From Intuition to Insight

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Intuition

The word intuition has a certain glow to it, something luring and secretive, as if just taking it in one's mouth would suffice to undergo it. Most people would like to be intuitive, if the word is taken in the sense of being in the position to gain knowledge in a direct and immediate way. Calling a person intuitive suggests that he or she has a capacity to see things that are not apparent and to look right into the heart of matters. It reminds of having insight in the etymological sense of the word.

Intuition is often defined as a direct way of gaining knowledge that does not rely on discursive processes. This means that it is not related to reasoning with concepts, making inferences, or drawing conclusions. Sometimes it is added that in intuitive knowledge the object is given as a whole, as an unanalysed unity. In latin, *intueri* means to behold or observe. The assumption that intuition is a way of gaining perceptual knowledge is a very likely one, although it is hard to say what its object then would be.

The Swedish philosopher Hans Larsson maintained that intuition consists in the ability to grasp several conceptions at once, and thereby put together a number of formerly unrelated ideas.[1] In intuition, he held, the subject is capable of directly grasping how the different ideas are related.

Sometimes intuition is mentioned in connection with *creativity*. It has been suggested that intuition prepares for creativity. Creativity is, in my view, a process that helps you deal with problems that you do not have a clue as to how to solve.[2] A creative person provides solutions to formerly intractable problems. Creative solutions often come suddenly and unexpectedly to the problem-solver. To hold that the breakthrough has been prepared for by intuition fits with the conception of intuition as a to a great extent unconscious process that leads to a sudden realisation, what we call an *insight*, of how to solve the problem at hand.

When I compare creativity to problem solving, I use the word "problem" in its everyday sense. It involves an intitial state in which the problem is identified, a goal state in which it is solved, and a set of processes that take you from the one state to another. Any number of states inbetween the first and the last one may be involved, depending on the complexity of the problem.

Seen as a cognitive activity, creativity involves much the same elements as problem solving, that is, knowledge representations, constraints and rules for

manipulating them, standards for evaluating solutions, and a halting rule that puts an end to the search.[3] Note that the information that the representations carry not necessarily has to be linguistic or rely on either conventional or arbitrary methods of representation.

Problems arise when knowledge is incoherent or insufficient, in the sense that there is a clash between or a lacuna among the set of representations supposed to cover a certain area. Anything can be a problem (as you might have experienced in daily life)—how not to make those puffy pancakes too heavy or doughy, how to graft fruit in the absence of the right material, how to build a hut for your kids in the woods, how to account for the origin of earth ... The elements involved in creativity, however, have a different character as compared to in normal problem solving, because creativity is an open-ended process. The parameters, the problem definition, the steps between different states, the end state, and so on, are diffuse and difficult to define. It is not clear which options are open to the subject in order to solve the problem.

Therefor, creative problem solving is heuristic, not algorithmic. That means that it is not guaranteed to lead to a solution, and that it makes use of so-called rules of thumb, instead of deductive ones, to direct the search. This property creativity has in common with intuition. There are no explicit rules for how to intuit a truth. On the contrary, much of what goes on in intuition and that leads to insight seems to be out of reach of the subject.

Some people have tried to systematize the creative process, for instance, by dividing it into phases. A popular categorisation was provided by Graham Wallas, who based his theory on autobiographical studies.[4] Since, this categorisation has been affirmed by several scientists and artists.[5] Wallas maintained that creativity has four phases: preparation, when you learn about the problem, incubation, when your knowledge, as it were, matures within you while you just let it rest, inspiration or illumination, when you find the solution, and finally, verification, when you look for proof and evidence for the solution. The different stages can overlap and may re-occur during the process of solving a single problem.

The stage that is the most interesting in relation to intuition apparently is the second one, *incubation*, since this is what directly leads to insight, that is, illumination. It has been debated whether something at all happens during this period, and if so, what is going on. It is, of course, difficult to test. The most parsimonious interpretation is that nothing happens until the moment when the subject comes up with the solution. If any calculations are made, they occur at that very moment.

Another interpretation is that during incubation, the subject will forget faulty or some of the less important information surrounding the problem. Inconsistent and incoherent ideas that disturb the problem-solving process may be suppressed or forgotten. That will make it easier for the subject to put to-

gether the remaining material and thus come up with an appropriate solution.

