Insight

Frédéric Vallée-Tourangeau and Gaëlle Vallée-Tourangeau

Kingston University

Author Note

Correspondence should be addressed to Frédéric Vallée-Tourangeau, Department of Psychology, Kingston University, Kingston-upon-Thames. UNITED KINGDOM, KT1 2EE, f.vallee-tourangeau@kingston.ac.uk or Gaëlle Vallée-Tourangeau, Department of Management, Kingston University, Kingston-upon-Thames, UNITED KIGDOM, KT2 7LB, g.vallee-tourangeau@kingston.ac.uk. We thank Paul March and Vlad Glăveanu for thoughtful comments on a previous version of this manuscript.

Abstract

Insight is a form of comprehension that results in the connection between two hitherto unappreciated, unacknowledged or simply unknown ideas, and, consequently, expands the realm of the possible. Making these connections is a powerful driver of creativity and innovation. As a putative cognitive process, insight has exercised psychological researchers for over 100 years. Efforts to capture insight under laboratory conditions are constrained by exigencies of operationalisation and control, as well as by an implicit ontological position that casts insight as a property of the brain. As a result, psychological research has focused on what we term second-order problem solving, which is reasoning triggered by problems presented as propositions that describe states of the world. People are tasked with finding new connections among the problem elements, but these connections can only be made by manipulating a mental representation of the problem. Creative cognition outside the psychologist's laboratory involves a great deal of interaction with the world. In contrast to second-order problem solving, first-order problem solving characterizes activities of embodied agents as they interact and manipulate the world around them. Creativity and insight emerge through a transactional process of transformation: physical features cue actions that change both the reasoner and the physical environment in which he or she is embedded. Insightful new possibles are realised through an active and mutually transforming exploration of the problem-solving environment. We discuss insight as an enacted process, involving action and perception. As a physical and perceptual activity, a degree of serendipity is inevitable and, in some circumstances, insight becomes 'outsight'. We identify eight key features of first-order creative cognition that map out a new programme of research on insight.

Keywords: creative cognition, first-order problem solving, interactivism, systemic thinking, material engagement.

Insight, as the word and its etymological origins suggest, is a form of inner sight. There is an interesting tension in the juxtaposition of inner and sight. Thus, it is something that happens within a private and subjective world, yet it involves ‘seeing’, a perceptual activity aimed at the outer physical environment, rather than the inner, psychological one. There is something quite interesting about the embodiment of many metaphorical expressions (Gibbs, Lima, & Francozo, 2004), and we will return to this perceptual element of insight (and suggest a new twist on an old term).

Insight is a form of comprehension that results in the connection between two hitherto unappreciated, unacknowledged or simply unknown ideas. Insight is thus a form of creativity, a type of discovery of a new possible. The insightful understanding can be expressed as a new proposition, and hence can be assigned a truth-value (Bickhard, 2009). The phenomenological signature of this type of inference (Bowden & Grunewald, 2018) and its coordinates of occurrence (Ovington, Saliba, Moran, Goldring & MacDonald, 2015) have led to the following observations: Insight can be sudden, it can be accompanied by a positive emotion, and it is sometimes experienced in prosaic quotidian activities (e.g., while bathing). These features have encouraged some researchers to conceive insight as a phenomenon largely driven by unconscious processes. For example, Ohlsson (e.g., 2018) conjectures that patterns of activation in semantic memory may result in the connection among disparate elements; when these associative connections reach a certain level of activation, they become consciously accessible and a new idea is born.

Historical and retrospective accounts often cast the experience of insight as a pivotal moment in problem solving, a consequential inflection point in conceptualisation that ushers in a significant breakthrough in design, science and art. Weisberg (2010, 2018) reviewed a number of these moments, including Frank

Lloyd Wright's design of Fallingwater, Wilkins's invention of radar, and da Vinci's design for the aerial screw. Whether these moments actually resulted from an experience of insight, with a distinctive phenomenological signature and unconscious origin, is debatable. The debate is partly fuelled by the unreliability and circumstantial character of these historical reconstructions and by plausible alternative explanations in terms of deliberate analysis and analogical reasoning that promoted the gradual rather than sudden reorganization of knowledge.

