Creativity and Surprise


Luis Macedo
University of Coimbra


Amílcar Cardoso
University of Coimbra

Creativity and Surprise

Luís Macedo (lmacedo@sun.isec.pt)
Instituto Superior de Engenharia de Coimbra/
CISUC-Centro de Informática e Sistemas da Universidade de Coimbra,
Quinta da Nora
3030 Coimbra - PORTUGAL

Amílcar Cardoso (amilcar@dei.uc.pt)
Departamento de Engenharia Informática
CISUC-Centro de Informática e Sistemas da Universidade de Coimbra; Pinhal de Marrocos
3030 Coimbra - PORTUGAL

Creativity and Surprise

Abstract

This paper describes a computational model for creativity in which surprise plays a central role. There is no doubt that creative products, being unexpected and unpredictable products, cause surprise. In order to make those products surprising and supported by recent evidences from neuroscience, which say emotions are biasing devices in decision-making, we defend that decisions made during the creative process may be, consciously or unconsciously, to some extent, surprise-guided. Moreover, when evaluating a product in what concerns to its creativity, the degree of surprise that product causes is certainly one part of that evaluation. We illustrate with examples the role played by surprise both in the production of creative products and in the evaluation of already existing creative products.

1 Introduction

Roughly speaking, agents accept percepts from the environment and generate actions. Selecting the “right” action is critical, because their performance depends heavily on that. This is one of the main concerns of Decision Theory. Resulting from the combination of Utility Theory and Probability Theory (Shafer & Pearl, 1990; Russel & Norvig, 1995), Decision-making provides artificial agents with processes to make “right” decisions. One example of those processes may be briefly described as follows: given a set o possible actions that the agent may take, the agent computes their possible results as well as the probabilities of these results and then it selects the action that maximizes a mathematical function, called Utility Function, which models its preferences (its behaviour).

In order to accomplish the task of building artificial agents that act and think like humans (Russel & Norvig, 1995), in addition to other human features, such an artificial intelligent agent should be able both to produce and to evaluate creative products.

A creative product has been usually defined as comprising originality (usually defined as the unexpected novelty) and appropriateness (defined as usefulness, aesthetic value, rightness, etc.). Considering that the basic definition of surprise says "to encounter suddenly or unexpectedly"; "to cause to feel wonder, astonishment, or amazement, as at something unanticipated", there seems to be no doubt that those creative products cause emotional states of surprise in their viewers (Boden, 1992; 1995). In other words, something unpredictable, unanticipated or unexpected causes surprise. There is no doubt that both creative artistic products and creative scientific products are surprising. In order to make something surprising, the sequence of steps taken to build it should be guided by surprise. Actually, during the process of composing a music piece, painting, or writing a story, the author, consciously or unconsciously, keep in mind that the product should be unexpected, somehow unpredictable for the others and possibly to himself. Therefore, surprise seems to play an important role both in the process of producing and in the process of evaluating a creative product.

Moreover, recent research in Neuroscience has provided evidence indicating that emotions, and hence surprise, play an important role in abilities and mechanisms usually associated with rational and intelligent behaviour such as creativity (Damásio, 1994; LeDoux, 1996; Adolphs, 1996). For instance, results from recent studies of patients with lesions of the prefrontal cortex suggest an important role of emotions in decision-making (Damásio, 1994; Bechara et al., 1997; Curchland, 1996). These patients are unable to make good decisions. Nonetheless, according to Damásio's experiments, pure cognitive abilities such as the ones measured by the traditional I.Q. rating remained unchanged. Moreover, all those patients shared another common feature: they had a strong impairment on their emotional assessment of situation. It is worth noticing that those patients have less creative abilities after the lesion.

Although research in Artificial Intelligence has almost ignored this significant role of emotions on reasoning, several models for emotions have been proposed in the past years (for a detailed review see Picard, 1997; Pfeifer, 1998; Hudlicka & Fellous, 1996). Particularly in what concerns specifically to surprise, Peters (1998) and Ortony & Partridge (1987) have addressed the issue in their works. Although arguing that there is much more to surprisingness than expectation failure, Ortony & Partridge defend that those concepts are closely related.

In this paper we address the issue of computationally modelling the role of surprise emotion in creative reasoning / creative decision-making and creativity evaluation. It is worth noticing that the subjacent concept of creativity taken is the combination theory of creativity: creativity consists of combining previously uncombined things. Besides, within this paper we consider creativity as the result of a sequence of steps (decisions) partially guided by surprise emotion. Models of creativity such as those proposed by Wallas (1926), Dewey (1910), Guilford (1968), etc., are the background of our model (Macedo et al., 1997; 1998). Supported by the idea that humans are surprised when they perceive something that they do not expect, we propose an approximate mathematical function for surprise. This function is based on another mathematical function that measures the degree of not expecting an event (product). Relying heavily on Probability Theory, that function computes the improbability of that product given the knowledge base of the agent.