Yet another possibility is that during incubation, unconscious processes operate on the material until a solution is found. Once a solution is retrieved, the subject will become aware of it, and accordingly has an insight. This means that intuitive solutions are created from memory.

In science, an insight constitutes a kind of discovery, that stands in need of justification. If the processes that lead to insight cannot be accounted for, or if it is assumed that insight does not rely on any specific processes at all, but only on timing or sheer luck, or perhaps on processes that run independently of the subject, this kind of discovery will in many cases be considered irrational.[6] Justification will then constitute the rational part of science.

If one, however, denies that discovery and justification belong to different contexts, then, although discovery is considered non-rational, the rational process of justification will lend some of its lucidness and logic to discovery. Whether it is acceptable or not that such an important part of science as discovery should be considered irrational is debated. It seems that for many people it is less problematic to say that artistic than scientific works are the results of irrational processes. But if the creative process that lies behind science and art is similar, as I believe, then irrationality cannot simply be transferred to art.

In this article, I will discuss two suggestions as to which the processes that occur during incubation might be. They have in common that they state that intuition depends on memory and that it is not a conscious process. The first one stresses the use of mental images, or perceptual representations, in creativity and intuition. The hypothesis is that insight results from operations on such images as stored in memory. The second one maintains that insight results from retrieval. During incubation, the material that has been gathered about the problem during the preparation phase lies waiting until a cue appears that will trigger the appropriate solution.

Before I bring up these opposing views, I want to call attention to the roles of contextual as well context-independent information about the subject matter in creativity. The two kinds of information are behind two distinct routes to creativity.

Contextual and context-independent information

In saying that inuition is an unconscious process, I mean that it is something of which we are not aware and thus, of course, something that we do not verbalise as it goes on. We may be able to influence the process indirectly by, for instance, preparing ourselves for solving a certain task, not engaging in interferring activities while waiting for an insight, and so on.

There are other processes than intuition that involve knowledge that are in

a similar way not open to introspection or supervised by the subject. Take, for instance, activities that are achieved by having recourse to so-called *know how*, like cooking, performing experiments in the lab, or playing tennis. Gilbert Ryle described know how as competence regarding the performance of operations.[7] To know how is to perform an operation or task well. Intelligent performance does not necessarily involve reflection. It suffices to execute the action in a sucessful way. This depends on being able to apply rules as a product of practise and also on being able to modify the rules if one learns that they do not work or are not well-adapted to their purpose.

Knowledge of how to do things, like riding the bike, kneading dough, or mixing chemicals, depend on memorizing patterns of motoractivity. It is a skill of the body that can be exercised while we focus our attention on other tasks, like the outline of our next book or different sorts of recipes. We do not have to attend to what we are doing to trigger bodily skills—we can grab the bike and start cycling while simultaneously reflecting about the black holes of the universe. A great deal of professional knowledge consists in having access to this kind of memorized motorpatterns. It is an embodied memory that partly runs itself.

Recently, it has been suggested that intuitive thinking and even creativity is related to know how by the way it works. Intuition depends in a similar way as do know how on mental representations that are not predominantly linguistic or arbitrary, but primarily iconic. They have a structural similarity to what they represent and function as guides to action during specific environmental conditions. In this sense, memory is more or less tuned to the body of the agent.

Memory constitutes an integral part of an account of intuition. Intuition is not sheer guess-work or luck, but a *skill*. It depends on having the right sort of knowledge that will allow one to excercise this skill. The preparation stage described by Wallas is crucial to intuition. It makes sure that the subject learns the skill, both by practising actions and gaining theoretical knowledge.

Nevertheless, completely situation-determined behaviour can take you a long way, as demonstrated by mobots having a so-called subsumption architecture.[8] These systems do not rely on the manipulation of symbolic or static representations to achieve goals, and there is no central control. The systems are reactive and massively parallel, and do not plan ahead by way of an objective world-model, but continuously update the information they have about the surroundings and act on that. They consist of distinct subsystems that cannot communicate, but can subsume each others activity, as the mobot moves around in a changing environment, trying to cope with its task.

