CREATIVITY IN PEOPLE VS IN METHODS

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RESUMEN

Esta comunicación, cuyo título se traduce al castellano como "La creatividad de las personas frente a la de los métodos", pretende analizar el tipo de influencia que ejercen los métodos de generación de ideas y las características de las personas sobre el proceso de diseño y los resultados que se obtienen. Para ello, se ha realizado un análisis de protocolo y un análisis de soluciones producidas en un experimento de diseño. Los resultados muestran que los estímulos de los métodos de generación de ideas pueden ejercer una influencia mayor en la actividad de diseño que las características creativas de las personas que intervienen.

Palabras clave: creatividad, métodos de diseño, análisis de protocolo

ABSTRACT

This paper aims to analyse the type of influence that idea-finding methods and designers' problem solving traits exert on the way the design process unfolds and in the outcomes. This is researched by means of protocol analysis and outcome-based analysis of a design experiment. This experiment shows that stimuli can have a greater influence on the design activity than that of the designers' problem solving traits.

Key Words: creativity, design methods, protocol analysis

0 INTRODUCTION AND OBJECTIVE

A high number of methods have been proposed to stimulate designers' creative capacity. However, little is known about the effects that these methods have on the design process and on the resulting concepts. Isaksen [1] identified a general tendency of people to believe that only gifted, creative people can produce creative results, leaving little credit to the influence methods may exert on design.

The objective of this paper is to compare idea-finding methods with designers' problem solving traits regarding the effects that they produce in the way the design process takes place and in the outcomes. This is researched by means of analysing a design experiment. Studying

the effects of idea-finding design methods experimentally can provide some light into their usability, and in how they can be used to stimulate designers creativity effectively.

In previous publications [2], the design experiment which is discussed here has been analysed. This paper analyses further some aspects of the outcomes from the experiment and discusses the implications of all the results.

1 RESEARCH METHOD

Analysing and comparing the effects of design methods and designers' problem solving traits on the design activity of various experimental sessions is a troublesome task, since both, how the design activity unfolds and the results, can be affected by other factors, such as the level of experience the designers have with the problem, the means to express ideas [3], the characteristics of the problem itself, or the working atmosphere. Moreover, how much relative influence these different factors can actually exert on the design activity is not known.

The way to go about this problem was to set up an experiment where the people and method factors varied, keeping fixed the rest of factors. Four teams were created, two of them being innovative and the other two adaptive (in Kirton's terms [4]). One of the innovative teams and one of the adaptive ones were asked to use a hypothetically innovative idea-finding method (SCAMPER) to generate ideas to a design problem. The two remaining innovative and adaptive teams were asked to use a hypothetically adaptive idea-finding method (Visual Stimuli) (Figure 1).

The way the design activity unfolded for the four teams was studied and compared by means of protocol analysis, using the analytical method of design as reflective practice [5]. Outcome-based analysis was also carried out, using mainly contributions from Shah and Vargas Hernández [5], Kirton [4], and Deng [7].

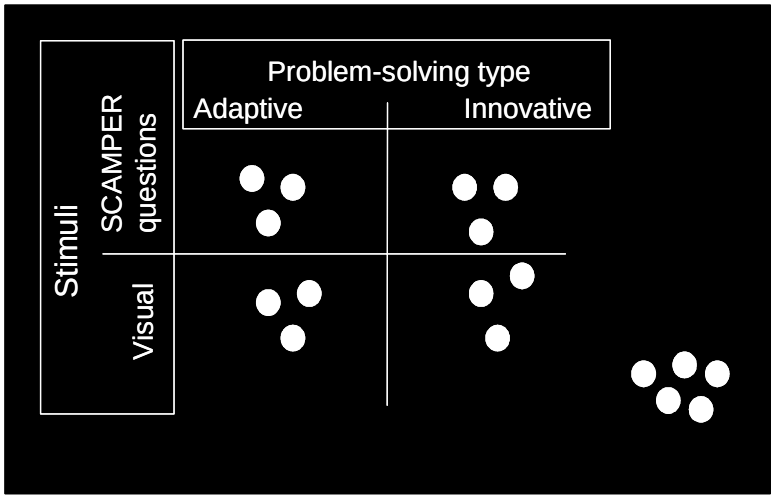


Fig. 1 - Type of stimuli and type of problem-solving style of the 4 teams

1.1 Design of the experiment

The chosen hypothetically innovative method SCAMPER consists of posing questions to designers that have been proven to stimulate their creativity. In the chosen hypothetically adaptive method Visual Stimuli, images were used to stimulate the creativity of designers, which were obtained on the internet related in shape and function to the paradigm concept of the design object. The initial thoughts were that SCAMPER would be more innovative than Visual Stimuli for two main reasons:

a) In SCAMPER the questions are ambiguous and interpretable, and each of them could lead designers to a number of conceptual alternatives.
b) With Visual Stimuli designers were thought to jump into solving the details of the concepts that the images from internet suggest.

However, the experiment showed a significantly different influence of methods on design than what was initially thought.

