. https://doi.org/10.1002/jocb.409

Vallée-Tourangeau, F., Ross, W., Rufflato Rech, R., Vallée-Tourangeau, G. (2020). Insight as discovery. *Journal of Cognitive Psychology, 33*(6-7), 718-737.

https://doi.org/10.1080/20445911.2020.1822367
Wiley, J., & Danek, A. H. (2024). Restructuring processes and Aha! experiences in insight problem solving. *Nature Reviews Psychology, 3*, 42–55. https://doi.org/10.1038/s44159-023-00257-x
Webb, M. E., Little, D. R., & Cropper, S. J. (2016). Insight is not in the problem: Investigating insight in problem solving across task types. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.01424
Weisberg, R. W. (2015). Toward an integrated theory of insight in problem solving. *Thinking & Reasoning*, *21*(1), 5–39. https://doi.org/10.1080/13546783.2014.886625