But the behaviour of these mobots is determined by the immediate context they are set in. They cannot rise above the given to produce an unexpected or unpredicted solution to a problem. An understanding of the inferential and se-

mantic relations between representations or concepts is necessary for solving many problems, as is a general understanding of causal relations, and more particularly of the causal relations between different segments of actions or series of actions. These kinds of knowledge depend on having concepts with a more or less stable basis over time in order that they are kept in mind, and on establishing a network of such concepts. Generalisation, long-term memory, adaptation to future expectations, transfer of expertise, etc., are competences needed for creativity that are under conceptual, and not perceptual and contextual, control.[9]

Still, this does not mean that intuition relies entirely on context-independent representations. It has to be connected to the environment and the particular problem that lies before the subject. Intuition does not consist in free association. On the contrary, there is a certain direction to it. It is locked to a target, aimed at solving a difficulty that is of immediate concern to the subject. Thus, the solution will be a result of an interplay between contextual and context-independent information.[10]

How should the memory involved in intuition be described? The view that is connected with the advocation of *embodied cognition*, that is, cognition that depends on the body and the environment of the subject, describes memory in predominantly functional terms. Its function is to guide action, and it does so by storing information in a subject-relative fashion. This view highlights the non-conceptual or informational properties of mental representations. The symbols that are stored in memory are iconic or schematic, as described above. Consequently, they are referent-dependent, since they only succeed in carrying a content if they reflect some of the properties of the referent by sharing a certain form with it, a form that emulates the function of the referent.

The symbols are also dependent on the environment and on the subject's physical and perceptual apparatus. The dependence can take different forms. The content will depend on the kind of interaction that is going on between the referent and the subject and on the function that the referent has acquired in that interaction. These factors depend, in turn, on the physical and mental make-up of the subject. And all the factors mentioned depend on in which environment the interaction is set, for developmental and evolutionary reasons alike.[11]

Theories about embodied cognition usually ground concepts in perception instead of in language. Arthur Glenberg suggests that conceptualisation of perceptual information consists in an encoding of a particular subject's possible physical interaction with the world.[12] Concepts are interrelated by combining in different patterns of action. Conceptualisation is, according to Glenberg, a mesh of spatio-functional properties projectable from the context of action and the environment with patterns of interaction from memory.

If you want to find your way through the woods, and you are looking for a path home, your, mostly tacit, knowledge of your own capacity to find your way over rocks and through shrubbery towards the goal together with continuous information from the environment will help you deal with this task. Meshed patterns of action are always constrained by how your body deals with action. Glenberg maintains that such patterns of action produce emergent and creative features of thought, and that consequently at least some aspects of creativity depend on the analogue nature of embodied actions, and not only on conceptual or propositional content.

Above, I pointed out that context-independent information is necessary for creativity. It should be possible to transfer content, or conceptions, from one setting and one type of interaction to another. The question is how the requirement for context-independence can be matched with an account of embodied memory, like Glenberg's. Creativity, considered as a skill, and also as partly relying on theoretical knowledge, cannot just be a contextually emergent phenomenon linked to specific patterns of action. Emergence as such is, as opposed to creativity, sooner connected to chance or luck than to competence.

Creativity depends on being able to detach oneself and one's conceptions from the actual context. This is possible with *iconic* representations. They are referent-dependent, but they do not depend on that the referent is present in the same context, or at the same location and time, as the subject. The dependence consists in that the representation refers to (or is about) a certain entity by being similar to it, most probably, by sharing sharing form or structure with it. The theory presented in the next section makes use of such representations.

Operations on mental images

Lawrence Barsalou has in a series of articles advanced a theory of perceptual symbols designed to replace common theories of meaning as in thought and language.[13] He describes these perceptual symbols as extractions of information from particular perceptual states. For instance, a perception of a chair can give rise to a schematic representation of its shape if the subject has attended to the shape of the object. The perceptual symbols consist in configurations of neurons in the brain and are multimodal. They are continuously updated and transformed whenever new relevant information about the referent or referents belonging to the same category is encountered. Importantly, Barsalou holds that the perceptual symbols never are holistic, but they are structured, containing components and relations between these, and also nested substructures.

In an article on creativity, Barsalou and Jesse Prinz describe how opera-

tions on perceptual symbols, or mental images, can give rise to creativity and thus also to intuitive knowledge.[14] Barsalou and Prinz describe these operations as of two kinds. The first consists in *constructing complex representations* (I will call this "construction", for short) from simple ones in a productive manner. Productivity means in this context that "a finite set of representations can produce an indefinitely large number of structures through combinatorial and recursive mechanisms".[15] As compared to the reductive formation of perceptual symbols, productivity is a kind of systematic adding back of information to a symbol. But productivity does not only rely on filling in information, but also on replacement, transformation, and deletion of structure in a symbol.

