

Develop and evaluate visual analogies to support insight and creative problem solving

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ABSTRACT

While most of the work on analogies has focused on the role of conceptual metaphors in learning and understanding, less attention has been paid to the visual analogies for insight and creative problems. This paper reports the result of two preliminary experimental studies investigating the role of visual analogies for cueing the insight problem solving process. A systematic construction, reflection on and analyses of visual cues for insight problems could lead us to guidelines on how analogies are formed and how these guidelines could be applied in the creative design process.

Keywords

Problem solving, visual insight, visual analogies, discrete and continuous animation, realism, image schemata, embodied cognition theory.

1. MOTIVATION AND AIMS

The use of cutting-edge technology required by nearly every domain and field, and a better understanding of changes in how the visual information and communication is created and presented will make our interaction more meaningful and effective. Analogy is one of the most common methods of explaining unknown concepts and new ideas. The use of visual analogy in reasoning and problem solving was investigated by some of the world's leading researchers, mostly in educational and instructional psychology, science education and mathematics, while focus on visual cues for problem solving was less explored and restricted mostly to their facilitative role [3], instructional design and computational modelling [8]. The impact of visual analogies on the insight problems (as opposed to creative problems) is easier to measure and we argue that their benefits could also extend to the creative problem solving.

- The aim of this proposal is to investigate the role of visual analogies in visual/perceptual insight problems and identify the principles of constructing effective visual analogies.
- The main challenge is the development of a set of successful analogies able to ensure analogical transfer. Creating, reflecting on, and investigating these visual analogies in two perceptual insight problems will lead us to a better understanding on how visual analogies are formed and how they could inspire designers in looking for visual analogies to support their creative process.

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2. OBJECTIVES

- To develop a portfolio of 2D and 3D, static and dynamic visual analogies for two perceptual insight problems, i.e. the eight-coin and the cheap necklace problems.
- To experimentally measure the importance of surface, structural aspect, functions and relations of the components that form visual analogies in the insight problem solving.
- To develop guidelines for constructing effective visual analogies for the perceptual insight problem of eight coins.
- To test the applicability of the developed guidelines for a different perceptual insight problem, i.e. necklace problem.
- To develop visual analogies and guidelines for constructing effective visual analogies, and test the above guidelines for its support in creative problem solving in the design process.

3. RELATED WORK

Whereas much work has focused on investigating the role of verbal cues in both verbal and visual insight problems, fewer efforts have focused on investigating the role of visual insight in visual perceptual problems. The dual code theory [8] states that visual and verbal information are processed along two distinct channels, one is dealing with the verbal information and another with perceptual systems. This theory suggests the superiority of memory for images, because images engage multiple representations and associations with external knowledge thus encouraging a better encoding than words [7]. Research into child psychology on learning and memory for pictorial and verbal information successfully replicate findings suggesting the superiority of memory for pictures over words [9], a superiority, which is also maintained in adulthood [4].

A number of researchers have investigated the role of visual analogies in visual insight problems [5]. In a well-known work, Dreistadt [2] showed large incubation effect of visual analogies provided for the farm and ten-trees problem (Table 1).

Table 1. Problems	Sample size and the success rate	Working time (min)	Incubation time (min)
Farm [2]	40 / 70%	12	8
Ten-trees [2]	40 / 70%	12	8
Nine dots [1]	110 / 24%	3	0
8 coin Exp.1 [6]	56 / 42%	6	0
8 coin Exp.2 [6]	52 / 33%	8	0

Chronicle et al [1], on the other hand, investigated the use of visual analogy for the nine dots problem. The findings suggest that a perceptual cue to the shape of the solution gave rise to only minimal improvements in performance (24%), while exposure to the correct solution leads to a floor performance. They suggest that in the case of visual problems, the incubation effects arise

only after entering the impasse state that contributes to the strategic shift needed to restructure a problem representation [1].

4. COMPLETED WORK

4.1 Methodology

The experiments on insight problem solving are investigated in laboratory settings. The strengths of this method are that one can manipulate the variables of interest and can measure the impact on success rate. Weakness: created artificial situation.

4.2 Experimental Study 1

This experiment was a partial replication of the eight-coin problem. We used the same eight coins, the most difficult stimulus configuration, the same procedure both as instruction and timing as in Ormerod et al [6]. The experiment involved a mix factorial design with two between factors: surface and process aspects and one within factor: insight aspect, i.e. 3 x 2 x 2. Each visual cue was presented on a printed 8 x 10 inches paper. 50 students from Lancaster University participated in this study. The participants were randomly assigned to one of the six conditions of the experiment and instructed: "By moving two coins only, rearrange the coins in such a way that each coin will touch exactly three others. After 2 minutes of working on the problem, they were provided with 1st hint, and after another 2 minutes with the second hint – a total time of 6 minutes. They were allowed to make as many attempts as they wish with the condition that they must start a new attempt from the original configuration. Participants who solved the problem at any time were scored as successful and excluded from further participation on this task. Findings showed that the *extended cue hypothesis* was validated by the main effect of grouping plus stacking insight cues leading to significantly more correct solutions than the grouping only. *Process hypothesis* was refuted by the failure to identify the main effect in transformational aspect of the insight. This led us to investigate the role of operators such as forces and gestures in the transformational changes of the insights. *Depth hypothesis* was validated by the main effect of 3D surface cues supporting better incubation effect than those capturing 2D ones.

4.3 Experimental Study 2

We used the same eight-coin problem as in previous experiment, the same methodology, and procedure. We had three IVs: dynamism with two between levels: continuous and discrete animations, depth cues with two between levels: schematic and realistic and one within IV of insight cues capturing image schemata through forces and gestures.

Conditions		Image Schemata		Total:
		Forces	Gestures	
	Control Group	N/A	N/A	2 (7.69)
Discrete Animation	Schematic	5	8	13 (50.0)
	Realistic	5	10	15 (57.7)
Continuous Animation	Schematic	8	7	15 (57.7)
	Realistic	8	11	19 (73.0)

Table 2. The results for Experimental Study 2

Note: the numbers are the correct solutions per condition and in parentheses are the percentages of the success rate per that condition.

The DV was the success rate in solving the problems. 136 students from Lancaster University participated in this experiment. 6 participants were excluded from analyses. The participants were provided with a storyboard of 7 still frames or animated sequences as cues (see the result in the Table 2.).The main outcome of this study is that each condition has led to success rate above 50% (highest 73%), known the fact that

these kinds of problems are difficult to solve without visual help. Also, compared with other studies on visual analogy in problem solving, our participants were limited to the cues exposure (see Table 1), thus suggesting that the effectiveness of cueing depends on the content, structure, form of delivery, visual perception and the nature of object manipulation. Compared with the results of the experiment 1, where the static images failed to capture the transformational process of the insight, here we want to emphasize the importance of image schemata in problem solving and to test it further in the next experimental study.

5. FEATURE WORK

Experiment 3 - Design, organize, and run the eight-coin problem with the animated simulation focused on forces and gestures (same methodology as in previous experiments).

Experiment 4 - Design, organize, and run "the cheap necklace" insight problem to test the guidelines of successful cues design.

Design protocol study – Design, organize, and run the experiment involving a design brief for a creative design problem. Following the guidelines, for constructing effective analogies emerged from our previous experiments the researcher will develop and create visual material for this study and test its effectiveness in supporting the design process.

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