THE ROLE OF AMBIGUITY AND DISCREPANCY IN EARLY PHASES OF INNOVATION

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Abstract

Innovation literature mainly focuses on eliminating ambiguity and discrepancy from the early phases of innovation. This study questions this implicit assumption, as it may provide an oversimplified view on, how to attain proficiency. Instead of narrowly focusing on reducing ambiguity and discrepancy, we seek to understand if it might be there for a reason. Through a laboratory experiment, we propose ambiguity and discrepancy actually have a function in concept development. Accordingly the paper contributes with a better understanding of, the role ambiguity and discrepancy as triggers of sense making in conceptualisation in the early phases of innovation.

Keywords: Innovation, Conceptual design, Design methods, Ambiguity, Discrepancy

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1 INTRODUCTION

According to prior research in design and innovation, the early phases of innovation are considered important determinants of successful innovations (Elmquist and Segrestin 2007, Kim and Wilemon 2002, Khurana and Rosenthal 1998). Even though much empirical evidence shows the importance of early phase proficiency and its positive effect on a firm's innovation level, the early phases has shown to be the weakest area in the innovation process, hence also termed the fuzzy front end (Koen, 2001). Due to the ambiguous and contradictory nature both research and management of the early phases is difficult compared to the following new product development process (Koen et al. 2001, Cooper and Kleinschmidt, 1987). Accordingly extant literature focuses on how to reduce the ambiguous and contradicting nature of the early phases (e.g. Andersson 2013, Koen et al. 2001). Several studies have attempted to define activities in the early phases, to clarify *'what'* kind of activities happen in this phase (Koen's et al. 2001, Ulrich and Eppingers 2008) and *how to* do the specific activities, e.g. generate multiple ideas and select among them (Vincenti, 1994; Murmann and Frenken, 2006). These models are commonly to create predictability and clarity; hence reducing experienced ambiguity and discrepancy in this phase. The aim is to remove the fuzziness from the 'fuzzy front end' (Koen et al. 2001). This aim builds on the implicit assumption, that what is experienced as ambiguous and contradicting should be reduced to create early phase proficiency. Nonetheless the empiric results from studies largely conclude, that there is no common process for the early phases, it differs from firm to firm, and even within a single firm differs from project to project (Frishammar and Floren 2008, Kim and Wilemon 2002, Khurana and Rosenthal 1998). Likewise studies show ambiguity and discrepancy still remains in the early phases both in practise and literature (Andersson 2013).

The narrow focus in extant research on reducing ambiguity and discrepancy provides an oversimplified view on conceptualisation in the early phases. This study questions the implicit assumption of how to attain proficiency of conceptualization in the early phases. Instead of narrowly focusing on reducing the ambiguous and contradicting character, this study seeks to examine, if the ambiguity and discrepancy might be there for a reason. Thus the aim of the present paper is to achieve a better understanding of, what role ambiguity and discrepancy have in conceptualisation in the early phases of innovation.

The remainder of the paper is structured as following. First, we review the existing literature on the early phase innovation. Next we couple this to the literature on ambiguity and discrepancy to build a theoretical model to study the role of ambiguity and discrepancy upon. Then we examine the role of ambiguity and discrepancy in conceptualization in the early phases, using a laboratory experiment setup with 32 design engineering master students. A laboratory experiment setup was evaluated to be a proper method to study the phenomenon, to be able to clear the study from contextual interference. Finally the paper concludes with a discussion of ambiguity and discrepancy as a driver of a particular form of concept development.

2 THEORETICAL FRAMING

2.1 Definition and relevance of the early phases

The early phase innovation activities are in literature also termed the 'Fuzzy Front End', 'Early stages', 'Formation', 'Preject', 'Phase 0' or 'Search'. Koen et al. (2001) defines the early innovation activities as preceding the formal and well-structured new product development process, likewise Kim and Wilemon (1999) defines the early phases of innovation as the period between when an opportunity is first considered, to when an idea is judged ready for development.

While the early innovation activities, only remains a small part of the overall development process, they are considered crucial for innovation success for several reasons. Although the cost incurred in the early phases may be no more than 8% of the total product development cost, the decisions often determine more than 60% of the total costs (Ullman 1997, Cooper and Kaplan 1999). Equally the concept frame is determined in early phases, which likewise locks in a products innovation potential, i.e. if the project definition outlines the development of a certain product type, characteristic or technology, the product will be developed within these frames (Ulrich and Eppinger, 2008). Moreover even though most projects fail during commercialization or at the end of the development process, the origins of it often seem to be established at the early phase due to incorrect or unclear project concepts

(Bacon et al. 1994). Altogether much empirical evidence shows the importance of proficiency in the early phases.