The second operation on perceptual symbols is so-called *propositional construal*. That means that perceptual symbols can describe a perceived situation in many different ways by highlighting certain aspects of it rather than others, and that one aspect of the situation can be construed in several different manners. Both construction and propositional construal depends on mapping symbols into each other according to spatial schemata.

Barsalou and Prinz finally maintain that since perceptual symbols vary with their embodiment, that is, that the same symbol implemented in different beings may function differently, *variable embodiment* as well gives rise to creativity. Barsalou and Prinz have in mind a kind of adaptive creativity that allows for the individual to function appropriately in particular settings or environments. Roughly, adaptation consists in the capacity to change in order to fit into a new situation. It is a kind of specialisation, that actually runs counter to the usual conception that we have of creativity as generalisation, or an ability to transcend specific contexts. The notion of variable embodiment does not really harmonise with the present discussion, since it makes creativity a property unrelated to individual minds and intentions.

Barsalou and Prinz are careful to point out that they intend to describe mundane, as opposed to genuine, creativity. By *mundane creativity*, they mean a kind of creativity that graces all normally functioning human beings. It consists in producing novel cognitions and behaviour. Since everybody does it, it does not qualify as exceptional creativity, but is a precondition for it.

A first question that arises in connection to Barsalou's and Prinz' theory is why we are entitled to call construction and propositional construal creative. Barsalou and Prinz mean that construction and propositional construal are creative because they are the operations that make it possible to construe the same perceived state of affairs in an indefinite number of ways. The results are a function of what the subject "chooses" to describe or to what she directs her attention and in what fashion she does so.

Mundane creativity has an affinity to so-called *linguistic creativity*. The latter consists in the ability to produce an infinite number of new expressions

from a given set of atomic expressions by the use of recursive rules. It allows us to produce as well as understand sentences that we have never encountered before. But I think that the similarity is of a superficial kind, and that it actually is the difference between linguistic and mundane creativity that is of interest as regards creativity.

It seems to me that Barsalou and Prinz misconceive the relation between the two kinds of creativity. Linguistic creativity is not creative, in the normal sense of the word. That a product (or result) is creative usually means that it is achieved in a way that was not lined out from the start and that the product was not foreseeable. If creativity obeys rules, these rules do not lie open to us. If they had been known, we would just be able to follow them and be unceasingly creative. This is, hélas, not the case. On the contrary, creativity is notoriously difficult to explain or understand and even to achieve.

The manner of thinking that is involved in construction and propositional construal, on the other hand, seems to be genuinely creative. The reason is that it does not follow the same kind of rules as those posited to explain linguistic creativity. A preferable name for the latter ability would be *semantic competence*. Semantic competence consists according to the received view of having access to a finite set of rules and principles that allow speakers to derive the interpretation of complex expressions from atomic ones. There are definite and predictable patterns among expressions. Semantic competence relies on given rules that are applied mechanically without regard to the context or environment, as in a calculus.

The *mapping* between domains or perceptual symbols that Barsalou and Prinz bring up does not work according to such rules as account for semantic competence. The mechanisms behind mapping are context-dependent, and also depend on the current activity of the subject. They are as well open-ended and dynamic. Mapping occurs in many kinds of thinking and acting, namely in situations that predominantly make use of perceptual symbols. Especially metaphorical mapping can produce novel and surprising results that are not derivable from a prior set of rules or constraints.

It seems that in fact mundane creativity is genuine as far as the operations on perceptual symbols go. The only likeness between it and semantic competence is that both are in a very loose sense productive, meaning that some representations can give rise to other representations. The new representations are when accounted for by semantic competence predictable, when explained by mundane creativity not so.[16]

But Barsalou's and Prinz' theory raises another problem for creativity, having to do with the character of the symbols. Barsalou and Prinz focus on perception. They maintain that meaning is perceptually grounded. But it is not clear how perceptual symbols can acquire the context-independence necessary for creativity and intuitive insight.