The participants were Engineering Design PhD students or doctors, most of them with experience in designing (Table 1). The initial 17 possible participants met for approximately 40 minutes and were given the initial requirements of the problem along with technical and market data. The market data had been obtained through a questionnaire sent to Spanish architects and engineers, as well as architecture and industrial design students.

SCAMPER questions		Visual stimuli	
Innovative team	Adaptive team	Innovative team	Adaptive team
10, 15?, 5?	7, 8, 14	2, 0.5, 5?	5, 4, 14

Table 1 - Professional experience of participants in design activities

During this time, the problem was read individually with three to four people using two exemplars of the object that was to be redesigned, namely a tubular map case (Figure 2). Any doubts regarding the initial requirements of the problem were discussed and settled. The task was to generate ideas for a tubular map case allowing for one-by-one removal and insertion of maps.

The problem solving style of each participant was identified using Kirton's theory of problem solving style [4], which explores an individual's preferred approach to solve problems. Kirton contends that different people solve problems in different ways. The problem solving style can be described on a continuum ranging from extreme adaptor to extreme innovator. Adaptors tend to make improvements to existing solutions to achieve a solution, while working within a problem structure, generating ideas that have immediate application, and working through a problem in detail to completion. However, innovators will frequently break the paradigm, look for new solutions rather than improve, and generate many ideas that may have no immediate practical value. These are descriptions of extreme adaptors and innovators. In practice, a person's adaptor/innovator characteristic can be measured on a continuum. Most people are not at the extremes. It should be stressed that the adaptor/innovator characteristic of a person is not related to the creative ability of that person. The adaptor and innovator have different preferred approaches to problem solving that do not inherently produce more or less creative results. However, different problem solving styles are suitable for different problem conditions. The KAI inventory developed by Kirton was

used to identify the problem solving style of each potential participant. The result was used to form two innovative teams and two adaptive teams that were as similar as possible (Table 2).

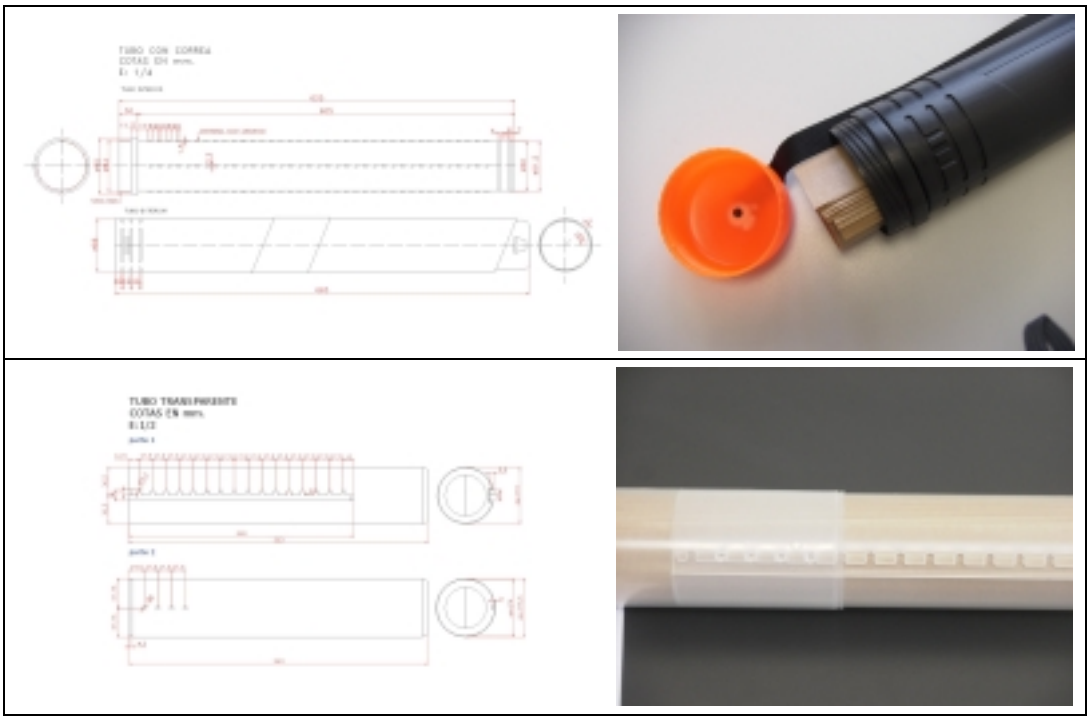


Fig. 2 - Exemplars of the object to be redesigned

Table 2 represents the name given to the different teams (i.e. the number of the room where they were recorded), the problem solving style of its members, and the type of stimulus they were influenced by.

Team name	Team problem solving style	KAI score of group members	Stimulus
2444	Adaptive	2x79 96	Images
2422	Innovative	106 117 122	Images
2418	Innovative	112 116 123	SCAMPER questions
2443	Adaptive	76 82 95	SCAMPER questions

Table 2 - Teams' arrangement in the experiment

Each group then went into a different room where a facilitator (one in every room) gave them precise instructions on how to proceed. The instructions were not only explained by the facilitator, but also written on the display to favour as much similarity as possible between the four sessions. An attempt was made to make the rooms look as similar as possible by hiding objects with papers. The four sessions were conducted simultaneously for 45 minutes. Figure 3

gives a flavour of the actual set up of the session. The first 5 minutes of the idea creation session had no additional stimuli, and then 7 additional stimuli were introduced by means of a computer display every 5 minutes (Table 3).

