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INSPIRING CO-EVOLUTION MOVES AND CREATIVITY IN DESIGN TEAMS

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Abstract: Our aim was to understand the relationship between stimuli and inspiration among design team members during the co-evolution of problem and solution in the ideation phase of the design process. Case studies with follow-up interviews were conducted with two multidisciplinary student design teams. The results show that there is a clear relation between designers' inspiration process and the use of stimuli. It shows that stimuli improve communication between designers, and thus help to support a frame of shared understanding. These two together enable a more fast-paced co-evolution process. We discovered differences between near future and far future focussed objectives for design teams, which includes more use of stimuli for shared understanding or inspiration. These findings together can ultimately support designers to be more effective and creative in future projects.

Keywords: *co-evolution, creativity, stimuli, shared understanding*

1. Introduction

One of the most prominent insights in the field of design process in the last 50 years is the understanding of idea development as an 'iterative process' (Roozenburg & Eekels, 1995). These iterations can also be described as a cyclic process, where designers repeatedly reframe and refine both their understanding of the problem and solution, going back and forth until they are firmly defined. Design process is rarely a linear one, but is rather an evolution of both problem and solution space.
This notion of evolution in design is described by the co-evolution model, first defined by Maher (e.g., Maher, 1994, 2000; Poon & Maher, 1997). It describes the relationship between problem space (expected behaviour) and solution space (structure), which can evolve alongside and influence one another through time (Figure 1). This was supported by Dorst and Cross (2001), who pointed out that creative design is an iterative process of refining the problem statement and solution, until a bridge connects both of them. Thus, designers are not only required to generate creative solutions, but also to define the problem of the ambiguous design issues beforehand. As such, problem definition is a predecessor for creativity, as it is the main trigger for the design process. Since designers generally start from an open and complex design problem, the search for information is seen as a facilitating tool to move between problem and solution space. As such, co-evolution occurs every time that a new event or information arises which triggers a change in the understanding of the problem and solution, until a matching pair is found (Dorst & Cross, 2001).

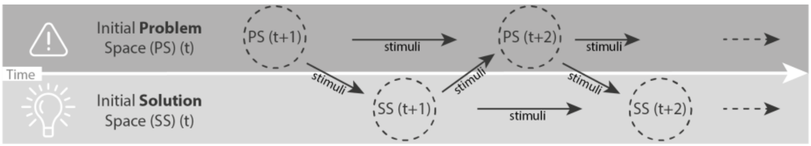

Figure 1. The model of co-evolution of problem & solution space (adapted from Dorst & Cross, 2001)

This model emphasizes the importance of surprise in the design process, which relates to Schön's notion of 'surprise', in which the eventual solution is constantly improved by framing and reframing of the problem (1984). Thus, surprising information can become inspirational when it changes the designers' perspective on initial problem statements, together with the development of ideas (Gonçalves et al., 2013; 2016). Besides surprising information, collaborative activity is another factor that strongly influences the co-evolution. Wiltsching et al. (2013) argue that about 67% of the co-evolution activities within a team's design process are collaborative design activities. Although design teams collaboration has been extensively researched (e.g. Avolio & Yammarino, 2002), only a limited few have focussed on co-evolution in teams (Hey et al., 2007; Wiltsching et al, 2013; Cash and Gonçalves, 2017). In design practice and education, most design activities are performed within a team context, rather than by an individual designer. Therefore, researching co-evolution in design team can be relevant for design practice to elaborate on what triggers co-evolution moves.

Additionally, there is a shift within design practice from teams consisting of only designers to multidisciplinary teams, involving specialists from a multitude of professions. Specially with approaches such as Design Thinking (Brown & Wyatt, 2010), the boundaries of design practice are expanding to include multiple perspectives, so that complex problems can be solved in a designerly way. Carlile (2004) indicated that differences in the amount and type of knowledge, unique to a specialisation, are crucial to solve a complex problem. However, difficulties of communication can rise among different domains due to the use of different language and methodology. These issues are confirmed by Valkenburg and Dorst (1998), who argued that the main difficulty lies in synchronizing the thoughts and activities of team members, i.e., create a shared understanding. To design solutions for complex problems, multidisciplinary teams can be key, as long as there is a shared understanding of the problem and solution space (Arias et al., 2000).