2.2 Ambiguity and discrepancy in the early phases

The problems tackled in the early phases are characterized by being 'wicked' or 'ill-defined' (Montoya-Weiss and O'Driscoll 2000). Wicked problems are complex, indeterminate and ill-defined problems in the sense they are characterized by incomplete, changing, contradicting and interdepended information, which are difficult to gather (Buchanan 1992, Rittel and Webber, 1973). Challenges like conflicting organizational pressure, tacit knowledge, complex information processing and a limited amount of information to build decisions upon, makes the early phase hard to manage, hence its characterised as ambiguous and contradictory (Koen et al. 2002, Khurana and Rosenthal 1997).

This ambiguity and discrepancy in the early phases, often results in an unstructured and explorative process, which leads to ad-hoc planning in many organisations (Montoya-Weiss and O'Driscoll 2000). Accordingly research on the early phases has largely focused on how to reduce the ambiguity and discrepancy through creating clarity and predictability in the process (Andersson 2013, Koen et al. 2001). Accordingly extant literature narrowly focuses on two aspects: firstly studies of how to define activities of the process (Koen et al. 2001), second studies of methods for generating multiple ideas and selecting among them to identify the best idea (Murmann and Frenken, 2006).

Firstly much attention has been put on defining activities in the early phases. In order to identify *'what'* kind of activities happen. Several process models have been developed to describe the activities taking place. Koen et al. (2001) describes the early phases as consisting of idea genesis, idea selection, concept & technology development, opportunity identification and opportunity analysis. Equally Ulrich and Eppinger (2008) identify customer needs, establish target specifications, generate product concepts, select product concepts, test product concepts, set final specification and plan downstream development. These process models search to reduce experienced ambiguity and discrepancy in the early phases by categorising a sequence of activities. Contrary the effort scholars commonly acknowledge, that there is no such 'one procedure' for the early phases, it highly differs from one project to another (Frishammar and Floren 2008, Kim and Wilemon 2002, Khurana and Rosenthal 1998).

Second the ambiguous and contradicting character has been ascribed to wide divergence in decisions to be made, whilst having limited knowledge and insufficient information to base them upon. This problem is also termed the design paradox (Ullmann 1998) and is evident in the concept development phases, where a majority of decisions are materialised and tested, including business objective, technologies, target markets, capabilities and product features (Hey 2007). Extant literature has put much attention to the issue of handling this process of divergence and convergence of decisions (Ulrich and Eppinger 2005). Scholars have focused on methods of *how to* generate multiple ideas and select among them, i.e. a variation and selection approach. (Murmann and Frenken, 2006). Accordingly they argue the central tasks in conceptualization in the early phases are firstly to generate a range of solutions to an innovation problem, second to select appropriate solution from the alternatives available (Girotra, Terwiesch, & Ulrich, 2009). By narrowing down concept development to generation of multiple ideas and criteria for selecting the best concept, research aims to clarify and straight out the process (Ulrich and Eppinger 2008). However we argue extant research presents an oversimplified view on conceptualisation in the early phases. It builds on a narrow and implicit assumption, that ambiguity and discrepancy should be reduced. Accordingly the subsequent will examine literature on the role of ambiguity and discrepancy.

2.3 The role of ambiguity and discrepancy

Much of previous research on concept development have focused on decreasing the fuzziness by clarifying process models or a defining a broad variation and selection approach (Ulrich and Eppinger 2008). However this paper seeks to understand if the experienced fuzziness actually has a function in the early phases. To deal with the experienced fuzziness in the early phases, it can be divided into experienced uncertainty, ambiguity (also termed equivocality in literature) and contradictory (also termed discrepancy, dissonance, disharmony in literature) (Anderson 2013). Uncertainty is defined as the difference between information required performing a task and information available by the organisation (Galbraith 1973). Thereby uncertainty is simply handled by collection of new information in order to provide certainty.