The next section presents an overview of the architecture that we propose for a creative agent. The different component modules are described briefly. Section 3 illustrates the connection of surprise and creativity in that agent, showing how surprise can influence both the production and the evaluation of creative products. At last, some conclusions are made.

2 An Architecture for a Creative Agent

A possible architecture for a creative agent that takes surprise into account in its creative reasoning/decision-making is depicted at a high level in Figure 1. It comprises the following modules (some other modules are not considered in this paper): sensors/perception, memory, emotion generation, and reasoning/decision-making. In a few words: the external sensors provide the reasoning/decision-making and the emotion generation modules with information obtained from the world (which is also recorded); the reasoning/decision-making module computes the current state of the world (external and internal), then applies probability theory to predict possible states of the world for the available actions (internal or external) that it can perform, and finally it applies the Utility Function (which makes use of the intensity of the generated surprise emotion) to each one of those states of the world, and selects the available action that maximizes that function.

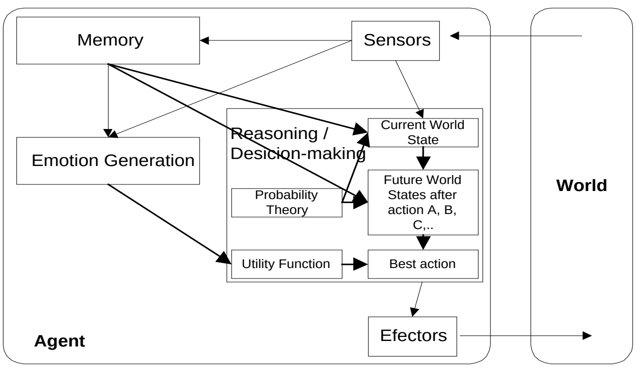

Figure 1 – Agent's architecture.

The following subsections explain in more detail each one of the main modules.

2.1 Memory

At the current stage of development, the agent's memory is of episodic kind, comprising cases of previously perceived objects. This episodic knowledge is graph-based represented (Macedo & Cardoso, 1998). Figure 2 shows an example of a graph-based representation of a building. In this environment of buildings, three kinds of information of the buildings are represented: structure (shape of the roof, facade, door and windows), function (e.g.: house, church, shop, etc.) and behaviour (e.g.: static, mobile) (Goel, 1992). Notice that for the sake of simplicity the structure of the buildings was confined to comprise only the roof, the facade, a door and a window. Also, for the same reason, their shapes are the very well known geometrical shapes like triangular, squared, rectangular, pentagonal, etc.

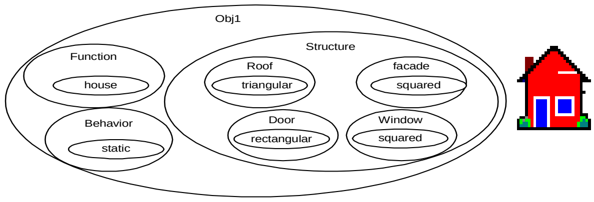

Figure 2 - Graph-based representations and respective graphic representation of the shape of a building, which in this case is a house.

2.2 Emotion Generation

Although the emotion generation module may comprise other emotions, in this paper we are only concerned with surprise. According to its definition, the surprise provoked in an agent *Agt* by a product Obj_k is function of the degree of not expecting Obj_k, considering the set of products present in the memory of the agent *Agt:*

$$Surprise(Agt,Obj_k)=f_1(Degree\_of\_not\_Expecting(Obj_k,Agt(Memory)), arg_1,\ldots, arg_n)$$

f_1 is the exact function of surprise that leaves open the possibility to take into account parameters (represented by arg_i with i=1, …, n), such as those claimed by Ortony and Partridge (1987), other than the measure of the degree of not expecting a product, respectively. However, in this paper we do not consider the contribution for the surprise function of those other parameters, and then we approximate surprise function as follows:

$$Surprise(Agt,Obj_k)=Degree\_of\_not\_Expecting(Obj_k,Agt(Memory))$$

Notice that, in comparison to Ortony & Partridge's approach, in our approach we do not consider inference rules to deduce not explicitly represented propositions from the knowledge base. Thus, deducible propositions are confined to the explicitly represented ones, which in our model are the episodic knowledge stored in memory. Everything else is a non-deducible proposition.

