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DESIGN FINDS A WAY: CREATIVE STRATEGIES TO COPE WITH BARRIERS TO CREATIVITY

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Abstract

Creativity is quintessential in design ideation, as it fuels innovation in an ever-changing world. However, designers often experience states of being stuck and fixated, either on their own solutions, on examples or on the design process. A think-aloud protocol study and interviews were conducted with 31 novice designers in order to capture their strategies to cope with fixation and other types of hindrances to creativity. The findings corroborate past research on design fixation, adding a qualitative perspective to the existing growing body of knowledge on this topic. Furthermore, the study reveals the opportunistic and sometimes unexpected strategies designers apply in order to continue ideation. This paper contributes to the understanding of the opportunistic behaviour of designers in ideation and has implications for the study of design fixation and other barriers to creativity at the methodological level.

Keywords: Creativity, Design methods, Early design phases, Design fixation, Opportunism

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1 INTRODUCTION

A blank page, waiting to be filled with ideas, can be an intimidating sight. Yet, in design and comparable fields, it is usually required that creative ideas are generated on demand. Design problems are considered to be wicked (Rittel and Webber, 1984), dynamic and interconnected and their outcome is usually required to be innovative. Such requirement for creativity emerge from an ever-changing world, where many issues need to be taken into account, such as technological, sustainable or ethical ones. Thus, investigating design creativity is an essential step towards supporting the constant demand for innovative solutions. From the many phases designers go through, ideation is the one where creativity is most likely to flourish, as constrains are momentarily lifted and idea exploration is welcomed (Osborn, 1957). Yet, ideation can be hampered by a number of obstacles, such as fixation effects or task-related complications, which can hinder the generation of creative solutions (Agogué et al., 2014; Cardoso and Badke-Schaub, 2011; Jansson and Smith, 1991; Purcell and Gero, 1996). In order to support ideation, a large variety of design methods are available to designers (e.g., Chulvi et al., 2012). This paper presents a qualitative study, composed by verbal protocol analysis and interviews, on the type of hindrances to creativity designers encounter while solving an open design problem and the respective formal and informal strategies they used to overcome such obstacles. This study is part of a larger research project, on the designers' use of stimuli for inspirational purposes and its influence on design creativity. Given the setup of the study, participants were allowed to use external stimuli but not obliged to use it. Thus, when barriers to creativity arose, many other strategies (besides the use of stimuli) were observable. The aim of this paper is to complement recent qualitative research on fixation and to support design creativity, by focusing on a variety of different perspectives on formal and opportunistic design strategies.

2 THEORETICAL REVIEW

The creative design process can be defined as an accumulation of precedents, where ideas are built upon previous ones, in a combination of incremental steps and sudden creative leaps (Crilly, 2009). This means that, although sudden insights seem to be disconnected from previous ideas, they usually result from earlier cumulative attempts to bridge the problem and solution space (Dorst and Cross, 2001). Creative ideas, i.e., *novel* and *appropriate* solutions to a problem (Smith and Ward, 2012), do not usually come effortless: from understanding the multidimensional context of a problem, to delving into information, until the fine-grain elaboration of the solution, many obstacles can be encountered. Some of them are cognitive and refer to situations where designers feel *stuck* or *fixated*, either on the exploration of solutions, on the understanding of the problem or on how they approach the process (Crilly, 2015; Youmans and Arciszewski, 2014). Such cognitive obstacles are classified under the term design fixation: a state where designers are unconsciously influenced by earlier ideas, precedents or assumptions, which causes them to halt the exploration of solutions. This definition entails a number of considerations: that fixation is not perceived consciously by designers; that it has detrimental effects on the exploration of solutions; and that it comprises a number of behaviours under the same umbrella. For instance, fixation caused by *prior concepts* relates to *premature conceptualisation* (Darke, 1979; Smith and Ward, 2012), where designers become too attached to their first ideas and fail to consider alternatives. Fixation caused by *examples* relates to the most common understanding of design fixation, where designers unconsciously and inappropriately repeat features of similar examples (Cardoso and Badke-Schaub, 2011; Jansson and Smith, 1991; Purcell and Gero, 1996). Finally, fixation caused by *assumptions* is related to the phenomenon of *mental set* (Luchins and Luchins, 1959), which refers to a tendency to follow the same approach irrespectively of the problem at hand.