To Barsalou, a concept is a sort of simulator that contains the knowledge that allows a subject to represent an entity or event adequately.[17] It is used to identify members of a category and provides categorical inferences about their structure, history and behaviour, and suggests ways of interacting with them. Thus, perception is first parsed into schematic components and form perceptual symbols. These components are integrated across instances into frames, from which simulators develop that represent types of entities. From the frames, new simulators can be created in appropriate settings.

Still, the instantiations of simulators are always evoked by and tuned to the context. How could they then support context-independent thought? The capacity to entertain representations that are not dependent on the actual context, and that can be associated with and subsequently moved between any (non-present) contexts does seem integral to creativity.

If we take Barsalou's and Prinz' line, the subject's ability to envision new scenarios becomes highly important as well as her ability to shift contents between scenarios to work out a creative solution. Since the simulators themselves are context-dependent, the subject will only have access to representations that are detached from the actual context if she can invent or create new contexts, for instance, by make-believe. But then we have lost touch with the initial question of what happens during incubation and that leads to insight. That process, we supposed, was not conscious or voluntary.

It appears that to explain creativity with the help of Barsalou's theory about the combination of perceptual symbols, we cannot only make do with the the perceptual symbols that he suggests. Combinatorial mappings do not suffice to give us creative products, unless we move from embodied and context-dependent representations to detached ones. Of how to make this move, I am not yet sure.[18]

Memory processes

An attempt to account for what is going on before one has an insight has been given by Pat Langley and Randolph Jones.[19] They give a computational model of scientific insight, and conceive of insight as a memory-related phenomenon that depends on mechanisms of *indexing* and *retrieval* and on *reasoning by analogy*. As they see it, nothing happens during incubation. Analogies are first cued by external events or perhaps internally generated in free association or dreaming, and then formed during illumination in a rapid spreading activation process.[20]

During the preparation phase, concepts depicting some entity or event that the subject has gained information about are indexed behaviorally before they are stored in memory. This means that the indices describe the processes that the perceived entities or events are involved in. An example is a situation in

which we have two containers with different levels of liquid. When connected by a pipe, the liquid will start flowing between them until a similar level is reached. This situation may be indexed "equilibrium".

Concepts are connected in memory as in a network or semantic field. Memory consists of nodes connected by labeled links. Some nodes correspond to general concepts like water. They can, for instance, be activated by interaction with the environment. Links between concepts that have been activated often are stronger than others. This means that they will react easier on incoming information than other ones.

The more attention given to a problem in the preparation stage, the greater is the number of ways in which it will be indexed and the more firmly the links will be established. This is why experts have more insights concerning the field they specialise in than non-experts do. Experts are also better at indexing new entities discovered in their field.

When the subject indexes a new situation, a spreading activation process starts. If the index is retrieved, meaning that the subject has encountered a similar situation before, an existing schema, consisting of a set of connected concepts, will be activated.

Langley and Jones point out that this accounts for insights like Archimedes' in which new knowledge becomes a source of the analogy. But it does not account for insights that rely on knowledge that already is stored. In those cases, we have to assume that the cue retrieves an existing, but forgotten schema, instead of using a new one derived from the actual context, that will enter into an analogical relationship with the schema the subject currently is working on.

To sum up the theory, illumination consists in mapping from a source structure stored in long term memory by a recognition process to a target structure. The conscious part of insight comes with the elaboration of the retrieved analogy and with evaluation. Indexing and retreival are both unconscious and do not involve attention. Langley and Jones are careful to deny that unconscious reasoning occurs. In their account, creativity depends on having access to a conceptual structure or a means of categorising that is stable. Humans construct knowledge structures that enable creativity to flourish. The first stages involved in creativity, indexing and retrieval, are automatic in the sense that they do not involve any deliberate activity on behalf of the subject.

There are several differences between Langley's and Jones' view and the one advocated by Barsalou et al. The ones that I find most interesting in this particular context are first, that the theory involves context-independent representations, second, that the processes that lie behind insight and analogy do not require the attention of the subject, and third, that nothing happens during incubation.

I brought up the need for context-independent representations to explain creativity in the last section. As I see it, it is an advantage of Langley's and Jones' theory that it makes use of such representations. It should be noted, however, that a similar mechanism could be used to account for creativity with the help of Barsalou's theory. Barsalou suggests that a linguistic symbol is a schematic memory of a perceived spoken or written expression, and that word simulators can index and control concept simulators. One could then, in line with Langley and Jones, hold that creativity depends only on word simulators and not on perceptual symbols. This would of course be the opposite of what Barsalou himself maintains. He places creativity on the perceptual level.