The degree of expecting that an event X occurs is given by its probability P(X). Although other probabilistic methods might be used to compute P(X), in case of products comprising several components we may compute the probability of the whole product Obj_k computing the mean of the conditional probabilities of their n constituent parts:

$$P(Obj_k)=\frac{\sum_{l=1}^{n} P(Obj_k^l|Obj_k^1,Obj_k^2,\ldots,Obj_k^{l-1},Obj_k^{l+1},\ldots,Obj_k^n)}{n}$$

Each one of those conditional probabilities is given by the Bayes' formula (Shafer & Pearl, 1990). Considering that the probability of an event X is the quantification of expecting that event, then the improbability of X defines the quantification of not expecting X: $P(\neg X)=1-P(X)$. Thus, the above approximate function of surprise becomes:

$$SURPRISE(Agt, Obj_k)=1-P(Obj_k)$$

2.3 Creative Reasoning/Decision-making

In this paper, the creative reasoning/decision-making is confined to the influence of surprise emotion. This module makes use of an Utility Function which is solely based on the surprise function defined above:

$$U(S)=f(U_{surprise}(S))=f(SURPRISE(Agt,Obj(S)))$$

Notice that, in this context, a world state *S* is simplified to seeing or imagining an object or product.

Taking into account the function of surprise in the process of producing products (for instance, in planning, problem solving, etc.), the agent becomes able to anticipate the degree of surprise of the hypothetical products it may produce. This means, its creative process is surprise-driven, i.e., every action the agent may take in the process of producing a product is previously evaluated so that it can select the best action (by the best action we mean the action that maximizes the surprise of the product and also - but not considered in this paper - other properties of a creative product such as the appropriateness). If the agent's surprise function takes into account only the agent's knowledge base then the agent might create something that is surprising to it but not to other agents (this is related with Boden's concept of psychological-creativity (Boden, 1992). However, if the agent's surprise function takes into account not only the agent's knowledge base but also predictions of the knowledge bases of other agents, then it produces with more probability surprising products to those agents (this is related with Boden's concept of historical-creativity). Thus, surprise plays an important role to make the process of producing products as a divergent process (Guilford, 1968; Macedo et al., 1997). Actually, a variety of products may be achieved by looking for unexpected products.

On the other hand, the agent or other agents may use the same surprise function to evaluate products that have already been produced.

Notice that the surprise functions of two different agents might give different values for a same product since it depends on the agents' knowledge base. For the same reason the surprise function of an agent may assign different values for a same product in two different moments of time. This seems to be true also in humans.

3 Some Illustrative Experiments

Let us present examples that show the influence of the insensitivity of surprise emotion on both the production and the evaluation of creative products. These examples were taken from SC-EUNE, an artificial agent that Explores UNcertain and UNknown Environments guided by Surprise and Curiosity (in this case, the curiosity was not taken into account).

3.1 Evaluation of Creative Products

Consider the scene where the agent is in an environment with a few objects (depicted in Figure 3). Suppose that after a complete study of those objects, the agent obtained the information that they are all static houses. In what concerns to their structure the three objects are described as follows: Obj1 has a triangular roof, a squared facade, a rectangular door, and a squared window; Obj2 has a triangular roof, a squared facade, a rectangular door and a circular window; Obj3 has a triangular roof, a triangular facade, a rectangular door, and a squared window. Suppose also that the agent has perceived before one hundred objects. These objects were stored in its episodic memory as four cases (listed in Figure 4).

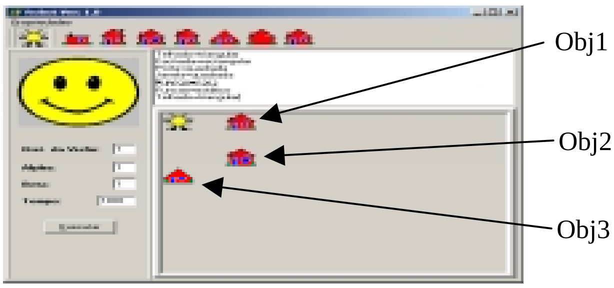

Figure 3 - An autonomous agent acting in an environment comprising different types of buildings.

Field \ Case	C_1	C_2	C_3	C_4
Structure				
Function	House	House	Church	Hotel
Behavior	Static	Static	Static	Static
Abs. Freq.	50	40	5	5

Figure 4 - Descriptive example of the previous 100 perceptions of an agent.

Applying the Utility Function described above to each one of the buildings present in the environment, comes:

U(Obj1)=Usurprise(Obj1)=1-P(Obj1)=1-0.9026=0.0974=9.74%

U(Obj2)=Usurprise(Obj2)=1-P(Obj2)=1-0.8785=0.1215=12.15%

U(Obj3)=Usurprise(Obj3)=1-P(Obj3)=1-0.725=0.275=27.5%

Thus, in what concerns to surprise, the objects are ranked as follows (from highest to lowest Utility): Obj3, followed by Obj2, and finally Obj1. Therefore, a possible behaviour of the agent may be to focus its attention on the building that has the highest utility value (Obj3), which in this case is the one that causes more surprise.