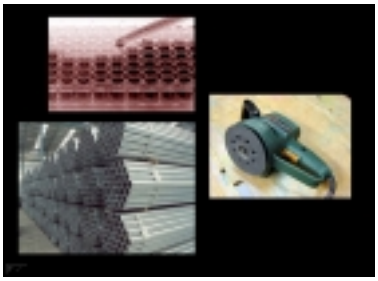
Fig. 3 – One of the four teams

Each stimulus contained three images or questions. Each team was influenced by a total of eight stimuli episodes. The black boxes are screenshots of the images they could see in the screen. The first black empty box represents the first five minutes without additional stimulus; the order of the stimuli was then top-down as in Table 3. The participants were asked to seek stimulation from the display. The SCAMPER questions of Table 3 are in Spanish, as seen by the participants. Their translation follows next:

- Questions of stimuli episode 2:
  - What can be blended, mixed, or included?
  - What if you reverse the assemble?
  - What are other ways to use it?
- Questions of stimuli episode 3:
  - What can you substitute?
  - What can be combined?
  - What else is like a tubular map case?
- Questions of stimuli episode 4:
  - What ideas can you combine?
  - What can you make bigger, or smaller?
  - How can you change colour, sound, smell, or touch?
- Questions of stimuli episode 5:
  - What parts can you do without?
  - What parts can you repeat, duplicate, triplicate…?
  - Does its shape suggest other uses for it?
- Questions of stimuli episode 6:
  - Can it be reversed inside out?
  - What parts can be longer or thicker?
  - What parts should be added?
- Questions of stimuli episode 7:
  - What other process of introduction/extraction can be used?
  - What else is like a classifier?
  - What if there is no tubular case?

- Questions of stimuli episode 8:

  How can you make it more compact or shorter?
  Can it be turned upside down?
  Does its shape suggest other uses for it?

	SCAMPER QUESTIONS	VISUAL STIMULI
Stimuli episode 1 (5 minutes)		
Stimuli episode 2 (5 minutes)		¿Qué partes se pueden **doblar, mezclar o incluir**? ¿Cómo se puede **ensamblar al contrario**? ¿Para qué **otra cosa se puede usar**?
Stimuli episode 3 (5 minutes)		¿Qué parte puedes **sustituir**? ¿Qué partes se pueden **combinar**? ¿Qué se **parece a un tubo portaplanos**?
Stimuli episode 4 (5 minutes)		¿Qué ideas **puedes combinar**? ¿Qué partes se pueden hacer **más grandes** o **más pequeñas**? ¿Qué debe cambiar de **color, olor, sonido o tacto**?
Stimuli episode 5 (5 minutes)		¿De qué partes se puede **prescindir**? ¿Qué partes se pueden **repetir, duplicar, triplicar...**? ¿Sugiere su forma **otros usos**?

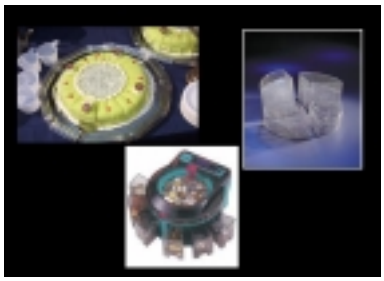
Stimuli episode 6 (5 minutes)		¿Puede estar **lo de dentro fuera y lo de fuera dentro**? ¿Qué parte se puede hacer **más larga o gruesa**? ¿Qué elementos se deben **añadir**?
Stimuli episode 7 (5 minutes)		¿Qué otro **proceso** de introducción, extracción, organización se puede usar? ¿Qué se **parece a un clasificador**? ¿Qué se puede hacer **si no hay tubo**?
Stimuli episode 8 (5 minutes)		¿Cómo se puede hacer **más compacto o más corto**? ¿Se puede **poner al revés**? ¿Sugiere su forma **otros usos**?

Table 3 - Stimuli episodes in the experiment

1.2 Outcome-based Analysis

Several criteria are considered for the outcome-based evaluation. Shah and Vargas-Hernandez [6] have proposed to measure novelty, variety, quality, and quantity to evaluate the effectiveness of idea-generation methods. 'Novelty is a measure of how unusual or unexpected an idea is as compared to other ideas. Not every new idea is novel since it may be considered usual or expected to some degree and this is only known after the idea is obtained and analysed. Variety is a measure of the explored solution space during the idea generation process. The generation of similar ideas indicates low variety and hence, less probability of finding better ideas in other areas of the solution space. Quality, in this context, is a measure of the feasibility of an idea and how close it comes to meet the design specifications. Quantity is the total number of ideas generated. The rationale for this measure is that generating more ideas increases the chance of better ideas' [6].