In an attempt to explore the field of fixation, Sachs (1999) used the term *stuckness* and characterized it as a number of situations recognized in design education and practice, which always have the same result: the inhibition of creative thinking. These hindrances ranged from *Being at a standstill*; *Taking too long*; *Not moving past an initial diagram*; *Fixation*; and *Repetition* (Sachs, 1999). In this study, in order to elicit participants information on fixation, we used the expression *being stuck*, as it was considered more colloquial and carried a less negative connotation than the term *fixation*.

To cope with these cognitive phenomena and other impediments to creativity, designers have many resources to their avail. For instance, design methods, such as Brainstorming (Osborn, 1957) and Morphological Analysis (Pahl and Beitz, 1996) can be used to explore and subsequently structure the

solution and problem space, and many more have proved their efficiency (Chulvi et al., 2012). However, in practice, designers tend to stick to a small number of trustworthy methods, which have proved time after time to be able to support ideation (Gonçalves et al., 2014). Finding inspiration in external stimuli is another strategy to support creativity, as stimuli can be used to reduce uncertainty, inform the evolution of the problem and solution space and to stimulate ideation (Gonçalves et al., 2016).
Besides searching for inspirational information and using design methods, designers are also known to follow opportunistic strategies in design. For instance, Guindon (1990) demonstrated that designers apply cognitive shortcuts to decompose solutions, especially in ideation, which results in redefinitions of the problem. Moreover, opportunism has been indicated as one possible hypothesis to explain how incubation in creative problem solving occurs (Seifert et al., 1995). Taking this into consideration, it is possible to argue that other informal and opportunistic strategies are likely to exist in the designers 'toolbox', which can potentially be helpful when fixation occurs.

3 RESEARCH METHOD

This study was composed by a controlled ideation session, where participants were asked to generate as many ideas as they could while thinking aloud, followed by a semi-structured interview. Verbal protocols were used, as the participants were working individually and this method enables the analysis of intuitive and unconscious processes. Verbal protocols have showed to be a valid method in design, with only limited influence on the participants' behaviour (e.g., Atman and Bursic, 1998). Combining verbal protocol with other types of inquiry, such as interviews and pen-and-paper ideas, is beneficial to increase the validity and richness of the cognitive processes obtained. Thus, the ideas created during the ideation session by the participants were also used to support the in-depth qualitative analysis of protocols and interviews. Each idea also received a creativity score. However, due to the limited number of participants per condition, this quantitative analysis was not included in the paper, as it was considered to be inadequate to support generalizability of the findings. No hypotheses were defined beforehand, as the study was of an explorative nature.
The design brief used in the ideation session was to *'design a product to help children of young age (3-5 years old) sleep alone through the night, in their own bed'*. This brief was selected as it was sufficiently open-ended and ill-defined to enable the exploration of many solutions. A pre-test showed that the brief was accessible for a short ideation session and did not require specific technical knowledge. A search tool was created to investigate how designers search and use stimuli when solving a design problem, which allowed us to capture the designers' stimuli use behaviour in a controlled manner. All stimuli were carefully chosen to fit this study and included, in total, 200 stimuli, composed by 100 images and 100 short texts. The stimuli could be either closely or distantly related to the design brief at hand (problem-specific), but also visual and textual.

3.1 Conditions

31 Master design students from an Industrial Design Engineering faculty agreed to participate in this study. Their average age was 24 years old, and 17 participants were female. They had, in average, five years of design education and only four participants had past professional experience. Participants were randomly allocated to one of the following three conditions.