Langley and Jones deny that *attention* is relevant for indexing and for retrieval of analogies. I find this hard to believe. In their view, it seems that the conceptual network carries a heavy load and somehow by itself will find the right analogies. One thing that tells against that is, for instance, that attention is required both to index entities and to pick up cues.[21] Perception requires an active subject that searches for information and interacts with the environment. It is not passive or reactive. Perception also depends on both internal and external states of the subject in the actual context, like motion, orientation, emotion, discrimination biases, etc.

Furthermore, I believe that a subject working on a certain problem has a special *preparedness* for detecting certain kinds of similarities during incubation. Langley and Jones might try to explain this by referring to how the links between concepts become strengthened during preparation. But this preparedness would also be reflected during incubation, that is, on the path to insight. The preparedness would not, as I see it, only reside in the links between nodes, but also in the perception of (possible) cues.

Finally, it seems that to be able to profit from contextual information, a subject does not only need normal automatic discrimination and categorisation processes, but also voluntarily controlled attention processes. John Flowers and Calvin Garbin assert that a subject with both of these capacities would exhibit less interference from a harmful context, while still maintaining benefits from a helpful one.[22] The interaction going on between subject and context does not, I believe, receive enough attention by Langley and Jones. Flowers and Garbin emphasise that perception in creative thinking is influenced by automatic as well as executively controlled processing, the latter comprising spatial selective attention, manipulation of mental images, controlled cross-modal representation, and spontaneously generated mental constructions.

This leads over to the statement that incubation just is a waiting-phase. This contention has the advantage of being parsimonious, but that does not make it more plausible *per se*. I believe that during incubation, strategies based on different kinds of attention are very important. This means that perceptual processes are predominant during that phase. But these processes

should not only operate on contextual representations, but also on context-independent ones.

The conclusion is similar to the one drawn from the discussion in the last section. It remains to explain how stable concepts are related to perceptual symbols, and how unconscious processes relate to voluntary and conscious ones. It is also important to understand how unconscious processes that nevertheless require attention are connected to conscious and voluntary strategies in the search for analogies.

Concluding remarks

It seems that incubation involves more than just waiting for the right cue to turn up. It clearly depends on memory and also on unconscious processes that include indexing and retrieval, as well as such that involve operations on images or perceptual representations. Among the latter we find shifts in modalities and perspective in the representation of a complete situation, and superimposition of images of different situations.

For incubation to lead to illumination, the subject should be active during it, or the chance that appropriate cues will show up is very small. She also has to be prepared for the right cue, a state that depends on the first stage of preparation and gathering of information. More or less successful cues will cause changes in the way she perceives and represents the situation, that is, among the data that she has been gathering.

In the end, a picture of how to deal with the situation or problem will surface and result in an insight. All this means that reconstruction and recreation of memories play an important role to intuition, both during incubation and in recall. Intuition is a process that ends in insight.

Notes

1. Larsson, Hans, *Intuition.* Dialoger: Stockholm (1892/1997) p. 16 and p. 21.
2. This view is rather common within cognitive science and cognitive psychology. See e.g. Garnham, A. & Oakhill, J., *Thinking and Reasoning.* Blackwell: Oxford (1994).
3. The rules that are used in manipulating knowledge-representations in order to reach a creative solution to a problem are of a certain kind. I distinguish between two kinds of rule: intra-representational and inter-representational. The former kind covers *transformations* of knowledge-representations that concern form, modality, and organization, while the latter pertains to *transfers* of content or structure between representations. Such transfers are based on similarity judgements. See "The Gist of Creativity", in *The Complexity of Creativity*, Andersson, Å. E. & Sahlin, N.-E. (eds.), Kluwer Academic Publishers: Dordrecht (1997). Note that the concept of manipulation should not be taken in a literal sense here. The subject does not normally operate directly on the representations that reflect a certain problem. In many cases, solutions depend on cognitive processes that are outside the reach of the subject. It is nevertheless possible to train people to become more successful in problem solving, by, e.g., formulating the problem in a certain way, using particular step-wise rules of thought, or using mental imagery.