Insight in the Laboratory

Insight can be studied under laboratory conditions. Researchers present participants with a problem, the solution to which resists the direct and effortless application of long-term memory knowledge. For example, neuroscience researchers use remote associate problems that consist of three words—e.g., 'blue', 'cottage' 'cake'—and participants' goal is to find a word that could be associated to each three to produce a meaningful combination (Kounios & Beeman, 2014). Participants who answer 'cheese' are then asked to indicate whether they experienced the solution as an insightful one (using Likert-scale ratings on dimensions such as suddenness, pleasantness) or as the product of an effortful analysis of the words and their possible connection. Insightful answers are more likely to be associated with neural activation in the right temporal lobe. Researchers attribute this hemispheric asymmetry to the right hemisphere's relatively coarser semantic coding, which results in broader more diffuse activation of semantic elements (Kounios & Beeman, 2014).

Other researchers have employed so-called 'insight' problems (Weisberg, 1995; Webb, Little, & Cropper, 2018). Such problems are designed to encourage a misleading initial interpretation. Take for example: How do you place 17 animals in four enclosures such that there is an odd number of animals in each enclosure? (Vallée-Tourangeau, Steffensen, Vallée-Tourangeau, & Sirota, 2016). The problem masquerades as a simple arithmetic one, and indeed participants initially engage in a fruitless search for four odd numbers that can add up to 17. Thus, the initial interpretation inexorably leads to an impasse: the state that insight problems are designed to produce. These problems offer a strategic window through which researchers can observe how the impasse is overcome and a breakthrough experienced. In the case of the 17 animals problem (see Figure 1), participants must shift the focus of their efforts and seek to exploit set overlaps, double counting at least one animal.

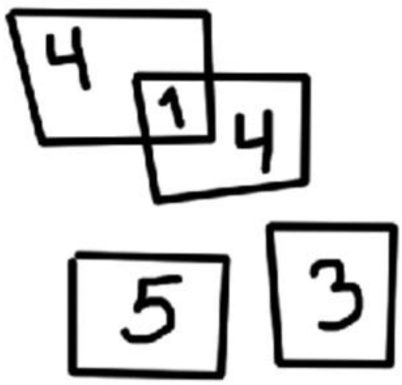

Figure 1. A possible solution to the 17 animals problem.

Insight coincides with a conceptual restructuring. Drawing from Gestalt ideas, Ohlsson (1992) proposed that representational change is achieved when the conceptual elements of a problem cohere in a new gestalt, from which the solution to the problem is more clearly anticipated in a participant’s mental look ahead horizon. Thus, in the 17 animals problem, representational restructuring involves casting overlapping sets as the key to the solution, and once this is achieved, the solution can be crafted. The question that animates psychologists at this juncture is what drives the experience of insight in such circumstances; in other words, how do people manage to restructure their representation of the problem so that they clearly appreciate the fruitlessness of their initial interpretation? What brings about a new more fruitful interpretation?

Different answers to these questions are proposed by competing perspectives. The special processes view (e.g., Ohlsson, 2018) casts restructuring in terms of unconscious semantic inferences. In turn, the business-as-usual view (e.g., Weisberg, 2018) proposes that restructuring is evidenced through the deliberate, conscious and effortful analysis of the problem elements. The main research strategy employed to adjudicate these proposals involves profiling participants in terms of their cognitive capacities, such as their working memory capacity. Working memory corresponds to a limited-capacity system and range of processes that support the temporary storage and conscious manipulation of information (Baddeley, 2012). Researchers then determine the degree of correlation between scores on these measures with performance on insight problems. If insight is the product of unconscious semantic inferences, then working memory capacity should explain little variance in problem solving performance. In turn, if insight is the product of deliberate analysis, then measures of working memory capacity should correlate strongly with performance. Recent evidence appears to endorse the business-as-usual camp (Chuderski & Jastrzębski, 2018), but the debate is far from resolved (DeCaro, 2018).

First-order Problem Solving and Interactivity

Let us pause and reflect on the research methodology employed by psychologists to measure insight and the cognitive processes that promote it. Laboratory work inevitably involves scaling down complex phenomena in terms of essential components amenable to operationalisation and experimental manipulation. Thus, laboratory participants are presented with a set of propositions that describe, ambiguously, some complex states of an abstract world. Problem solving, and hence insight is therefore also constrained to take place in this virtual world of an internal mind. No matter how dynamic the debate between the special processes and business-as-usual camps, the research methodology constrains the nature of the explanation for insight