- *Control* condition (N = 10), where the participants were not able to use external stimuli, as they did not receive access to the search tool. They did not know of its existence.
- *Unlimited* condition (N = 10), where the participants were able to use the search tool, with no restrictions. They could use it at any point during the session, as many times as they would like, for as long as they wished. Consequently, participants were able to search for many different keywords and stimuli within the given time of ideation.
- *Limited* condition (N = 11), where the participants were able to use the search tool, but with limited access. They were informed that they could only search for *one* keyword and choose *one* stimulus during the whole ideation (diverging and converging phases combined). There were no other restrictions, as participants could choose the moment when to use the search tool. No extra time was given to stimuli search, as it was the case with the *Unlimited* condition.

With these three conditions, different types of access to stimuli and their influence in design could be investigated. The *unlimited* condition is the closest to design *in the wild*: the participants could spend as much time as they wished searching for information, which could limit their time for ideation. Likewise,

designers in practice are often confronted with an overload of information (Atman et al., 1999) and a considerable portion of time is spent in its management (Court et al., 1993). However, even *in the wild*, designers are forced to cut their search short and prioritise their stimuli selection, as their time is often restricted. Thus, the *Limited* condition aims to represent an exaggerated prioritisation of stimuli, in order to better capture their selection strategies. Finally, the control condition provides a baseline of ideation without any stimuli.

3.2 Ideation session

The experiment took, on average, one hour, and it was composed of three phases: a *diverging* phase (participants created as many ideas as they could in 30 minutes); a *converging* phase (elaboration of a final concept for 10 minutes); and an *interview* (participants retrospectively reflected on the session). During the *diverging* and *converging* phases, the participants were asked to think aloud, and were reminded of it if they fell silent for more than 20 seconds, by rule of thumb. The division of the session in a diverging and converging phase enabled to explore a somewhat more complete perspective of the design process (in comparison to a simple idea generation task). By asking the participants to converge, our goal was to also represent later stages of the design process.

3.3 Analysis of the design protocols and interviews

All ideation sessions were videotaped in three angles (to capture the participant's body language, the ideas being generated and the overall scene). Additionally, the use of the search tool was also synchronously recorded. The software INTERACT Mangold International was used to code segments of the participants' speech in the four recordings simultaneously. Furthermore, the solutions were also analysed, by identifying them as single ideas and by matching them with the protocol sessions. This analysis enabled to map which ideas were influenced by stimuli from the search tool. Approximately 21 hours of design protocol videos and 418 single ideas were analysed and from this, a coding scheme emerged with a total of 5 themes and 29 codes. Each code was mutually exclusive, but individual segments could contain more codes (from other themes) simultaneously.
All interviews were videotaped, transcribed verbatim and coded using the software Atlas-ti. The author coded the 31 interviews, with a second coder analysing a subset of the data and reaching an agreement of 74.1%. After several coding iterations, a coding scheme with 5 themes, 14 categories and 57 codes emerged (different from the protocol analysis). This paper focus solely on the themes regarding the generation of ideas and coping with constraints encountered.

4 RESULTS

This sections presents the results of the analysis of the design protocols and interviews, concerning two main topics: the hindrances to creativity felt by the participants during the design exercise and the strategies they used to overcome them. The total number of ideas created during the *diverging* phase was 387, across the three conditions. The *Control* condition generated 145 ideas (M = 13.5), whilst both experimental conditions created exactly 121 ideas (*Limited* M = 11.0 and *Unlimited* M = 11.1). The number of concepts resulting from the *converging* phase was 31 (as each participant had to create only one final concept). Further quantitative results are not included here, as explained in section 3.