The results of this study will add new insights in the areas of inspiration, design teams and co-evolution. Due to the increasing number of multidisciplinary teams in companies and design education, and involvement of different stakeholders in the design process, specific knowledge about communication and inspiration is especially useful. The main research question is the following:

How do stimuli influence the inspiration process (and thus creativity) among design team members during co-evolution of the problem and solution space during the ideation phase?

The aim of this study is to better understand for what purpose design teams use stimuli, as well as how stimuli influence co-evolution and the creative output. As stated by Gonçalves et. al. (2016), stimuli can be defined as information which triggers a positive, negative or neutral reaction. We expect that stimuli will be used to create a frame of shared understanding among team members (Hey et al., 2007) and to trigger individual inspiration. Furthermore, we expect that stimuli triggers co-evolution moves between problem and solution space. When new or surprising information arises, shifts between spaces can occur (Adams et al., 2003). By supporting shared understanding, stimuli can potentially enable team members to understand each other better and, as such, build on each other's ideas more easily. This can enhance the pace of the process (Valkenburg & Dorst, 1998). Inspiration has been described as ´the process of searching, selecting, retrieving and implementing stimuli in design´, which can potentially lead to creativity. In this context, a stimulus becomes inspirational when it triggers a move between the problem and solution space (Gonçalves et al., 2016).

2. The case study

We conducted a case study as this method enabled us to investigate multidisciplinary teams in-depth within their real-life context (Yin, 2013), with the focus on the behaviour of participants to see the interaction between the context, stimuli and group work. The cases were representative, contextually similar and studied using direct replication (Grey, 2014). Everything the teams did and used (stimuli) was at their own discretion. The observers did not give tasks or try to interfere in this process.

2.1. The sample and set-up

Two multidisciplinary design teams from an Industrial Design Engineering Faculty were selected. Each team consisted of five MSc students with varied MSc directions and specialties: strategic, interactive and integrated design. Both teams were, during observation, in the same design phase and their process ran for the same duration (five months); a comparability which would not be possible in practice. Both teams worked within the context of a mandatory course in the second year of all MSc programmes. The goal of the course is to experience teamwork with other disciplines, while developing innovative solutions for a real company. Team 1 was composed by four males and one female, while team 2 had two females and one male. The participants had an average age of 25 and had multiple nationalities.

All observations were conducted in identical studios, their fixed working environment throughout the whole project. Stimuli presented in the studios (e.g. posters or drawings on the walls) were photographed for later analysis. The interaction between participants during sessions was recorded from multiple angles. The case study took two half-day sessions per case, with similar time intervals (one week). These separate moments were chosen to capture thin slices of the activities of the design teams over a larger period of time. The participants were aware that they were being observed, but did not know the research question. The focus of the observations was on the stimuli the participants used, how were they used and how they influenced the co-evolution. The duration of the sessions varied from two to three hours. After the sessions, two of the participants were interviewed individually, in semi-structured interviews, to deepen our understanding of the design process and to expand our observations, which enabled participant validation. Figure 2 shows an overview of the data collection.

