7 IDEA FIXATION IN DESIGN: THE INFLUENCE OF PICTURES AND WORDS

Carlos Cardoso[a] **and Petra Badke-Schaub**[b]

Faculty of Industrial Design Engineering, TU Delft, Landbergstraat 15, 2628 CE Delft, The Netherlands, Fax: +31 (0)15 27 87662, Tel: +31 (0)15 27 83451. E-mail: [a]*c.m.cardoso@tudelft.nl,* [b]*p.g.badke-schaub@tudelft.nl*

During design problem solving designers often search for support in external sources of information, such as pictures, written descriptions and physical examples of available solutions. While devising new concepts designers sometimes become too attached to particular ideas, either developed by them or induced by external precedents. Inadequate adoption of features and principles from other existing solutions has been described as design fixation. These issues have been discussed as having an impact on design creativity and innovation. The study presented here investigated the influence pictorial and written representations, of a particular solution, had upon a group of industrial design students addressing a design problem. The results clearly demonstrate the presence of fixation with the participants exposed to the pictorial example, but not to the written material. Reasons for such discrepancy are discussed and examined in terms of the implications it might place upon designers' inclination to favour specific sources of information.

Keywords: Design Fixation, Pictorial, and Written Representations.

1. INTRODUCTION

Design problems are commonly characterised as ill-defined and ill-structured (Simon, 1973), frequently presenting unclear initial conditions and in turn including a multitude of possible solutions (Badke-Schaub & Buerschaper, 2001). Whilst designing, students and professionals utilise different techniques, methods and sources of inspiration to both structure problems as well as to develop solutions. However, throughout the design process, designers (especially experienced ones) often get particularly attached to certain dominant concepts, which they continually try to improve instead of diverging onto alternative solutions (Rowe, 1987; Lawson, 1997; Günther and Ehrlenspiel, 1999). This strong premature, and sometimes inappropriate, attachment to design features/concepts designers are working on (as well as on other existing designs) might be interpreted as a certain type 'fixation' in design.

2. TYPES OF FIXATION

The notion of fixation originated primarily in Gestalt theory, where a series of studies were conducted to explore the occurrence of this behaviour (Maier, 1931; Duncker, 1945; Luchins and Luchins, 1959). Fixation unfolded into different categories, generally referred as a series of 'inappropriate' assumptions people exhibited when trying to solve a particular problem they were presented with. For instance, one type of fixation, termed as "functional fixedness", describes a behaviour whereby people can only conceive of a single and typical use or function for a particular object (e.g., a hammer is for knocking nails) when it was advantageous to use it for an untypical task (Maier, 1931; Duncker, 1945). In this type of fixation, people are hindered by their experience with the use of particular devices and cannot think of novel ways to utilise such objects. Another type of fixation, coined as "mechanised thought" or "mental set", describes a behaviour whereby participants in an experiment were asked to tackle a

set of problems, which could be solved using the same algorithm. When they came to the last problem, which could not be solved by the algorithm used earlier but instead through an easier approach, they were fixated on using the original algorithm; ultimately, failing to notice an obvious solution to the problem (Luchins and Luchins, 1959).

Fixation, which has since been studied in several fields, was later revisited in the area of design. Design research on fixation has demonstrated that designers' ability to come up with new ideas could be hindered when presented with pictorial representations of existing solutions (Jansson and Smith, 1991). Such research encompassed a set of experiments involving senior mechanical engineering students, as well as one with professional engineers. In these experiments the participants were presented with a picture of an existing solution prior to addressing a particular problem. It was found that the different pictures presented, which were directly related to the problem at hand, had a major influence upon the designers' ideas. That is, a significant number of the ideas developed by the designers incorporated a number of characteristics from the given example, even features that were explicitly poorly designed. The main outcome of such research was the conclusion that designers who were exposed to pictorial representations, became 'fixated' and were thus prevented from considering other (new) ways of solving the problem in question. This led to a redefinition of previous notions on fixation, with the term "design fixation" put forward as the restrictive, premature, and often inappropriate, attachment to a set of ideas during the design process (Jansson and Smith, 1991). Further studies on this topic, using some of the same priming material examples and experimental conditions implemented by Jansson and Smith (1991), investigated the role of disciplinary background in relation to the presence of fixation (Purcell and Gero, 1996). These studies confirmed the presence of design fixation on students from a mechanical engineering background, but found no evidence of 'traditional' fixation effects on industrial design students (Purcell and Gero, 1996). The main conclusions were that fixation could be related to educational programmes, industrial designers being trained to generate as many novel ideas as possible.