Creative problem solving outside the psychologist’s laboratory proceeds in a very different manner and calls upon researchers to question their ontological assumptions and methodological prescriptions. Clearly, professional artists, designers, and engineers have a different occupational trajectory and a level of expertise that make them different them from the naïve participants in a psychologist’s experiment, working on a so-called knowledge-lean problem. More important, insight can be considered as an enacted phenomenon (e.g., Henok, Vallée-Tourangeau, & Vallée-Tourangeau, 2018), that is, it manifests through physical actions with and through the world within which a reasoning agent is embedded. Some problem-solving researchers have paid insufficient attention to the interactive nature of thinking, focusing rather on what has been termed second-order problem solving (Vallée-Tourangeau & March, 2019), that is problem solving that proceeds from abstract descriptions of states of the world and must inevitably involve changes in mental representations. In contrast, first-order problem solving proceeds through the active manipulation of a physical model of the problem. Take the 17 animals problem again. When participants are invited to solve the problem by building a physical model of a solution—using pipe cleaning pieces and animal figurines—they are more likely to derive a correct solution compared to participants who are asked to sketch a solution of the problem (Vallée-Tourangeau et al., 2016). Interactivity is an ontological substrate (Steffensen, 2017) from which new ideas arise. Casting insight as the product of first-order problem solving activity identifies a much broader range of important features of creativity and discovery and opens up the field of enquiry beyond the confines of the current debate in cognitive psychology. We limit our discussion here to eight features of first-order problem solving that have not been considered in current models of insight.

1. External Storage. Working with a physical model of a problem reduces the need to mentally represent the problem. The world is its own best model (to adapt Brooks, 1990) and there is no need to represent it, or to mentally manipulate these mental representations, or to rehearse and store these representations. The world is there to see and act upon. Expanding storage frees internal cognitive resources and reduces working memory burden (Vallée-Tourangeau et al., 2016; Vallée-Tourangeau & Vallée-Tourangeau, under review) resulting in more flexible reasoning.

2. Boundary Objects. Interim solutions, proto models and sketches are transactive memory objects (Fiore & Wiltshire, 2016) that bridge the past to future possibilities. Creative problem solving and the occurrence of an 'insight' occurs along a trajectory dotted with such boundary objects.

3. Unfolding and Undergoing. Problem solving is a transformative activity. The reasoner at time 1 is not the same reasoner at the time of the solution. He or she has been transformed by the proto-solutions formulated in the process of arriving at a satisfactory or correct solution. This process of transformation is shaped contingently by the intermediary steps to a solution. Insight reflects a transformation.

(Ingold, 2014; Glăveanu, Lubart, Bonnardel, Botella, de Biaisi, et al., 2013; Vallée-Tourangeau & Vallée-Tourangeau, 2014).

4. Serendipity. When thinking with and through the world, the construction and manipulation of a physical model of the problem can capitalize on felicitous but unplanned results. Serendipity plays a role for large and small discoveries (Copeland, 2017); so-called strong serendipity in science involves discovering something completely unexpected (Alcock, 2010). A weaker form of serendipity is observed in insight problem solving when the task environment supports the interaction between an agent and a physical model of the problem (e.g., Fioratou & Cowley, 2009) and fortuitous configurations can exert a significant influence on the problem-solving trajectory (Steffensen et al. 2016; Ross, forthcoming; Ross & Vallée-Tourangeau, 2019).

5. Moving Fast, Thinking Slow (Heteroscalarity). Processes operating at different time scales are involved when manipulating external representations in problem solving (Bocanegra, Poletiek, Ftitache, Clark, 2019). Action-perception loops operate quickly, triggered by the direct perception of an action affordance in the environment, and are not mediated by slower deliberative thinking. The resulting environmental changes may also facilitate more contemplative reflections, engaging different types of cognitive processes.

6. Executive Functions. If creative problem solving is a process driven by actions in the world then we must conceive of executive function (e.g., the allocation of attentional resources) and executive control (e.g., what information from long term memory to retrieve) as systemic processes (Vallée-Tourangeau, Abadie, & Vallée-Tourangeau, 2015; Vallée-Tourangeau & Vallée-Tourangeau, under review). The endogenous homuncular challenge of central executive functions in traditional models of working memory is reformulated by acknowledging distributed exogenous factors that come about through changes in the world; these changes guide and constrain the allocation of attention and the retrieval of long-term memory knowledge.

7. Gesturing Expands Thinking. Gesturing lightens the load on the speech-based memory store, by shifting some of the representational burden on a visuospatial store (Goldin-Meadow & Wagner, 2005). The linear constraints of a speech-based representational system do not characterize how information can be conveyed in gesturing. Gestures can also enhance creative problem solving by exploring the praxic potential of objects, unveiling additional action affordances (Kirk & Lewis, 2017).