Figure 2. The data collection process

2.2. Data analysis

The data consisted of observations, video and audio recording of design teams' processes and follow-up interviews, to ensure data triangulation (Ravitch & Mittenfeller, 2015). Their final solution and report was collected. During the coding process, the categories were based on the main themes in the research question: *co-evolution*, *stimuli*, *inspiration* and *creativity*. The data of each session, including interviews, was coded separately by two of the authors. For example, a code for stimuli is `using physical stimuli´. Multiple coding was applied through a coding check of the other researcher's results, until agreement was achieved, as shown in Figure 3. Both projects lasted twenty weeks: starting with a problem statement given by the company and ending with a report and solution embodiment. The ideation phase took five to six weeks, during this phase we observed, they mainly focussed on the creation and development of ideas and turning them into concepts. The teams were chosen due to their different design assignments, although both were open and ambiguous problems:

- Team 1's design brief was future-oriented: "employing the haptic experience and manipulation of 3D product shapes to improve team effectiveness in reaching consensus". The goal was to use artificial intelligence to create an atmosphere of mutual learning between employees and tool.
- Team 2's design brief was implementation-focused: "solving the problem of poor physician blood pressure monitoring in the management of hypertensive patients in Nigeria". The goal was to design an affordable, accessible and durable blood pressure monitor, to be used by a local team of volunteers, doctors and developers.

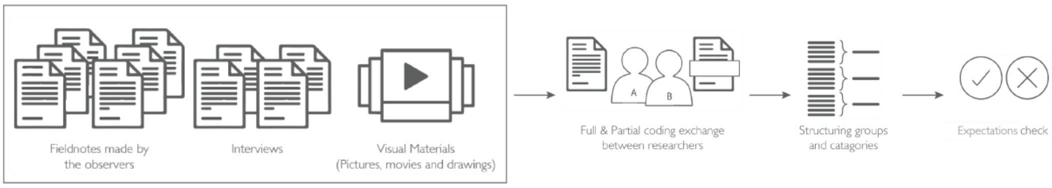

Figure 3. The data analysis process

3. Results

The following section includes the results of two sources of data: the case study analysis of the design process (including observational notes, video and photo materials) and the interviews.

3.1 The purpose of stimuli

Both interviews and observations showed that there was a variety of representation modalities of stimuli used, including multimodal ones (Table 1). We consider both external stimuli as well as self-created ones in this analysis, as long as they had an influence on the process.

Table 1. Types of stimuli representation modalities and content

Representation modalities	**Content of stimuli**
Verbal	Discussion sessions and 'Reverse Thinking' (ideation method)
Textual & Visual	Post-its, flip-over sheets and whiteboard, websites (e.g. Slack or Dezeen)
Visual	Body language (e.g. gestures), personal sketches and storyboards
Multimodal	Videos (on YouTube, Slack)
Physical	Environments and prototypes (or mock-ups)

We have identified four main purposes for stimuli use by design teams: to inspire themselves; to inspire other team members; to explain their ideas to team members; and to test their assumptions.

3.1.1. Inspiration for themselves

We found that participants often seek for ways to get inspired individually, by browsing websites (e.g. Dezeen, Pinterest), which are heavy on pictorial stimulation and are not directly connected to their project. They also go out of the project's frame of reference by talking to external people, to get inspired: *"I also like to talk to people outside my group, or just take a walk or do something else. That inspires me as well, because in this way I'm not only fixed in the project itself"* (Participant 2.1). They argue that this inspirational information is *"stored somewhere in my mind, and then sometimes, just like today [during the session], it came out. Sometimes I would make a link right away, but this time it stayed in my mind like memory backup."* (Participant 1.4). Previously encountered information, stored in our long-term memory, can become inspirational when enough associative links are connected between the problem and stimulus. In this case, an unrelated video was shown to this participant, which became relevant in the context of the design problem, regarding the implicit atmosphere of it.

Another example of stimuli used for self-inspiration was the stored information on the walls of the studios. Team 1 hanged their ideas on the wall as visible archive and to seek for new opportunities (Figure 4a). Team 2 used the walls to exhibit results from previous phases to always have these available (Figure 4b). They created their own context.