To measure **variety and quantity**, the number of alternative solutions and the degree of variation had to be considered. The concepts of action function [7], structure at the conceptual level, and structure at the detail level were used. Action functions are related to physical principles. For example, for the purpose function 'allow for one-by-one extraction of the maps', action functions are 'devices to secure the diameter of concentrically rolled up maps', and 'divisions inside the case for individual rolls storage'. The structure represents the way

the function action is transformed in material form. Two levels of definition of this material form are considered, conceptual structure and detail structure.

As we began to analyse **novelty**, we realised that novelty is a relative term: there is for example newness with respect to the current paradigm and newness with respect to what others can produce (or non-obviousness [8]). As indicated in the introduction, in previous publications regarding this experiment, the non-obviousness of the solutions created by the teams had not been covered. In this paper, this matter is analysed.

The concept of **non-obviousness** takes into consideration the fact that what is novel about a solution could be not the given solution by itself, but the function that it resolves (i.e., allow for one-by-one extraction of the maps). Obvious solutions in this experiment are those that, even if they are far from the current paradigm, all groups thought about them. Non-obvious solutions are solutions which few groups thought about. It was observed in the analysis of non-obviousness of solutions of the four groups that no solution of a group was equal to any of the solutions of the other groups in all respects. For this reason, the concepts of Action Function, Structure and Detail were used here again. The novelty of solutions was explored at these three levels.

The **newness with respect to the current paradigm** was measured for the four change type patterns detected:

- Type 1: New parts are added to the tubular case to change its characteristics.
- Type 2: The tubular case is changed so much that it is not a tubular case any more.
- Type 3: The change involves changes even in the characteristics of the paper.
- Type 4: The whole system changes.

The quality of a solution developed at a conceptual level is to a large extent related to its feasibility. **Feasibility** is however an uncertain measure at early stages. In the search for objectivity of this measure, two parameters that may not give an exact measure of feasibility were chosen, though they have a potential to be positively correlated to it: refinement level measured in time dedicated to a solution and number of reflections (using reflection in Schön's terms [9], as suggested in [5]).

1.3 Protocol Analysis

The process-based evaluation of the influence exerted by the additional stimuli required data collection via protocol studies and analysis using an ideation cognitive model. The model used for analysis is that of designing as a reflective practice, based on Schön's [9] theory and further developed as a coding system for analysing design activity by Valkenburg [5].

Schön discusses that professionals design by engaging in a situation without having a full understanding of things before they act. They create their own design situation and engage in situations in a sort of intuitive, routine experience-based process until they come to a situation where the result becomes unexpected. As a response to the surprise, the professional ignores it, or quickly improvises a way out, or reflects upon what has happened. This capacity to

respond to surprises through improvisation by readjusting to the new situation is what he calls reflection-in-action. Reflection-in-action is a process that professionals can realise without knowing what they are doing. When Reflection-on-action is the action of the person looking back on its previous mindset, strategies, or objectives as a process of self-analysis and evaluation to understand how the previous way of framing the problem has contributed to the unexpected results. Reflection-on-action constitutes an insightful process of learning.

The model was developed into a coding system to analyse group design activity [5]. It distinguishes basically four types of design actions: naming, framing, moving, and reflecting. Naming is explicitly stating relevant factors of the design problem. Moving is engaging with the situation towards a solution by generating ideas, combining them, evaluating them, sorting information, making an inventory, etc. Reflecting is explicitly expressing a surprise situation. A frame is a perspective from where to look at the problem and, therefore, framing is the action of establishing a frame. Valkenburg modified this model somewhat since it was found to be slightly unreliable due to actions not always being distinguishable. A simplification of the modified coding system model was made for this experiment with the aim to increase the reliability. After using the coding systems in several trials, we realised, as Valkenburg did [5], that the difference between naming and moving is occasionally very weak. For this reason, we did not distinguish between them. Both types of actions are coded as moving. The protocol analysis consisted of identifying episodes, moves, reflections, and frames, and the links between all these actions. The process and graphical coding (figure 4) followed for the analysis is as suggested by Valkenburg [5].

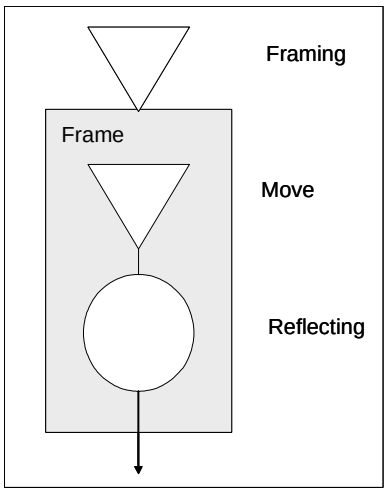


Figure 4. Graphical coding

2 RESULTS

The reader is requested to refer to [2], to see a further description of the research results regarding the protocol analysis by means of the method of design as reflective practice and the outcome-based analysis. Here, a summary of those results is presented and emphasis is made on the implications of the results.

2.1 Quantity and variation

Figures 5 and 6 show a remarkable pattern that the teams with similar additional stimuli share. Groups influenced by images produced a major number of solution alternatives. Figure 5 displays the time dedicated to each solution alternative. It clearly shows that groups influenced by SCAMPER questions (2418 and 2443) showed preference for a solution to which the group dedicated time to develop further, whereas groups influenced by images (2444 and 2422) were in a continuous flux of solution alternatives generation. The number of alternative solutions for the different types of change can be found in table 7.