Both the aforementioned studies, which explored the occurrence of fixation during idea generation, incorporated the use of pictorial representations as the main fixation stimuli. Purcell and Gero (1996), though, carried out one experiment where participants were presented with written instructions versus pictorial material as triggers for fixation. However, possible differences in the effects caused by these distinct priming materials were not explicitly discussed.

The study presented here explores the topic of design fixation further by comparing the effects of designers' exposure to different types of representational material during the ideation phase. The design fixation studies performed earlier (Jansson and Smith, 1991; Purcell and Gero, 1996) were particularly pertinent given the importance that pictorial sources of information have on design processes. This is especially the case when considering that during idea generation designers find inspiration in a variety of sources, especially in visual representations (Eckert and Stacey, 2001). However, design practitioners also come across other sources of information during the design process, such as: existing physical designs and its contexts; external encoded sources like books and drawings; and their own internal recollection of background experiences (Eastman, 2001). The study presented here places emphasis on the influence of pictorial versus written representations of a precedent design solution, which will be compared as potential fixation stimuli. The study does not primarily presuppose any possible positive or negative effects originating from these different types of representations, but rather their influence as sources of fixation.

3. EXPERIMENTAL SET UP

The study presented in this paper comprises the analysis of the results of 24 participants from a larger experiment where 72 masters students (from an industrial design engineering course) were asked to generate solutions for the same design problem, yet under different treatment conditions.

The design exercise consisted of an assignment where students were asked to individually design through sketches: "a device that allows people to pickup a book from a shelf (e.g., in a library) that is out of their reach, for instance above their head." Attempts were made to devise a design brief

that was intentionally non-complex, as the participants were expected to be able to develop several concepts within the duration of the session. The participants were instructed to design as many ideas as they could during 60 minutes. They were also requested to explain their solution ideas by adding written notes to their sketches, if they thought it would help clarifying their designs in terms of usage, materials, mechanisms and so forth. Lastly, the design exercise explicitly stated that the solution/s should be: easy to use; possible to manufacture with existing technologies; and, that they should not damage the books. At the end of their sketching sessions, the participants were also asked to fill in a short questionnaire comprising a few questions about the assignment. The experimental design encompassed three distinct set up conditions, which resulted in three different groups of participants, namely:

1. Control group: eight participants were presented with the aforementioned design brief
2. Pictorial group: eight participants were provided with the design brief and a pictorial representation (priming material) of a possible existing solution (Figure 1)
3. Written group: eight participants were given the brief and a written description (priming material) of the same pictorial representation (Figure 1)

4. DATA ANALYSIS

The analysis of the results includes the measurement of: the number of ideas generated and the occurrence of fixation aspects.

In order to identify the occurrence of design fixation in the outcome of the treatment groups (pictorial and written) a system of categorisation was developed based on the characteristics of the existing example solution (Figure 1). The categorisation enabled assessing the designs from the treatment groups in terms of similarity (of features and principles) to the characteristics of the example provided to them. The participants' ideas showed signs of design fixation if they incorporated a:

1. design with a hand tool
2. design with extension of the arm/s
3. design using mechanic clamps/fingers (to grip book)
4. design using a tube/pole (as an arm extension).

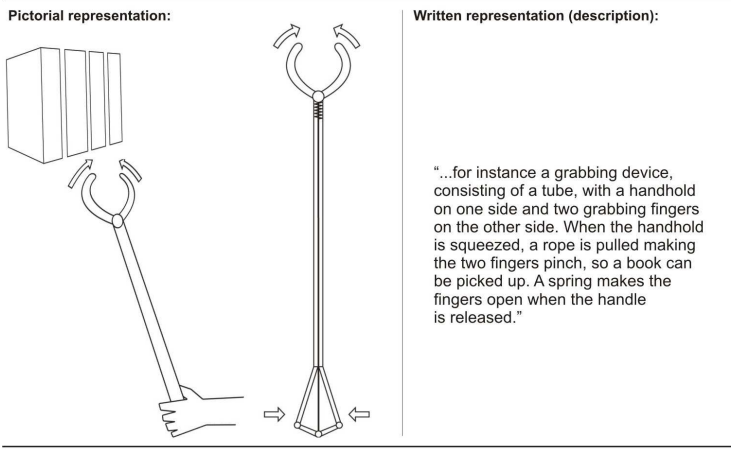

Figure 1. The left hand side of the figure shows the pictorial representation of an existing solution of a device to grab objects presented to the pictorial group. The right hand side of the figure shows the written description presented to the written group.