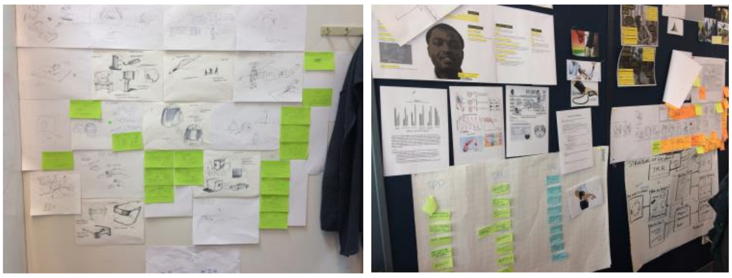

Figure 4 (a). Team 1's ideas on the walls of their studio. **(b)** and Team 2's progress on the walls of their studio.

3.1.2 Towards other team members

In the team context, stimuli seem to have two main purposes: to inspire one another, and to explain ideas. Inspiring information found individually was brought to the team, via discussions (verbal stimuli), drawings, videos and objects (physical stimuli). For instance, in both sessions with team 1 the participants used visual stimuli in an attempt to inspire their colleagues (Figure 5a & 5b).

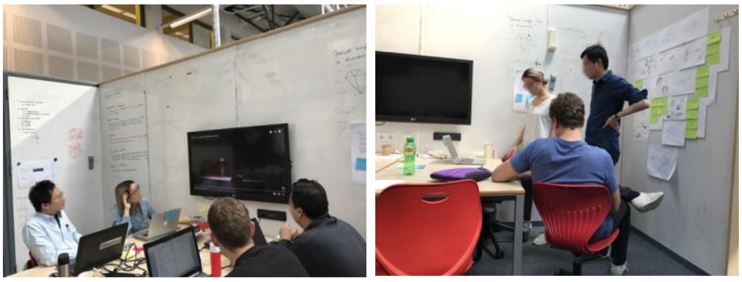

Figure 5 (a). Participant 1.4 shows a clip of the movie 'Big Hero 6' on YouTube (session 1.1). **(b).** Participant 1.2 shows a clip about 3D-mapping on Vimeo (session 1.2)

The use of these stimuli occasionally led to ideas, and stimuli became a source of inspiration. As an example, participant 1.2 showed the group a short movie, which led to a new idea (Figure 5b). Furthermore, the use of (mostly visual) stimuli helped with the explanation and communication of ideas, as *"a picture tells (more than) a thousand words"* (Participant 2.1), which suggests that designers prefer to have visuals alongside verbal explanations: *"We noticed that when we didn't use visualisation, we really don't understand each other"* (Participant 2.2). Thus, visualisation of ideas supports team members to communicate their ideas, and to even clarify one's ideas to oneself, as Participant 1.2 noted: "*I have difficulties to explain my ideas because it is not clear yet in my head. Through explanation I would organise my thoughts"*. Once sketches, even of incomplete or ambiguous ideas, are put on paper, they can become inspirational for other team members. These ambiguities sometimes actually inspired other team members, as they filled the gaps or associative links were created, which led to new ideas: "*If the idea is not explained well, then I try to fill the gap of ideas with my own interpretation…"* (Participant 1.2). Often, the same stimulus sparked different ideas in different team members, as it was interpreted differently. When the team had several ideas, they would try to make more abstract themes, which in turn could be used as stimuli for developing new concepts. This is a clear moment when self-created stimuli are used to further develop new ideas.

3.1.3 - Test their assumptions

In both teams, the participants used prototypes to inspire one another: *"...it's really nice to see sometimes…people at work, just building stuff…that gives me different insights"*. Besides being inspiring, the purpose of physical self-created stimuli was also to test ideas or assumptions. Team 1 used Lego to experiment with their testing methods (Figure 6a), which was their starting point for more elaborate testing. Team 2 used it to improve both their prototype and test set-up. In both cases the prototypes were used to explain the usage of their concept (Figure 6b).

Figure 6 (a). Team members participate in the experimental tests. **Figure 6 (b).** Team members are preparing the pilot tests for their experiment.