8. Embodiment. From a general interactionist perspective, the body can be seen as a semiotic medium and modality through which understanding is distilled and communicated. Body positioning and movements are used by teachers and learners to communicate and understand concepts or varying complexity (Alač & Hutchins, 2004; Azevedo & Mann, 2018). To adapt Hall and Nemirovsky (2012, p. 208) bodies don't simply serve "to carry around a mind that processed mental content". Rather sense-making is more productively understood in terms of interacting embodied agents (Steffensen, 2017).

Enacting the Possible

Creative problem solving in the world encourages us to appreciate the co-constitutive forces that synchronously and recursively shape the problem solver and the environment in which he or she is embedded. Interactivity continuously reify a shifting topography of action affordances. As a result, the possible is woven dynamically through movement and exploration. Creative problem solving of the first order kind reveals as well as creates the protean nature of the possible. The possible is thus best appreciated in terms of a transactional logic.

The genesis of a new idea is likely shaped by a complex configuration of processes involving a great deal of interactivity among people and things. Psychological research has hitherto been constrained by a dual commitment to methodological individualism and neurocentrism (Vallée-Tourangeau & Vallée-Tourangeau, 2014). From this perspective, a new idea arises in a person's head and the cranial events that bring this idea about can be quantified and imaged. Neuroscientific measuring instruments work mostly with immobilized participants and so they reduce the problem-solving activity to one that depends exclusively upon internal resources—such as a remote associate problem illustrated earlier.

However, the radical scaling down of the processes responsible for the genesis of new ideas that is necessitated by these theoretical and methodological commitments decreases the likelihood that these research efforts can offer an explanation of creative breakthroughs in science, the arts or indeed any other cognitive activity that has a physical component. Case studies of innovation and discovery track much longer temporal trajectories than those explored under laboratory conditions and involve a degree of interaction with artefacts and people that is rich and complex. Findings such as the relative hemispheric asymmetry in insightful solutions to remote associate problems do not meaningfully inform how new ideas are formulated and developed in science (e.g., Darwin's efforts to formulate the theory of evolution in successively clearer forms through 1837-1838) or the arts (e.g., Picasso's intense period of preparatory work leading to *Les demoiselles d'Avignon*). A reasoner may toil for days or months (or even years) on an engineering problem or a work of art. This is not to say that scientists, scholars, or artists cannot be profiled along psychometric dimensions (such as working memory capacity or thinking dispositions), but a creative arc can be complex, interactive and contingent. The lean theoretical offerings from the current debate in the psychology of insight are sharply exposed when discovery is seen as a protracted process that concatenates hunches, observations and actions over time and space.

Systemic Thinking Model (SysTM). A shift away from methodological individualism calls for a re-conceptualisation of human information processing. The shift must allow for, rather than dismiss, the constitutive elements of first-order problem solving. It must guide the study of the transactional processes coupling people and artefacts in the enactment of insight. The systemic thinking model (SysTM; Vallée-Tourangeau et al., 2015; Vallée-Tourangeau & Vallée-Tourangeau, 2017) aims to address this gap. SysTM conceives thinking as a cognitive process that evolves in time and space and results in a new cognitive outcome. As such, it provides a conceptual framework to account for the emergence of new "cognitive possibles," surpassing what was likely or achievable, through the situated use of higher cognitive operations ranging from making inferences, to problem-solving and decision-making.

The model distinguishes between deductive and inductive cognitive processing and posits that behaviour can be induced from possible actions offered by the immediate environment as much as it can be deduced from mental processing. Second-order problem-solving has been exclusively modelled through deductive processing where reasoners are constrained to rely on a mental representation of a problem space (Newell, 1980). First-order problem-solving however, is not well modelled by deductive processing proceeding from a representation of the problem space and its mental exploration. To account for the emergence of solutions in a situated agent-environment ecosystem, we need to extend our conception of cognitive activity to encompass not only deductive but also inductive processing. Inductive processing takes place in situations where it is possible to act upon, and interact with, the elements of a problem space. Such interactive situations support the perception of possible micro-actions within one's environment or "micro-affordances" (Ellis & Tucker, 2000) that can be acted upon without being mediated by goal-oriented symbolic activity. Three-dimensional artefacts can be picked up, moved, rotated in physical space, rearranged in the world. When agents engage in these exploratory actions, they transform their perceptual input while preserving their cognitive resources. This inductive processing paves the way to insightful, but unpremeditated and serendipitous 'aha' moments. Altogether, SysTM provides a framework to support the study and develop our understanding of how cognitive events may arise from the coordination of mental and physical resources underpinning insightful problem-solving.