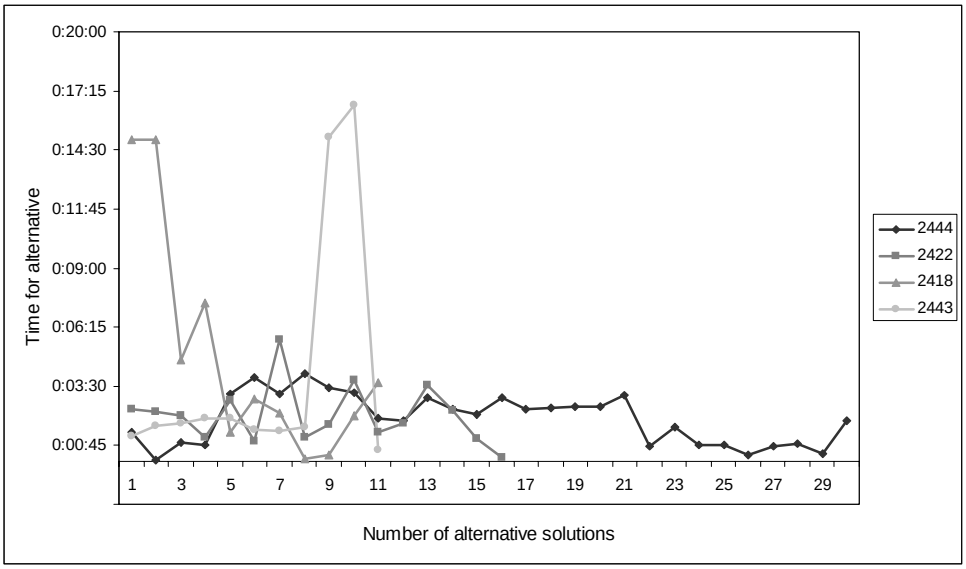


Figure 5 - Time of dedication to solution alternatives

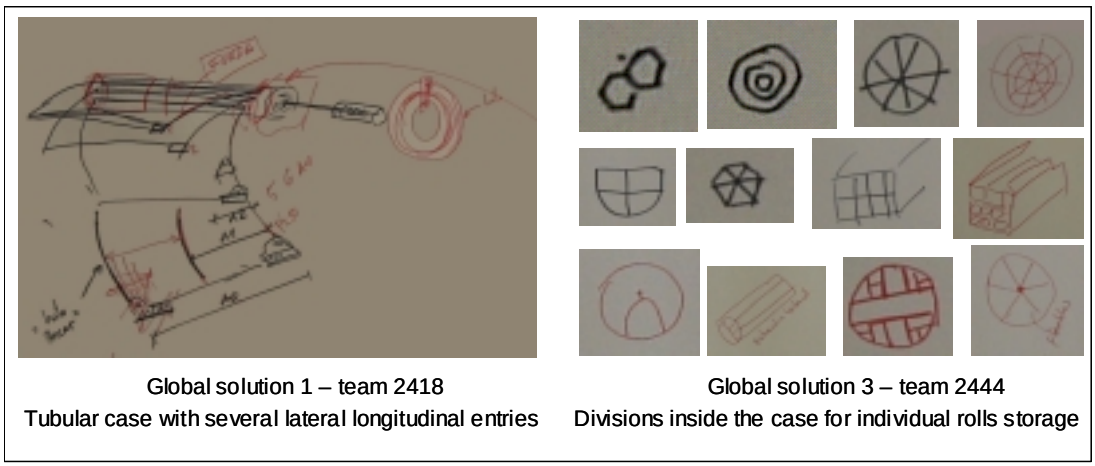


Figure 6 - Solution refinement vs. variety construction at working principle level

In terms of variety, teams inspired by images had a strong tendency to produce subsequent ideas that consider other similar ways to obtain the same action function as with a suggested solution, leading to numerous solution alternatives at conceptual structure level. Teams inspired by SCAMPER questions tended not only to vary construction at the conceptual strucuture level, but also produce subsequent ideas that further developed a suggested

solution, here named solution refinement. Figure 6 shows the drawings of the most developed global solution of group 2418 in terms of time, and of the most developed solution alternatives produced by group 2444, illustrating the idea of solution refinement as opposed to variety construction.

2.2 Novelty of solutions

Table 4 displays information regarding the novelty of the solutions developed by the teams with respect to the current paradigm. It shows the relative number of alternative solutions for each type of change, which has been calculated with respect to the total number of alternative solutions produced by each team.