Whereas the second and fourth signs of fixation are strongly correlated, they were kept as separate categories. In fact, several of the participants' sketches incorporated concepts where an extension of the arm was achieved through some sort of long tube/pole. However, in some other occasions arm extension was accomplished by devising different designs.

5. RESULTS

This section presents the number of solution ideas and the occurrence of design fixation effects for all three groups. Evidently, the 'sum of fixation aspects' for the control group cannot be interpreted as fixation, because this group was not exposed to priming material; the data simply relates to the features/principles that coincide with the priming example and may be regarded as a kind of baseline. An overview on the number of solution ideas and occurrence of design fixation effects can be taken from Figure 2.

Despite the apparent difference of the mean results between the three groups regarding the number of solution ideas (see Table 1), a Paired T-test applied to these values shows no significant results. Therefore, absence or presence of priming material does not affect significantly the number of solution ideas developed by the participants.

Conversely, the results on Table 2 also show that when combining the four different fixation aspects (i.e., "Sum of fixation aspects") the participants exposed to the pictorial example were significantly more fixated, when compared to the control ($p < 0.05$) and the written ($p < 0.01$) groups. On three out of four categories, which indicated the occurrence of design fixation, the participants from the pictorial group scored higher than the control group. They generated more solution ideas comprising a hand tool, more solutions with extensions of the arm, and more designs using a tube or a pole as arm extension. These findings resonate with studies performed with mechanical engineering students

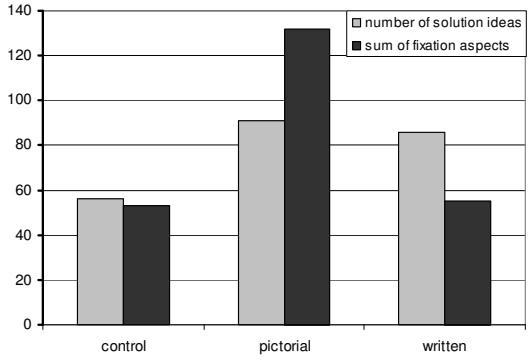

Figure 2. Total number of solution ideas and fixation aspects per group (one single solution idea can present from zero up to four fixation aspects).

Table 1. Total number of solution ideas generated per group (first row); average numbers of solution ideas (second row) and average numbers of different categories of fixation aspects per participant for each group (rows three to six).

	Control group (n=8)	**Pictorial group (n=8)**	**Written group (n=8)**
Total no. of solution ideas per group	56	91	86
Av. no. of solution ideas per participant	7.0	11.4	10.7
Av. no. of solution ideas with a hand tool	1.9	4.9	2.6
Av. no. of solution ideas with extension of the arm/s	2.0	4.7	2.0
Av. no. of solution ideas using mechanic clamps	1.0	2.6	0.5
Av. no. of solution ideas using a tube/pole	1.7	4.2	1.7

Table 2. Differences in frequency of occurrence of fixation aspects between the different groups — control, pictorial and written ($p < 0.05$ *; $p < 0.01$ **).

	Control vs Pictorial	Control vs Written	Pictorial vs Written
Sum of fixation aspects	0.03*	0.92	0.01**
No. of solution ideas with a hand tool	0.03*	0.63	0.12
No. of solution ideas with extension of the arm/s	0.03*	0.91	0.04*
No. of solution ideas using mechanic clamps (to grip book)	0.11	0.17	0.01**
No. of solution ideas using a tube/pole (as arm extension)	0.02*	1.00	0.02*

where the participants' ideas presented clear signs of fixation, by integrating a number of features comprised by a pictorial priming example (Jansson and Smith, 1991). When comparing the pictorial to the written group in terms of individual fixation aspects, the above results (Table 2) also indicate that the former group was significantly fixated on all categories, with exception of "No. of solution ideas with a hand tool". Lastly, the written group exhibited no significant fixation effects when evaluated against the control group ($p = 0.92$).