4.1 Encountering hindrances to creativity

Even though participants were very prolific in the generation of ideas, all 31 participants reported to have felt stuck, at varied stages. This was either commented during the ideation itself, in the moment of stuckness, and/or revealed during the interview, when looking back at the ideas created. Further analysis revealed that the feeling of being stuck could be unfolded in a number of phenomena, which is similar to Sach's multiple definition of stuckness (see Section 2). Rather than being a phenomenon in itself, feeling stuck could be seen as a consequence of many different hindrances to creativity. In general, participants reported feeling stuck whenever they could not produce any more ideas, and that was a result from one or more of these hindrances (Table 1):

Table 1. Hindrances to creativity experienced during the session and the number of participants who referred to them, across conditions

HINDRANCES TO CREATIVITY	CONTROL (N=10)	UNLIMITED (N=10)	LIMITED (N=11)
Mental set	6	5	1
Premature conceptualisation	4	0	0
Search tool failure/frustration	——	0	4
Awareness of design fixation risks	1	4	2
Design fixation (unconscious direct repetition of stimuli)	——	4	2
Stuckness (run out of ideas) CONSEQUENCE	10	10	11

Mental set: Defined as the inability to change approach to solve a task (Luchins and Luchins, 1959), mental set was the phenomenon mostly connected to the feeling of being stuck. 12 participants across conditions mentioned the inability to solve the problem differently. Considering the openness of the design brief used in this study, there was virtually an infinite number of directions to tackle it. To encourage children to sleep through the night, participants could design solutions that would keep them company, shelter them or track their sleep, being all of these very distinct approaches. Yet, participants reported difficulties in jumping between directions, especially in the *Control* condition, where they could only rely on past experiences and existing knowledge to continue ideation:

> *"But it took me quite a while for me to realize that maybe I should look into other directions (…) maybe it was too much of this one thing in the beginning, and I should have explored more options.(…) You get a little bit of narrow minded view". (C7)*

Premature conceptualisation: The unreflective commitment to first ideas, even when they are unsuitable to solve all requirements of the problem (Crilly, 2015; Smith and Ward, 2012), resulted in a momentary standstill in ideation and, thus, a feeling of being stuck in four *Control* participants:

> *"It might also be dangerous that you stick to this first idea, that you are really enthusiastic about and you have this ah-ha feeling about. Then it might be a threat for the quality of your project, if you don't force yourself to first take another point of view and explore that". (C5)*

Participants in the *Unlimited* and *Limited* conditions might have not experienced this early attachment to ideas since they had the opportunity to explore the search tool.

Failure to use search tool/stimulus: The *Limited* and *Unlimited* conditions were allowed to use the search tool, whenever they considered necessary. Thus, the search tool could be considered a formal strategy to cope when ideas ran out. However, four participants, all from the *Limited* condition, reported to have felt momentarily unable to continue producing ideas after their use of the search tool. Contrary to the previous hindrances, this failure is not a cognitive behaviour. It resulted from the *Limited* condition imposed restrictions, since occasionally their chosen stimuli did not fulfil the participant's expectations. Whenever the selections were unexpected or did not immediately stimulate the generation of new ideas, participants felt frustrated. Interestingly, four participants of the *Unlimited* condition (N=10) refused to use the search tool, even when they could not create more ideas and felt stuck. They reported that they did not want to be influenced by the stimuli provided and preferred to rely on their experience. This indicates that the participants might have been aware of the risks of becoming too attached to examples (e.g., Jansson and Smith, 1991). The following quote of participant U4 is representative of this awareness against actively searching for stimuli:

> *"But I do not search for the existing products that are there. Because I feel it sorts of narrows me down and I start thinking in that direction (…) directly related to the problem, no, I don't usually. I avoid doing that because then puts me on a sort of track". (U4)*

The participants also expressed that their refusal to use the search tool was due to the assumption that it would be similar to existing search engines and too many results would be shown. Furthermore, it was possible to understand that defining keywords to initiate the search was considered a difficult step in the inspiration process (Gonçalves et al., 2016). The remaining six participants of the *Unlimited* condition and all eleven participants of the *Limited* condition used the search tool and asserted how important

searching for stimuli is in their usual design work. These participants manifestly prefer to be surrounded by as much information as possible.