Group	Number of alternatives	Change type 1	Change type 2	Change type 3	Change type 4
2444	30	23	5	1	1
	1,00	0,77	0,17	0,03	0,03
2422	16	13	3	0	0
	1,00	0,81	0,19	0,00	0,00
2418	11	5	2	3	1
	1,00	0,45	0,18	0,27	0,09
2443	10	8	2	0	0
	1,00	0,80	0,20	0,00	0,00
TOTAL	67	49	12	4	2
	1,00	0,73	0,18	0,06	0,03

Table 4 - Types of change of alternative solutions

The expected pattern without stimulus is that innovative teams produce more revolutionary types of change than adaptive groups, i.e. more solutions of change types 3 and 4. Surprisingly, the results in this respect from the analysis is that the most innovative team using SCAMPER and the most adaptive team using Visual Stimuli produce more innovative solutions than the other two teams. Therefore, by only considering the change with respect to the current paradigm, no trend could be drawn on the influence of people's problem solving style or type of stimulus on the novelty of solutions.

However, if the influence of these factors is considered regarding novelty in terms of non-obviousness, the expected pattern is observed, i.e. innovative teams produce a higher percentage of non-obvious solutions than adaptive groups at functional level (Figure 7), whereas adaptive teams produce a higher percentage of non-obvious solutions than innovative teams at structure level (Figure 8). In Figure 7, above the mean behaviour line the behaviour of the team is innovative in comparison with the rest of the teams. In Figure 8, below the mean behaviour line, the behaviour of the team is innovative in comparison with the rest of the teams.

2.3 Feasibility of solutions

As previously indicated, Figure 5 shows that groups influenced by SCAMPER questions (2418 and 2443) showed preference for a solution to which the group dedicated time to develop further, whereas groups influenced by images (2444 and 2422) were in a continuous

flux of solution alternatives generation. The time spent on a solution represents to a given extent a measure of the degree of refinement of the solution.

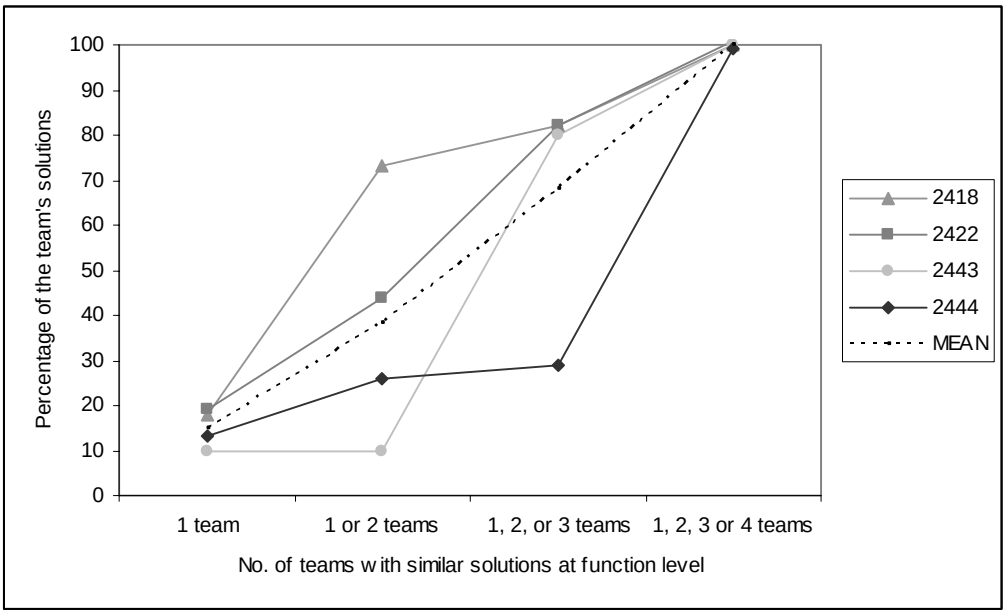


Figure 7 – Percentage of a team's solutions similar to other teams' solutions at functional level

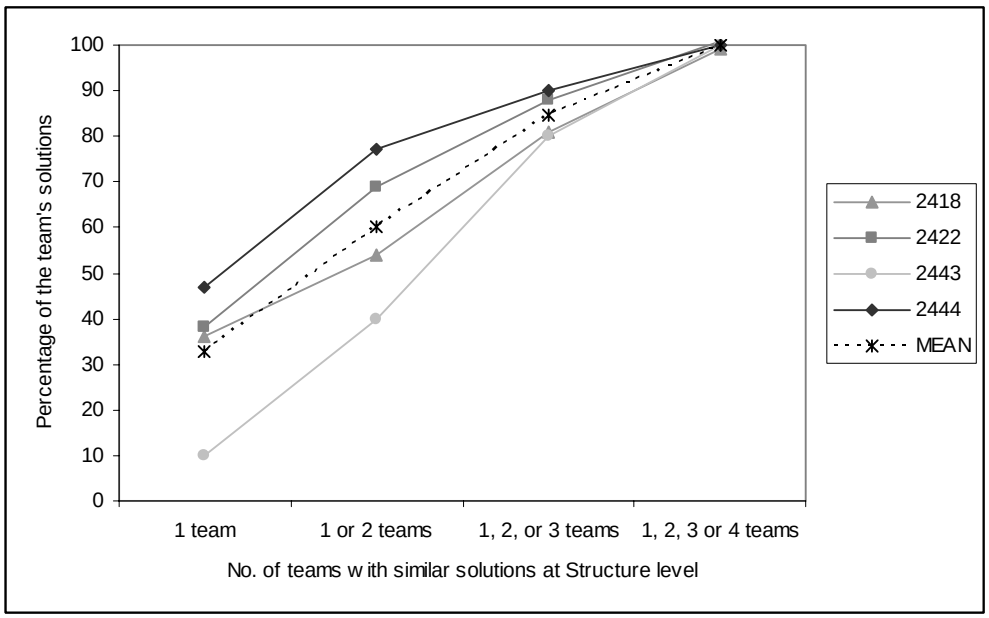


Figure 8 – Percentage of a team's solutions similar to other teams' solutions at structure level