3.2 The relationship between stimuli and co-evolution moves

Inspiring stimuli did in fact trigger iterations: when a stimulus was brought for team discussion, this was often followed by changes in direction or redesigns of ideas. Stimuli-triggered co-evolution moves occurred more often when the stimulus was used during a discussion and when the stimulus was related to the problem at hand (e.g. prototypes, Figure 6a & 6b): *"We have to design the screens and build the wireframe, and then we come to conclusions like, this isn't easy, or this is to extensive, or this is not really it. And then we revise it again, improve it, and get a different set of screens"* Participant 2.1). This interview quote suggests that using a prototype of the wireframes made the team realise the need to iterate, i.e., move between problem and solution space. Secondly, self-created stimuli (e.g. sketches) were used to reach agreement, rather than used for inspiration. They supported a frame of shared understanding faster than when no stimuli were used (as discussions were often prolonged without stimuli as anchors). Team 2, which had an implementation-focus design brief, had far less co-evolution moves within the problem space than the team with a future exploration focus (team 1). This can be related with the scope of team 2, which required a narrower set of solutions, and had clearly defined requirements (section 2.2) than team 1.

3.3 The relationship between co-evolutionary moves and creativity

During the interviews, we asked the participants to provide their own definition of creativity, which differed greatly per person and also per design brief. Whilst team 1 had to design for the future (>10 years), team 2's design brief required an implementable solution. The range of possible solutions had been predefined by the client, which gave team 2 a clear direction and confined their solution space. This seems to have also influenced their definition of creativity, which was primarily focussed on the usefulness aspect of creativity, instead of novelty: *"It's an answer to your problem. It offers an idea that will solve this problem"* (Participant 2.1). Conversely, team 1's design brief was more open, which made them focus more on the novelty aspect of creativity: *"I think that creativity part is how to use things that come up into your mind in a way that you haven't used before"* (Participant 1.2).

4. Discussion

4.1 The purpose of stimuli and their influence on co-evolution

This study has shown that stimuli support framing and shared understanding among team members and trigger (individual) inspiration. However, different types of stimuli support different purposes: external stimuli were used for inspiration purposes (e.g., browsing internet), while mostly self-created stimuli were used to create shared understanding (e.g. sketches). Particularly sketches are customizable by the maker, which enabled he/she to manipulate it until other team members understood the core idea. The study also showed that shared understanding supported by stimuli was a precursor for inspiration among team members. Without stimuli, discussions tended to take longer and were experienced as *"uninspiring"* and *"draining energy"* (Participant 2.1). When stimuli were used during discussion, they provided a tangible representation to changeable team framing. These stimuli 'anchors' not only supported shared understanding but also facilitated co-evolution moves, as it led to changes in understanding of the problem and new ideas. Thus, the use of stimuli can trigger a fast-paced design process. Yet, shared understanding does not invariably lead to co-evolution moves or inspiring ideas. It is not enough that teams agree, as that does not necessarily move the co-evolution process forward. Sometimes, misinterpretations are instead what triggers a spark of inspiration. Misinterpretations can be considered surprising information, which require a change in understanding. When ideas were not fully explained, participants tended to fill in the gaps, establishing new ephemeral ‘bridges’ between problem and solution (Dorst & Cross, 2001) or “pseudo-frames” (Hey et al., 2007) until it was possible to continue with the design process.

4.2 The effect of stimuli on creativity of the design solutions

As explored by many studies, there is a clear link between the influence of stimuli on inspiration and creativity (e.g. Gonçalves et al., 2013; Gonçalves, 2016). When stimuli sparked inspiration, it often resulted in a novel idea in that context and triggered a change either in problem or solution space. However, there were no explicit indications to connect stimuli used positively (or negatively) to creativity, even though that it was clear that the type of problem changed how designers perceived what was creative. While team 1 focussed more on novelty, the focus of team 2 was more on the usefulness aspect of creativity. This means that whatever creative results they were aiming for, they were largely dependent on the given design brief, and that influenced how many iterations occurred, with team 1 having more iterations on the problem space than team 2. Nevertheless, during the observations, we could not establish a link between stimuli and creativity of the solutions: the used stimuli, in terms of representation mode and distance, were similar for both teams.