Next ambiguity (or equivocality) is defined as multiple interpretations of the same phenomenon (1979, Daft and Macintosh 1981). Thereby ambiguity is not the quantity of information, but 'how' data is processed, due to a lack of clarity, high complexity or paradoxes (Neil and Rose 2007). When multiple interpretations of a relation exist, it creates ambiguity about the causality. The issue is characterized by being ill defined, so the either the question or answer is unknown, hence it is difficult to search for information Additionally more information alone does not decrease ambiguity, as information is difficult to interpret. Therefore, individuals reduce equivocality, by defining or creating an answer rather than learning the answer from searching additional information (Daft, Lengel & Trevino, 1987). Lastly contradictory (Dissonance, disharmony or discrepancy) is defined as a cognitive conflict, arising when two elements do not fit together, i.e. inconsistent with part of their frame of reference (Jerminas 2001). Andersson defines contradictory as: "*an individual's inconsistent or contradictory parts of a frame of reference about the phenomenon indicated through complete confusion, fuzziness, and lack of understanding* thus; there is a need for *sensemaking processes.*" (Andersson 2013, p 10) Weick (1995) explains ambiguity and contradictory as a trigger of sense-making and sense-making as a driver of change. Hence seeking ambiguity and contradictory may have a role in a concept development process, as drivers of sense making. Sense making is described as a cognitive process in which individuals give meaning by framing experiences (Weick 1995). Accordingly framing of a problem, serves as a device for sense making, which settles the parameters of the problem. Framing build implicit assumptions about parameters and priorities of a problem, it describes what is important and what criteria can be used to evaluate success. Accordingly Schön describes framing a sense-making process that frames underlying perceptions of belief and appreciation (Schön 1994). Thus taking an adductive approach (Lawson 2006, Cross 2006), where the aim is sense making rather than optimization (Krippendorff 2006).

2.4 Research model

Building on that we propose a research model to test the role of ambiguity and contradictory as triggers of sense making.

We hypothesise ambiguity and discrepancy in the concept development to trigger sense-making, which in the performance function leads to proposals with new meaning. The following section will go through how the phenomenon was studied.
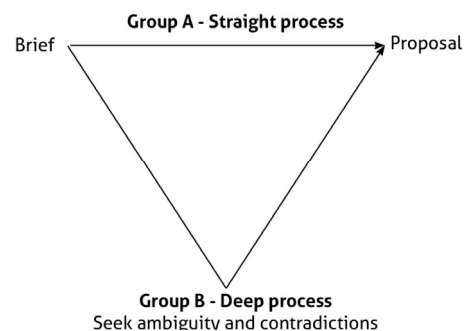

Figure 1. Research Model

3 METHODOLOGY

The objective with this study is to understand the influence of ambiguity and discrepancy in concept development. In order to do so a laboratory experiment is set up, to test the difference in solutions from respectively a straight proposal creation process and a process where ambiguity and discrepancy is sought before proposal creation. The hypothesis is that different approaches are suited for different purposes. The straight proposal creation process is more likely to create solutions within the present sociocultural meaning. Whereas seeking ambiguity and dissonance in concept development triggers a deep sense-making process, which in return creates solutions with a new sociocultural meaning.

3.1 Participants

The participants in the experiment are in terms of experience a homogeneous group of 1. MSc. industrial design engineering students. These participants were selected because they on the one hand needed to have a basic skill set (drawing abilities, product understanding), to be able to solve a conceptual assignment. On the other hand they needed not to be too experienced, so they do not revert to accustomed processes including questioning or reframing the assignment. Whereas more experienced designers have an experience in how to solve such an assignment, which they tend to lean upon. Hence the participants chosen were 1. MSc. students being somewhat skilled, but not too experienced.

3.2 Overall procedure

The students are randomly divided in two equal size groups. Both group receive the same basic task, to create proposals for the next version of a coffee-machine for specified firm. The coffee machine assignment was chosen because the coffee machine somewhat have an archetypical sociocultural meaning in Denmark. We expect a straight proposal creation process will not change on archetypical sociocultural meaning, but will focus on styling the expression. Contrary we expect seeking ambiguity and dissonance will trigger a deep sense making process. That will serve to question and significantly change the archetypical sociocultural meaning, hence the term deep sense-making.

In solving this task the participants are instructed to seek ambiguity and dissonance before creating proposals. In order to evaluate the difference in output, the solutions are compared to the solutions from a control group. The control group is instructed to go through a straightforward process going directly from task to proposal creation. The groups get an equal amount of time and are asked to deliver the same result. Below is an overview.