Much remains to be understood, however, in relation to the impact of micro-affordances on inductive processing and the mechanisms that underpin first-order creative cognition. There is increasing evidence suggesting that increasing interactivity and opportunities for inductive processing does elevate insightful performance (e.g., Fioratou & Cowley, 2009; Henok et al., 2018; Vallée-Tourangeau et al., 2016; Weller, Villejoubert, & Vallée-Tourangeau, 2011). For example, this has been established in complex probabilistic inference tasks: through the use of systematic video-based behavioural analyses, Vallée-Tourangeau et al. (2015, Experiment 4), demonstrated that reasoners who engaged in the most transformative actions were also more likely to make a correct Bayesian inference. Still, much remains to be understood about how this improvement is realised. Micro-affordances are largely studied in the context of motor-controlled actions (e.g., grasping) but little is known about how, when, and for whom they may support insight in particular, and cognitive performance more generally. More research is needed to identify how insight emanates from transactions between individual cognitive resources and environmental affordance properties along the spatio-temporal trajectory of thought.

Expanding the Realm of the Possible Through Insight: Methodological Reflections

Research efforts have offered interesting answers concerning the neural underpinnings of insight phenomenology, the role of a conceptual impasse as a triggering condition for unconscious representational restructuring processes, and the importance of cognitive capacities in the ability to solve so-called insight problems. These developments pertinently address what we have called second-order problem solving. They contribute to our psychological understanding how the impossible becomes possible in people's mind. Through second-order insight, people expand their cognitive reality, getting a sense that the realms of the possible are unbounded and amenable to expansion.

We contend, however, that creative cognition which the concept of insight might more meaningfully capture, is a first order problem solving *activity*. To better understand how people *make* the impossible possible, research should forefront interactivity and casts insight as a relational phenomenon. Methodologically this means designing problem solving tasks that allow participants to build and interact with physical models of the problem or the problem solution. Detailed qualitative coding of actions (e.g., Steffensen et al., 2016) and changes to the physical configuration of the problem can help better understand how the eight features of first-order problem solving outlined earlier contribute to the discovery of a new idea that results in the solution to a problem. Designing interactive problem-solving task environments is the best way to escape the Procrustean trap of methodological individualism. To cast insight as a relational phenomenon also encourages observing groups of reasoners as they labour to develop new ideas and solve problems (Fiore & Wiltshire, 2016). Steffensen (2017) offers an interesting example of problem solving in the wild and how insight is distilled through the language and actions of two interacting protagonists. Foregrounding interactivity thus also mean investing research capital in observing how insight emerges in dyadic collaborative problem-solving activity. The importance of the deep connection between people and the rich world within which they are situated for understanding insight also has implications for researchers of the possible more generally: in all likelihood, and perhaps paradoxically, what people find conceivable, imaginable or thinkable might be better understood at the point of contact between the mind, the hands, and the world. The possible is not just an intellectual concept, future research on the possible would benefit from expanding its scope to include the study of perceived affordances, that is the role played by the perception *possible* actions played in what people deem possible.

Conclusion

We opened this entry with some reflections on the etymology of the word ‘insight’, noting the tension between ‘inner’ and ‘sight’ and the relation with “new possibles”. When research focuses on the narrow neuro-temporal signature of insight in second-order problem solving, it seems appropriate to characterize insight as a mental phenomenon, as an inner state of mind. However, when creative problem solving is assessed from an interactivist perspective, the origins of the new possible seem to be in the world, that is based on the perception of changes in the world. Creative problem solving is synonymous with changes in the world—changes to a sketch, a manuscript, a sculpture, a prototype. These changes may reflect the implementation of a plan, but they may also be brought about or brought through actions that were not premeditated; the changes may also be entirely serendipitous in nature. A hyphen might be more appropriate in this instance, ‘in’-‘sight’ rather than ‘insight’, to better capture this perceptual dimension of creative problem solving and underscore the importance of enacting and tracking changes in the world in the genesis of new ideas. We recently conjectured (Vallée-Tourangeau & March, 2019) that new ideas are perceived rather than cogitated, and in that case, creativity and the genesis of new possibles might be better captured with the term ‘outsight’.

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