5. Conclusion

The research question *‘How do stimuli influence the inspiration (and thus creativity) among design team members during the co-evolution of the problem and solution space during the ideation phase?’* can be partly answered. Stimuli triggers inspiration for the individual designer (Gonçalves et al., 2013; 2016), and when working in groups, stimuli help designers explaining ideas and trigger inspirational exchanges with one another (Cash & Gonçalves, 2017). Stimuli can help design teams framing shared understanding and, as such, have a positive impact on the co-evolution of the design process, as supported by Hey et al. (2007). This study demonstrates that stimuli enable the design process to proceed more smoothly than when using no or only verbal communication, by forming ephemeral frames of shared understanding, throughout the design process (Figure 7).

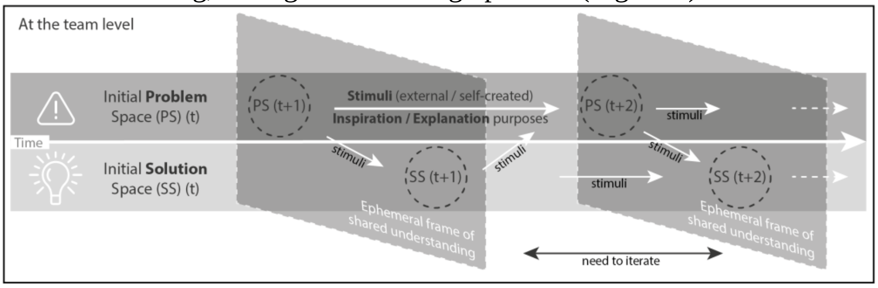

Figure 7. How the use of stimuli leads to more inspiration and possibly more creativity.

Another interesting observation in this study was the difference in use of stimuli in relation to the focus of the project. A difference is shown between idea exploration- and solution implementation-design assignments. More specifically, in the first case team 1 mainly used stimuli to inspire one another and trigger problem-focussed iterations. In the latter, team 2 focussed more on the usability aspect of creativity; as such, they mainly used stimuli to create a concrete direction to answer their set of requirements and instigate solution development.

5.1 Limitations

This research has some caveats that should be considered. Firstly, there were only observations for two half days in each team, of only two teams. A larger portion of the design process should be observed, to create a more complete view on the co-evolution moves among problem and solution spaces. Secondly, although the set-up of this study was convenient to obtain comparability of results, with similar conditions among design student teams, it is imperative to explore this topic in practice.

An important observation is that the use of stimuli is also dependent on the focus of the project. We noticed that far future focussed projects tend to use stimuli for exploration more often, while the nearer future focussed projects tend to use stimuli for framing understanding of the requirements of the solution. Another potential difference was the use of either more distantly or closely related stimuli (as both serve different purposes). However, we could not clearly identify this. Therefore, this should be further explored, as it might have an impact on communication in multidisciplinary teams.
This study adds to previous research on design teams´ collaboration (Hey et al., 2007; Cash & Gonçalves, 2017; Wiltsching et al., 2013; Avolio et al., 2002) and gives first insights in the research area of stimuli used within teams. The outcome of this research is interesting for members of multidisciplinary teams in both large and small-scale companies that have a focus on innovation. Our findings can already be triggers for education in universities during collaborative design projects: by stimulating the use of stimuli during projects, the communication between team members can be improved, which may lead to more efficient projects. Furthermore, making students more aware of all the possible stimuli to use could help them to (consciously) frame co-evolution moves supported by inspiration. The implementation in universities is a good starting point: these students will eventually become professional designers which are taught to use stimuli to explain and inspire.

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