6. DISCUSSION

As stated earlier in this paper (Section 2), the main purpose of the experiments presented here was to investigate the possible influence of pictorial and written representations during a short ideation design exercise. Of particular interest was to find out if these two different ways of representing an existing design solution would have a different effect upon designers addressing the same design brief.

6.1. Comparison to Earlier Experiments on Design Fixation

At the beginning of this research, it was hypothesised that a pictorial representation of an existing design solution would place greater influence (causing fixation on certain features/principles) upon the participants, when compared to the effects of a written description. The results presented earlier (Section 5) suggest that this was the case. Furthermore, the results are intriguing when compared to earlier studies, which found no evidence of fixation on designers exposed to pictorial representations and from similar educational backgrounds (Purcell and Gero, 1996). It is important to acknowledge, however, that these prior studies encompassed a series of experiments with a higher number of both participants and design exercises (Purcell and Gero, 1996). This may have enabled a more (reliable) quantitative investigation of the occurrence of design fixation in a larger sample of individuals. In turn, this would suggest that to further explore the presence of fixation aspects in the experimental set up conducted here, more participants would have to be involved.

6.2. Negative Attributes of the Priming Example

It is interesting to observe that the device depicted in the pictorial example used here (Figure 1), is in fact a poor solution for the task defined in the design brief. This type of device, often sold under the name of extendable reacher/grabber, is indeed meant to be utilised to grab objects that are out of arms' reach. However, if this device were to be used to pickup a book, especially the ones that are tightly placed against one another on library shelves, it would probably present a series of shortcomings. Three such shortcomings would be: 1) grabbing fingers/clamps that are too thick to be inserted in-between books, aggravated by being limited to pickup the books horizontally; 2) non-extendable tube, which prevents the user from reaching higher shelves; 3) poorly designed handle, which follows the same line as the tube, potentially causing discomfort and excessive strain upon one's wrist when positioned at certain angles.

In regard to "No. of solution ideas using mechanic clamps (to grip book)", Table 2 suggests no significant results on the probability of this aspect being a sign of fixation when the results from

control and the pictorial group are compared ($p < 0.11$). However, when revising all the solution ideas from all groups something else emerges. Due to the general simplicity of the sketches produced by all participants, details about attributes 2 (tube extension) and 3 (device's handle) could not be clearly verified. However, attribute 1 (clamping books with thick mechanical fingers) was easily recognised. Therefore, and despite the aforementioned apparent shortcomings of the priming example (and the lack of statistical significance before mentioned), a considerable number of solution ideas developed by the pictorial group reproduced variations of such poor attributes. This is especially the case with attribute 1 which is (arguably) the worst feature of the device represented by the pictorial example — i.e., clamping the books horizontally (Figure 3). The solution ideas generated by the pictorial group incorporated 15 concepts with horizontal clamping of books, against 5 for both the control and the written groups. Once again, this is similar to what Jansson and Smith (1991) found when they deliberately exposed their participants to pictorial examples depicting devices with clear negative characteristics. Ultimately, such participants were also fixated on negative features present in the pictorial examples.

6.3. Equivalence Between Pictures and Words

At the beginning of this project, attempts were made to create a certain level of equivalence between the information entailed by the pictorial and the written representations. However, inevitably they are unlikely to mirror each other. In fact, whilst pictures have been defined as iconic representations of an object's physical properties, words have been described as symbolic representations (Anderson, 1980; Tipper and Driver, 1984). Therefore, the difference in results between the outcome of the pictorial and written groups could in part be due to how the materials are perceived. Pictures are usually more concrete (than written material) and easily retrievable in its entirety. Over a long period of time, pictures are also more accessible than written material. Consequently, this graphic material influenced the pictorial group's solution ideas, which ended up showing signs of design fixation. On the other hand, the written material was more abstract leaving room for more interpretations; ultimately, causing minor levels of fixation on the features/principles that it was trying to represent.