Design fixation: Although design fixation was not consciously perceived and reported by any participant in the interview, many ideas in the session were directly related to chosen stimuli, as it can be seen in Figures 1 and 2. Arguably, these participants, who directly repeated features from the stimuli, were unintentionally fixated. Nevertheless, when the goal is exploration and to create as many ideas as possible, designers might feel the need to record these obvious ideas in order to move on to other directions, as justified by a participant from the *Control* condition:

> *" Just write all the previous ideas down, so you get rid of it, so it's out of your mind, and then I think this is also part of the problem analysis: what's really the problem". (C6)*

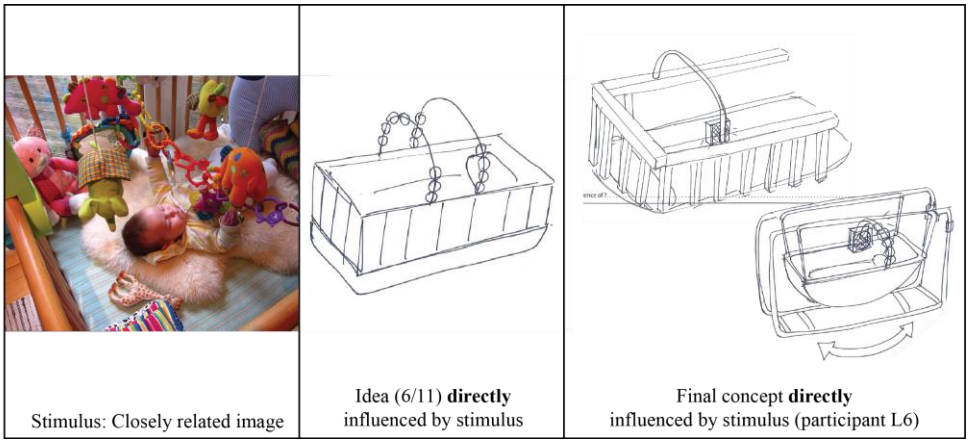


Figure 1. Direct influence of stimulus on an idea (diverging phase) and final concept (converging phase)

Thus, repeating examples at this early stage might not be an example of a barrier but a strategy to represent existing knowledge. Except in one situation (in the *Limited* condition, Figure 1), all direct repetition of examples occurred in the *diverging* phase. In their majority, ideas that were directly influenced by stimuli in the diverging phase evolved to become distinct concepts (Figure 2).

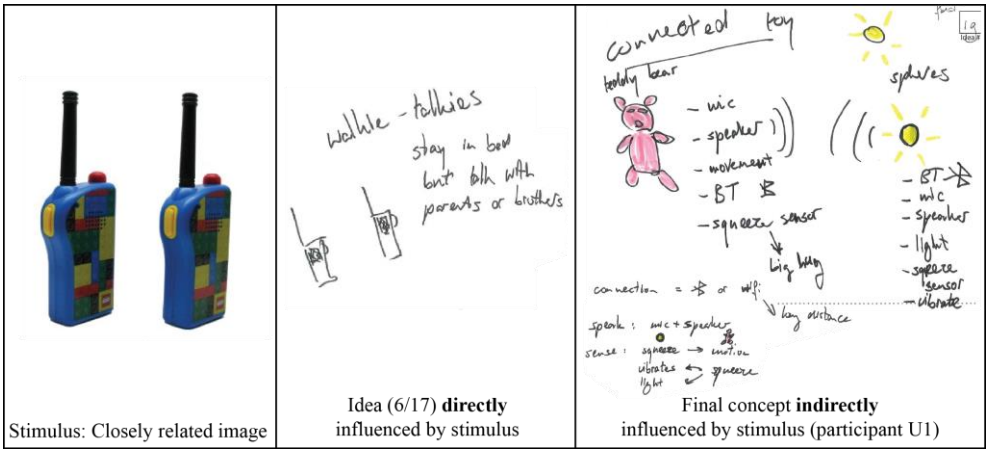


Figure 2. Direct influence of stimulus on an idea (diverging phase) and subsequent evolution into a distinct final concept (converging phase)

On the other hand, seven participants (one *Control*, four *Unlimited* and two *Limited*) did report to be conscious of the peril of relying too much on examples. These were also two of the four *Unlimited* participants who preferred not to use the search tool, precisely to avoid any attachment to stimuli.