4. Wallas, G., *The Art of Thought*. Cape: London (1926).
5. Although the second stage, incubation, seems to lack definite experimental evidence.
6. For instance, Karl Popper and Paul Feyerabend have maintained that discovery is a non-rational process.
7. *The Concept of Mind*. Hutchinson: London (1949).
8. Brooks, R., "Intelligence without Reason", in *Proceedings of the 12th International Joint Conference on Artificial Intelligence* (1991), pp. 569–595.
9. Cf. Kirsh, David, "Today the Earwig, Tomorrow Man?" *Artificial Intelligence*, Vol. 47 (1991), pp. 161–184.
10. I describe the interaction between context and context-independent representations in creativity in "Procedures and Strategies: Context-Dependence in Creativity". Creativity involves both procedural and strategic elements; it relies both on know how and on reflection. Ryle wrote: "The combination of the two assumptions that theorizing is the primary activity of minds and that theorizing is intrinsically a private, silent, or internal operation remains one of the main supports of the dogma of the ghost in the machine" (*The Concept of Mind*, p. 28). It also remains one of the main dogmas in our conception of creativity.
11. See e.g. Glenberg, A., "What Memory Is For", *Behavioral and Brain Sciences*, Vol. 20:1 (March 1997), pp. 1–19; Barsalou, L., "Perceptual Symbol Systems", *Behavioral and Brain Sciences* (1999).
12. "What Memory Is For".
13. Barsalou, L., "Flexibility, Structure, and Linguistic Vagary in Concepts: Manifestations of A Compositional System of Perceptual Symbols", in Collins, Gathercole & Conway (eds.) *Theories of Memories*. Erlbaum: London (1993); Barsalou, L., "Perceptual Symbol Systems"; Goldstone, R. & Barsalou, L., "Reuniting Perception and Conception", *Cognition, 65* (1998), pp. 231–262.
14. "Mundane Creativity in Perceptual Symbol Systems", in Ward, Smith & Vaid (eds.), *Creative Thought: An Investigation of Conceptual structures and Processes*. American Psychological Association: Washinton, DC. (1997), pp. 267–307
15. Ibid. p. 268.
16. I should mention that Barsalou and Prinz hold that perception grounds language, and that natural language functions in a similar way as does perception. Therefor, they would not accept the rather strict definition of semantic competence given above. I do not agree with Barsalou and Prinz on this, but believe that although perception underlies language, there are differences having to do both with the social character of language and its having a partly different neural basis than perception that give rise to structural dissimilarities between the two.
17. "Perceptual Symbol Systems".
18. The concept of simulation, or so-called off-line running of mental imagery, is popular these days to explain not only contextual, but also context-independent, conditional and counterfactual thought, as well as planning and creativity. For instance, Rick Grush has recently suggested that imagery, perception, and representation are operations of a neurally implemented emulator (internal model) of a subject's body and environment. When the emulator is run off-line it produces mental imagery, while when on-line it processes information from sensory systems, resulting in perception. See, e.g., Grush, R., "Perception, Imagery, and the Sensorimotor Loop", in *A Consciousness Reader*, (eds.) Esken & Heckmann Schoeningh Verlag (to appear). The evidence for the brain having a kind of internal model (or several simultaneous maps) of the subject itself and its environment seems overwhelming. But the concept of simulation or emulation does not, I think, succeed in bridging the gap between what goes on in our brain on a neural level and in our minds on a conceptual level. The concept of simulation might, I am afraid, black out the process instead of enlighten it.
19. "A Computational Model of Scientific Insight", in Sternberg (ed.), *The Nature of Creativity*. Cambridge UP: Cambridge (1988).
20. J. R. Anderson used the notion of spreading activation to explain human fact retrieval. See e.g. *The Architecture of Cognition*. Harvard UP: Cambridge, Ma. (1983). The over-all model could with some modifications be used to describe an analogous process in neural networks, although it originally was designed for symbolic and rule-based systems.

21. Conscious or intentional attention as in attention-focusing can be distinguished from attention attraction. The latter does not require that the subject purposively takes a certain attitude to the object of attention or explicity categorises it, but may still involve a phenomenal state of awareness of the object.
22. "Creativity and Perception", in *Handbook of Creativity,* Glover, J. A., Ronning, R. R. & Reynolds C. R. (eds.). Plenum Press: New York and London (1989).

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