Another parameter which has been used is the number of reflections. Reflections represent the moments when the teams have realised of potential problems with their solutions or processes. Sometimes they embark upon solving them and others they do not. It was observed

in the experiment that innovative teams reflect more often than adaptive teams (22 and 23 reflections of innovative teams vs. 4 and 8 reflections of adaptive teams, Table 5), and that teams using Visual Stimuli unattended more reflections than teams using SCAMPER (rate of attention of teams using Visual Stimuli is 0,50 and 0,55 vs. teams using SCAMPER of 0,83 and 1, Table 5).

Team name	**2444**	**2422**	**2418**	**2443**
Number of global solutions	8	7	8	4
Number of global solutions with reflections	3	7	6	4
Number of reflected global solutions	2	5	6	4
Number of alternatives	30	16	11	10
Number of alternatives with reflections	8	14	8	9
Number of reflected alternatives	7	7	8	9
Total number of solution-related reflections	4	22	23	8
Number of attended solution-related reflections	2	12	19	8
Number of unattended solution-related reflections	2	10	4	0
Rate of reflections (No. reflections/No. alternatives)	0,13	1,38	2,09	0,80
Rate of attention to reflections (No. attended reflections/No. reflections)	0,50	0,55	0,83	1,00
Rate of alternatives with reflections (No. reflected alternatives/No. alternatives)	0,27	0,88	0,73	0,90
Rate of reflected alternatives (No. reflected alternatives/No. alternatives)	0,23	0,44	0,73	0,90
Rate of global ideas with reflections (No. reflected global ideas/No. global ideas)	0,25	0,71	0,75	1,00
Rate of reflected global ideas (No. reflected global ideas/No. global ideas)	0,25	0,71	0,75	1,00

Table 5. Solution-related reflections

2.4 Protocol analysis

The main advantage of using the protocol analysis technique of Reflective Practice is that it is a powerful tool to explain why the results obtained are as they are. Figure 9 summarises the resulting analysis. For a correct understanding of how it has been built and how it should be interpreted the reader is requested to refer to [2, 5]. Here, just the implications of the resulting analysis are discussed.

Figure 9 explains why groups influenced by SCAMPER questions (2418 and 2443) showed preference for a solution to which the group dedicated time to develop further, whereas groups influenced by images (2444 and 2422) were in a continuous flux of solution alternatives generation: Whereas the SCAMPER questions can be used as sub-frames within the frame of a specific solution to develop it further (see the grey boxes of frames inside other grey boxes), the images of Visual Stimuli made the groups jump from one solution principle to another.