	Group 1	Group 2
Task	Develop a new product concept	Develop a new product concept
Process instruction	Straight proposal-making Instructions to go straight to solution mode	Deep sense-making Instructions to seek ambiguity (in how) and dissonance (in why) before going into solution mode.
Process delivery	None	Why paper: Midway deliver a A4 paper, pitching a number of contradictions concerning the current concept
Deliver	Proposal: A3 paper, pitching the final concept All working paper including initials, timestamp and notes	Proposal: A3 paper, pitching the final concept All working paper including initials, timestamp and notes

3.3 Tasks and instructions

In the experiment participants are given a concept development task, which was common for both groups. However the two groups are given different process instructions. Below is a specification of how the common task and the instructions are specified:

3.3.1 Instructions

The two groups are given the same assignment, however they are instructed to approach the task in different ways through different set of instructions (A+B). The aim with instruction A is to lead the students directly from assignment to proposal creation, whereas instruction B leads the students to seek ambiguity and dissonance before creating proposals.
Ambiguity is according to Weick (1979) defined as multiple interpretations of the same phenomenon. Thus the students are instructed to seek ambiguity, by questioning and identifying different interpretations of the same phenomenon, the coffee machine. Dissonance is according to Jerminas (2001) definition a state that arises when two elements do not fit together. The students are instructed to pursue this state through looking for

Figure 2.

inconsistencies and contradictions in the current solution. Below are the introductions given to the two groups of students.

Instructions A: "This is Melissas current top selling model for 2014. We want you to design the coffee machine for Melissa for 2015. We ask you to address the task by going straight to designing a new coffee machine. Look at the current coffee machine and come with proposals for a new one."

Instructions B: "This is Melissas current top selling model for 2014. We want you to design the coffee machine for Melissa for 2015. But first we want you to question and identify different interpretations of a coffee machine and compare that to the coffee drinking culture and phenomena

you know of. Look for inconsistencies and contradictions in the current solution, and new possible ways of conceptualizing the coffee machine and the coffee-drinking scenario.

After 30 min. and before 1 hour you need to deliver a paper explaining:

- − Different questions and interpretation of a coffee machine and coffee drinking culture, scenarios, habits and routines.
- − Inconsistencies and contradictions of the current solution

3.4 Analytical framework

Since the hypothesis is that the second approach will lead to change the meaning of the product the analysis framework focus is to define the change in meaning. Since this is a short laboratory experiment without a context of company, market and users, the main evaluation on change is relative to the outset, in this case a traditional tabletop home based filter coffee machine. The proposal are evaluated on 3 main criteria to define change in sociocultural meaning, the aspects are Product Category, Use Scenario and Product Architecture. Product Architecture is subdivided into internal change related to functionality, layout and construction and visual external change in the product appearance related to shape, color and size.

The concept of change is therefore subdivided into the following 2 categories:

3.4.1 Insignificant new or no meaning

The proposal is evaluated as not creating significant new sociocultural meaning if:

I.1. The proposal is a filter based coffee machine to be put on the kitchen table at home.

I.2. And there is no change is the use scenario

I.3. And there is no significant visible or understandable change in the product architecture compared to the given coffee machine that implies new functionality.

I.4. Or if the change/newness relates only to shape, colour and size but remain in the product category.

3.4.2 Significant new meaning

The proposal is evaluated as creating significant new sociocultural meaning if the proposal:

S.1. Goes beyond the original product category, i.e. differing from a filter based coffee machine to be put on the kitchen table at home. This would change the perception what the product is, albeit the evaluation is relative to the given starting point and not screened and tested on the market in this closed short laboratory setting.

S.2. And/or the proposal implies a significant change of the use and scenario of use of the product relative to the starting point.

S.3. And/or the proposal in compared to the given coffee machine significantly changes the relation and positioning of the internal and external components in the machine, or changing/adding/deleting components that would be visible or understandable for the market/user.

4 ANALYSIS

Analysing the sketches of the actual coffee machine the initial difference between the two groups was quite evident. Group A had 12 proposals that were variants of the filter based coffee machine and 4 proposals differed more from the original coffee machine and was categorised as creating significant new meaning. Group B only had 1 proposal that was a visual variant of the reference filter based coffee machine and 15 proposals that differed significantly from the starting point. The difference is significant with a 4/16 in group A and 15/16 in group B that proposes something that is significantly different from the starting point, in more popular terms the majority of participants in group B are thinking 'outside the box' compared to the original reference point.

4.1 Group A

Examining the 12 proposals in this group that looks like variants of the original filter based coffee machine it is evident that the main 'newness' is related criteria I.4 for insignificant change in meaning concerning shape, colour and size. Examples on this are A. 3, 5, 6, 7, 8, 9, 12, 14 and 16 (Fig.3) A few other proposals have some minor changes in the product architecture (I.3), but they are related to the positioning of the water container (behind or above filter) and change almost nothing in the use

scenario (I.2) and the perception of a traditional filter based table top coffee machine. Examples on this are A.2 and A.10 (Fig.3). Four proposals are going significantly different from the reference coffee machine. E.g. A.1 (Fig.3) is altering the use scenario (S.2) to 'His & Her' coffee machine and changing the product architecture (S.3) to a 2-cup and 2 water container structure.