Another possible explanation for the discrepancy of fixation effects between the pictorial and written groups could have also been related to how this material was utilised during the session. The picture is

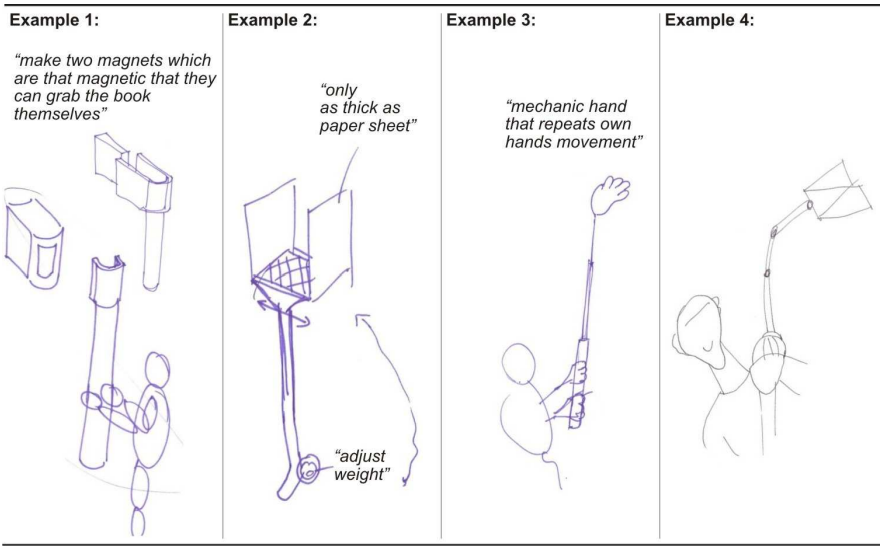

Figure 3. Examples of solution ideas generated by the pictorial group where the similarities with the pictorial representation (priming material, Figure 1) are quite clear. The written notes in Examples 1, 2 and 3 were typed for the purpose of clarity.

essentially much faster to view when compared to the text, which could take a few seconds to read and even more to understand what it actually tries to represent. Therefore, while the pictorial group had the possibility to repeatedly take a quick look at the picture (helping them to keep it constantly present in their mind); the written group would probably (re)read the text a lot less, if at all. In fact, feedback provided through a questionnaire, that was given at the end of each participant's session, indicate how some of the individuals in the written group dealt with, or even avoided, the text, saying: *"I didn't take into consideration the possible solution, because I didn't want [it] to affect me"*; *"it limits your ideas, so I didn't read it"*; *"I don't really understand, (or too lazy to imagine, I guess) I prefer drawings and less words to imagine the system"*. On the other hand, the pictorial group felt generally influenced by the picture of the device, stating that: *"started thinking in devices which you can hold in your hand (…) limited in the first few minutes"*; *"It did affect me (…) it limited the ability, because the starting point was 'fixed'."* ; *"it limited my initial ideas to some extent"*; *"it covered up the idea of grabbing, with the given limitation, I felt restricted to think in that way"*. In the end, it seems that the written text was easier to avoid, while the picture placed greater influence upon the participants.

7. CONCLUSIONS: IMPLICATIONS FOR DESIGN

The study presented here has demonstrated the occurrence of design fixation in a group of industrial design students exposed to a pictorial representation of an existing solution. The experiment has also shown that another group from the same educational background, which were given a written representation of the same object, was not significantly fixated by that example. The pictorial group generated solution ideas which integrated a lot of the features comprised by the priming example. Some of those features, which involved already negative aspects in the original example, were again reproduced by these participants resulting in (new) poorly designed solution ideas.

At first sight, this suggests that designers' creativity could at times be inappropriately biased by pictorial examples, ultimately representing a hindrance to innovative design. The strong influence of pictorial representations upon designers' creative performance could unveil serious implications regarding the use of visual material during design projects. Ultimately, the impact of pictorial representations upon designers' cognitive processes becomes particularly relevant in light of previous research which identified such professionals as visual communicators, usually preferring more visual means of information (Muller, 1989, Tovey, 1992, Henderson, 1999, Hanington, 2003).

On the other hand, the low level of design fixation for the designers exposed to a written description could be an indication to further explore such representations as alternative ways of conveying information during the design process. However, feedback from some of these participants suggests that the reason why the written description did not influence (fixate) them was actually due to the fact that they tried to avoid it, rather than taking it into consideration. This is again congruent with the 'professional tendency' designers have to be more receptive to visual methods of information gathering and processing.

Due to the number of participants and type of exercise (design brief) involved in this study, it is important to be conservative in regard to possible extrapolations. The overall findings are an indication that there might be a difference in how distinct external encoded sources of information influence designers' creative process, during idea generation. Up until this date though, fixation in the design process has not been empirically proven as a predominantly negative or positive influence. Further research is required to investigate the impact of different materials as potential sources of fixation during the design process. This could include, for instance, research on the influence that other sources of information, such as video and multi-media material, could place upon design practitioners.

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