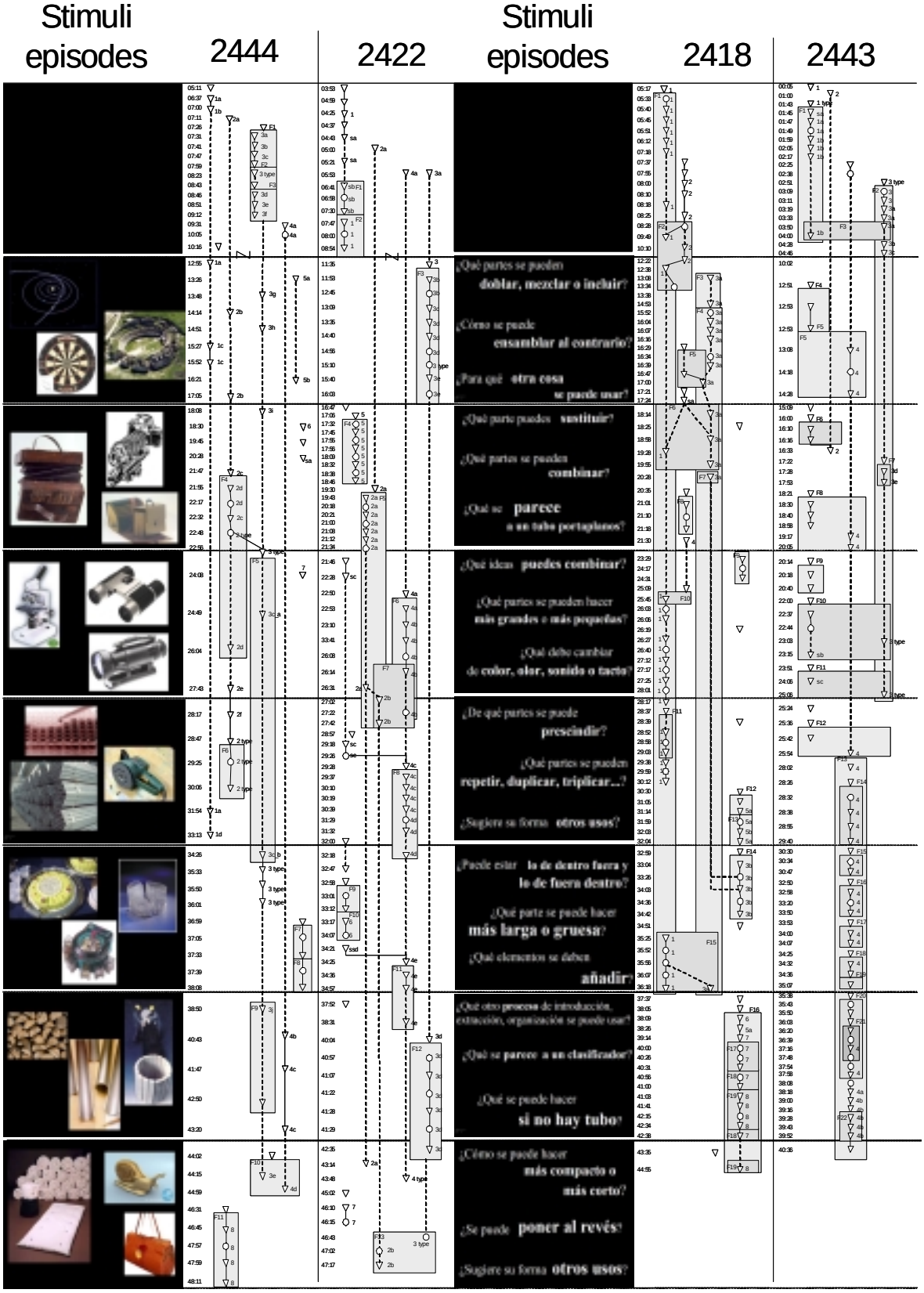


Figure 9 – Protocol Analysis of the sessions using the Reflective Practice Methodology

Christiaans [10] found that 'the more time a subject spent in defining and understanding the problem, and consequently using their own frame of reference in forming conceptual structures, the better able he/she was to achieve a creative result'. In the experiment, it has been observed that whereas the SCAMPER method allowed in the case of the two teams to incorporate the SCAMPER questions within their own frame (a solution-frame), the visual stimuli led the teams to be changing of solution-frames continuously, without reaching a satisfying pair problem-solution. Assuming that Christiaans' contribution is true, then we can state that SCAMPER is a better method to stimulate creativity than Visual Stimuli in the format it was displayed for the experiment because at it allows designers to keep working on their own frames, without hindering people's capacity to create.

3 CONCLUSIONS

The teams inspired by SCAMPER questions:

- Keep developing or retake selected solution alternatives during more stimulus episodes than groups inspired by images.
- Show preference for a solution to which the group dedicates time to develop further.
- Can use the SCAMPER questions within the frame of a frame-idea as a sub-frame to produce subsequent ideas that further develop the idea.
- Consider detail aspects of solutions and think about alternative solutions at this level.
- Engage in searching for solutions to uncertain design situations.

Whereas the teams inspired by images were observed to:

- Be in a continuous flux of solution alternatives generation.
- Use the images to produce subsequent ideas that consider other ways to obtain a similar action function as with a suggested solution, thereby leading to numerous solution alternatives at the conceptual structure level.
- Do not engage in detail aspects of solutions.
- Ignore uncertain design situations half of the times.

The influence exerted by the problem-solving style of the team members was mainly observed regarding:

- The frequency of reflections. Innovative teams reflected more often than adaptive teams.
- The level at which non-obvious solutions were generated. Innovative teams produce a higher percentage of solutions that are non-obvious at functional level, and adaptive teams produce a higher percentage of solutions that are non-obvious at structure level.

However, no trend could be drawn on the influence of people's problem solving style or type of stimulus on the novelty of solutions regarding the current paradigm.

For these reasons, this experiment shows that stimuli can have a greater influence on the design activity than that of the designers' traits, when exposed to experimental conditions and in terms of the measured creativity aspects. Stimulus with SCAMPER questions favour

refinement of solutions, by using a solution as a frame and the questions as sub-frames. Stimulus with images (similar in shape and function with the designed object displayed in intervals of time) favours the generation of numerous partial solutions, which the group does not further explore. The fact that innovative people tend to work in a more abstract way than adaptive people (functions are more abstract than structures) may condition the type of design methods that can suit different designers.

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4.2 References to Figures

[1-6, 9] Figures from López-Mesa, B.; "The use and suitability of design methods in practice. Considerations of problem-solving characteristics and the context of design". Ph.D. thesis, Lulea University of Technology (Sweden): Universitetstryckeriet, 2004. ISSN-1402-1757.

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4.3 References to Tables

[1-5] Tables from López-Mesa, B.; "The use and suitability of design methods in practice. Considerations of problem-solving characteristics and the context of design". Ph.D. thesis, Lulea University of Technology (Sweden): Universitetstryckeriet, 2004. ISSN-1402-1757.

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