4.2 Strategies to cope with hindrances to creativity

The previous section showed how the participants from this study felt frequently stuck. Despite their perception, they were able to continue ideation for the remainder of the session. Thus, the participants

were asked about the strategies they used to cope with the creative hindrances they encountered, which was combined with the direct observations of their behaviours during the session. These strategies are summarized in Table 2. For consistency, we excluded from this discussion coping strategies designers employ in their daily work, such as going for a walk and talk to colleagues.

Table 2. Coping strategies applied during the session and the number of participants who used them, across conditions

COPING STRATEGIES		CONTROL (N=10)	UNLIMITED (N=10)	LIMITED (N=11)
Reframing problem	By reformulating problem	5	5	6
	By listing problems/solutions	3	1	0
	By applying methods	0	3	3
Applying methods	Mindmap	0	3	2
	How to's	0	0	1
Combining ideas		4	3	2
Relying on personal experiences		10	10	11
Exhausting obvious ideas		6	3	2
Using search tool		——	6	11
Force fit		0	1	1
Goal-oriented doodling		4	2	1

Reframing the problem: Especially to cope with mental set and premature conceptualisation, participants indicated to follow three sub-strategies to reframe the problem: (1) To reformulate the problem, which consisted of rereading the design brief to reinterpret it, by focussing on different requirements; (2) To list problems/solutions, which involved the identification of problems to tackle or directions for solutions. Its purpose was to keep a record to support ideation; or (3) to apply methods, mainly mindmaps, to reframe the problem.

Applying methods: To initiate their idea generation session, five participants created mindmaps, prior to any search, and continued to use them throughout their session. Mindmaps were used to cover all initial ideas, but they also supported their browsing and stimuli selection. Only one other method was applied besides mindmap: "How to's". This method helps the reformulation of the problem by dividing it in sub-problem statements. Mindmaps and How to's were the only two formal methods employed by the participants during the sessions.

Combining previous ideas: The majority of participants who explicitly reported this strategy did not have access to external sources (four *Control*) or chose not to use the search tool (three *Unlimited*). It is important to notice that, although only a portion reported it as a coping strategy, all participants combined ideas at some point in their ideation. Combination of ideas has been considered one of the most important cognitive processes responsible for creative thinking (Estes and Ward, 2002; Smith and Ward, 2012). Although it arguably can reduce the flexibility of ideas (as combined ideas tend to be framed into similar directions), previous research supports that combination of ideas can lead to the emergence of novel features, especially between disparate concepts.

Relying on experience: To initiate the session or to cope with momentary halts in ideation, virtually all participants used their own personal experiences (although not all of them reported it as a strategy). In this case, their experience consisted of childhood memories, interaction with children, or prototypical examples present in culture, such as existing products for children. Hence, the first ideas generated were either plush toys and teddy bear type of solutions (24.1%) or solutions related to light (21.2%). The *Control* condition, without any external input, heavily relied on personal experiences.

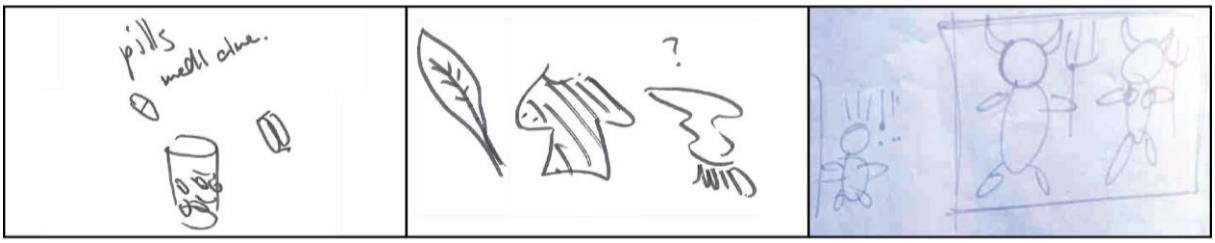
Exhausting obvious ideas: Although personal experiences enabled them to (re-)initiate ideation, 11 participants indicated that, in order to arrive to more creative ideas, it was essential to dispose of their first obvious ideas. In general, less obvious ideas populated the later stages of the ideation session.