3.2 Production of Creative Products

Suppose the agent is required to design the shape of a house. If the agent wants to put some creativity on it, although making that house surprising is no enough, it is for sure fundamental. Thus, suppose the agent has designed a house equal to the one described in case C_1 (Figure 4), but where the window is missing. Suppose now the agent wants to design the window so that the house becomes more surprising. According to the knowledge level of the agent, it might chose among a rectangular, a circular, a squared window, or no window at all. Applying the Utility Function above, the agent will select the window that leads to the building with the highest utility value. Thus, the agent ranks the actions as follows (from the highest to the lowest utility): no window (95.67%), rectangular window (95.44%), circular window (59.5%), and finally the squared window (49.38%). The agent selects the no window choice. This makes the new building more surprising than any other window. However, if the agent wants to put a window then the rectangular one is selected.

Conclusions

We have presented a computational model for the influence of surprise on the creativity of an agent. This influence may be found both on the production and on the evaluation of creative products. We have illustrated this influence by presenting some experiments with a simulated artificial agent acting in an environment of buildings. Although, in our opinion, surprise is a fundamental part of the creativity phenomenon, we believe that it is not the only emotion involved, especially in artistic creativity. Actually, there is no doubt that stories, poems, music pieces, paintings are full of emotions such as fear, love, anger, joy, etc. It is our aim in a future work to model the influence of other emotions on creative reasoning.

References

Adolphs, R. et al. (1996). Neuropsychological Approaches to Reasoning and Decision-Making. In A. Damásio et al., (Eds.), *Neurobiology of Decision-Making*. Berlin: Springer-Verlag.

Bechara A, Damasio H, Tranel D, Damasio AR, (1997). Deciding Advantageously Before Knowing the Advantageous Strategy. *Science* 275:1293-1295

Boden, M. (1992). *The Creative Mind: Myths and Mechanisms*. New York: Basic Books.

Boden, M. (1995). Creativity and unpredictability. *Constructions of the Mind - SEHR*, 4, 2.

Churchland, P. (1996). Feeling Reasons. In A. Damásio et al., (Eds.), *Neurobiology of Decision-Making*. Berlin: Springer-Verlag.

Damásio, A. (1994). *Descartes'error, Emotion Reason and the Human Brain*. Grosset/Putnam Books.

Dewey, J. (1910). *How we think*. Boston: D. C. Heath.

Goel, A. (1992). Representation of Design Functions in Experience-Based Design. In: Brown, D., Walderon, M., Yosnikawa, H. (Eds.): *Intelligent Computer Aided Design*. Elsevier Science.

Guilford Guilford, J. (1968). *Intelligence, creativity and their educational implications*. San Diego, CA: Robert Knapp.

Hudlicka, E., and Fellous, J. 1996. Review of Computational Models of Emotions. *Tech. Report 9612*, Psychometrix.

LeDoux, J.E. (1996). *The Emotional Brain*. New York, Simon and Schuster

Macedo, L., Pereira, F., Grilo, C., & Cardoso, A., (1997). A Model for Divergent Production of Plans: its Application in the Music Composition Domain. *Proceedings of Computational Models of Creative Computation*. Dublin: Dublin City University.

Macedo, L., & Cardoso, A., (1998). Nested Graph-Structured Representations for Cases. *Proceedings of the 4th European Workshop on Case-Based Reasoning* (pp. 1-12). Berlin: Springer Verlag.

Macedo, L., Pereira, F., Grilo, C., & Cardoso, A., (1998). A Computational Model for Creative Planning. In Schmid, U., Krems, J., Wysotzki, F. (Eds.), *Mind Modelling: A Cognitive Science Approach to Reasoning, Learning and Discovery*. Berlin: Pabst Science Publishers.

Ortony, A. & Partridge, D. (1987). Surprisingness and Expectation Failure: What's the Difference?. *Proceedings of the 10th International Joint Conference on Artificial Intelligence* (pp. 106-8). Los Altos, CA: Morgan Kaufmann.

Peters, M. (1998). Towards Artificial Forms of Intelligence, Creativity, and Surprise. In *Proceedings of the Twentieth Annual Conference of the Cognitive Science Society*, pp. 836--841, Madison, Wisconsin.

Pfeifer, R. (1988). Artificial Intelligence Models of Emotion. In: V. Hamilton, G. Bower, and N. Frijda (Eds.). *Cognite Perspectives of Emotion and Motivation*, 287-320. Netherlands: Kluwer.

Picard, R.(1997). *Affective Computing*. MIT Press.

Russel, S. & Norvig, P. (1995). *Artificial Intelligence - A Modern Approach*. Prentice Hall.

Shafer, G. & Pearl, J. (Eds.) (1990). *Readings in Uncertain Reasoning*. Palo Alto, CA: Morgan Kaufmann.

Wallas, G. (1926). *The art of thought*. Nova Iorque: Harcourt Brace.