> *"These things also come quite easy (…) And it's not that I really like them, but they are just associations I directly have, which I want to break away as fast as possible (…) to challenge what you already know. Because otherwise, you cannot come to new places." (U9)*

Using the search tool: As previously indicated, four *Unlimited* participants chose not to use the search tool. Otherwise, the search tool was used by the remaining participants once they ran out of ideas. Evidently, the *Control* condition could not use the search tool when feeling stuck. Resorting to the search tool was similar to using the Internet *in the wild*, where participants could search for information on the problem or simply find inspiration to fuel creativity.
Force fit: Instead of searching for specific keywords, a number of participants seemed to desire to be struck by inspiration randomly. Particularly, two participants (from the *Limited* and *Unlimited* conditions) reported that typing 'random' as keyword in search engines is an useful strategy to force opportunistic encounters with random stimuli when one does not know what to search for. Moreover, eight participants (one *Control*, three *Unlimited* and four *Limited*) indicated to use the Internet passively, where they hope to force a strike of inspiration. Force fit of random stimuli, even from disparate domains, is an example of the opportunistic behaviour of designers (Casakin and Goldschmidt, 2000; Guindon, 1990; Seifert et al., 1995). However, in the *Limited* condition, where participants had a single use of the search tool, forcing a stimulus into an idea resulted in the opposite reaction (as explained in Section 4.1).
Goal-oriented doodling: One of the most unexpected coping strategies was to generate inappropriate, incomplete or unrealistic ideas as icebreakers for ideation, as shown in Figure 3.

> *"So when I generate this idea I know that I was joking to myself but it was actually a solution. (…) So that's like an icebreaker. I mean these crazy ideas are not valid but they might have something that you might use. Or come from.". (C10)*

These doodles seem to have the clear goal of being starting points for potentially better ideas and it is another example of opportunism in design. In a diverging phase, these doodles are not meant to be taken as actual solutions (and evaluated as such), but explorations of the solution space.



Participant U1 idea 4 (of 10) Participant C1 idea 15 (of 15) Participant C10 idea 9 (of 20)

Figure 3. Examples of an inappropriate idea (left), an idea that started from a doodle of a feather (centre) and an unrealistic idea (right)

5 DISCUSSION

In general, an overwhelming sense of being *blocked* or *stuck* was reported by the participants, despite the large quantity of ideas generated. We did not arrive to a satisfactory assessment of their creative output, which prevented us to match the participants' perception with an objective evaluation of their outcome. Nonetheless, a number of relevant findings were possible to collect.
A large stream of research has extensively investigated the impact of design fixation, specifically on the repetition of features of examples, in design (e.g., Agogué et al., 2014; Cardoso and Badke-Schaub, 2011; Jansson and Smith, 1991; Purcell and Gero, 1996). Indeed, the unintentional repetition of precedents was observable in this study. Two contrasting behaviours were detected: whilst some participants repeated examples seen in the search tool, others were wary of using stimuli, showing to be aware of fixation effects (Crilly, 2015). The motivations of the participants who repeated examples seemed to have been to increase the number of ideas and to venture into different directions. Moreover, in the large majority of the cases, the participants' final concepts did not include repeated features as in their "fixated" ideas. Thus, design fixation was not necessarily detrimental and, in fact, premature conceptualisation (being fixated on their own ideas) and mental set (being fixated on the same approach) were observed more frequently than the mere repetition of examples.
The prevention and mitigation of design fixation have also been the focus of a number of studies (Agogué et al., 2014; Cheng et al., 2014; Goldschmidt, 2011; Linsey et al., 2010; Youmans and Arciszewski, 2014). These studies make recommendations for formal strategies on how to tackle design fixation situations. However, according to our findings, designers are also able to intuitively handle

hindrances to creativity, by creating and opportunistically adapting existing strategies to each situation (Guindon, 1990).
Usually, the first ideas, independently of the condition, were typical responses showing existing products. Whilst participants were aware that those ideas were potentially lacking in creativity, they still sketched them, as a participant from the *Control* condition explained:

> *"So I was thinking this is really lame (idea 1), but I have to just write down because this is what I'm thinking in the moment, you just have to get it out, and the afterwards, it becomes a bit more interesting. (...) It's almost too cliché to write down, but then you have to take it out of your head, because it's the first thing that you think of". (C7)*

The need to overcome the first wave of obvious ideas can be related to Parnes' theory of extended effort (1961). After the first burst of typical ideas, another wave of outlandish and surprising ideas takes place, as it was also observed in this study. Finally, a third wave of ideation usually combines the familiarity of ideas from the beginning with the novelty of the second wave, resulting in novel but useful solutions (Parnes, 1961). Furthermore, the behaviours observed in this study are also consistent with the two cognitive behaviours identified by Nijstad et al., coined as 'persistence and flexible pathway' (Nijstad et al., 2010). On one hand, the 'persistence pathway' is characterised by only incremental moves across the solution space, where ideas are similar between themselves. This is the pathway where obvious ideas arise, but can lead to the systematic exploration of the solution space and, eventually, to the development of creative ideas. On the other hand, following the 'flexible pathway' leads to versatile jumps between disparate ideas. Although opposing, creative thinking may include both behaviours: as observed in this study, the same participant could start by following a 'persistence pathway', where obvious ideas were exhausted, in order to explore a large amount of possible directions in the solution space. Within these incremental steps, associative jumps can occur and lead to the 'flexible pathway'. Thus, writing down all ideas, even the obvious or inadequate ones, should not be directly read as a symptom of fixation behaviours, but could be understood as persistence to represent the solution space.
These findings also point to a general methodological observation regarding the type of empirical studies done on fixation: evaluating the creative outcome of short ideation sessions, such as this one, is not representative and perhaps unfair to designers' capabilities, as the initial burst of ideas usually contains prototypical examples and obvious connections. Simply evaluating how many ideas repeated features of the stimuli presented does not necessarily indicate that participants were fixated. Instead, these might be implicit strategies to represent the solution space or to clear the path to more creative ideas after obvious ones. Both the problem and solution space understanding tend to mature over time (Dorst and Cross, 2001). Thus, it is reasonable to argue that, if extra time was given, participants would evolve from the initial stream of typical ideas into more creative solutions.

6 CONCLUSIONS

It is important to consider that these results are based on the retrospective perception of participants and on observations of their ideation sessions. Hence, there are caveats to consider. Firstly, it is still unclear what is the impact of the participants' behaviours on their creative outcome. Without a quantitative analysis of the pen-and-paper results, a full inquiry of the ideation process is not complete. Also, the participants of this study were Master students with limited experience, whose behaviours might differ from designers in practice. To complement these findings, future research could include a qualitative focus on different expertise levels, and on longitudinal design projects.
This study describes design fixation and other hindrances to creativity in a qualitative manner. Thus, it advances the study of barriers to creativity and how designers surpass them. Although the original focus of the study was not on design fixation, our findings inform the growing body of knowledge on this theme and approach it from a different methodological viewpoint. In the education realm, design students are encouraged to learn and practice a various range of formal design methods, being a large amount of them related to the exploration of the solution space. However, opportunistic behaviours and informal strategies are an important part of design students' toolboxes, and they seem to arise from opportunistic situations. This work reveals the existence of strategic shortcuts in design, in order to cope with creative barriers, such as design fixation. Understanding the formal and informal strategies designers employ in ideation can support a critical appraisal of design education. Furthermore, this work contributes to research on design creativity, and subsequently, innovation, as it triggers awareness on the creative ways designers cope with barriers to creativity.

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