A.11 (Fig.3) is changing the coffee making process (S.2) and product architecture significantly (S.3), rearranging and deleting components (the filter is removed). A.13 (Fig.3) is changing product category to capsule-based coffee machine. A.15 is changing and revealing the product architecture in a different way (S.3) and by hanging the machine on the wall it differ from the table top based machine (S.1)
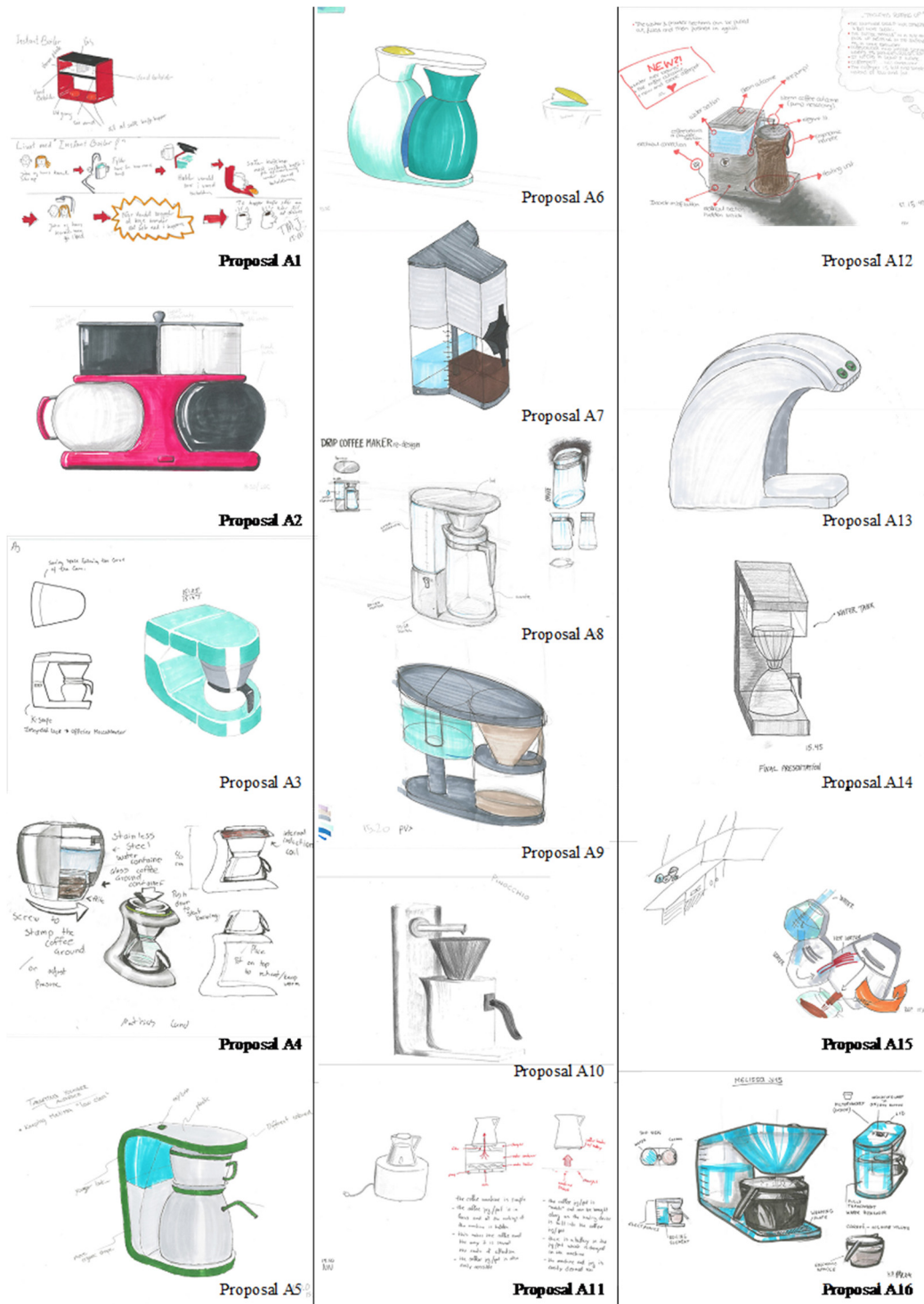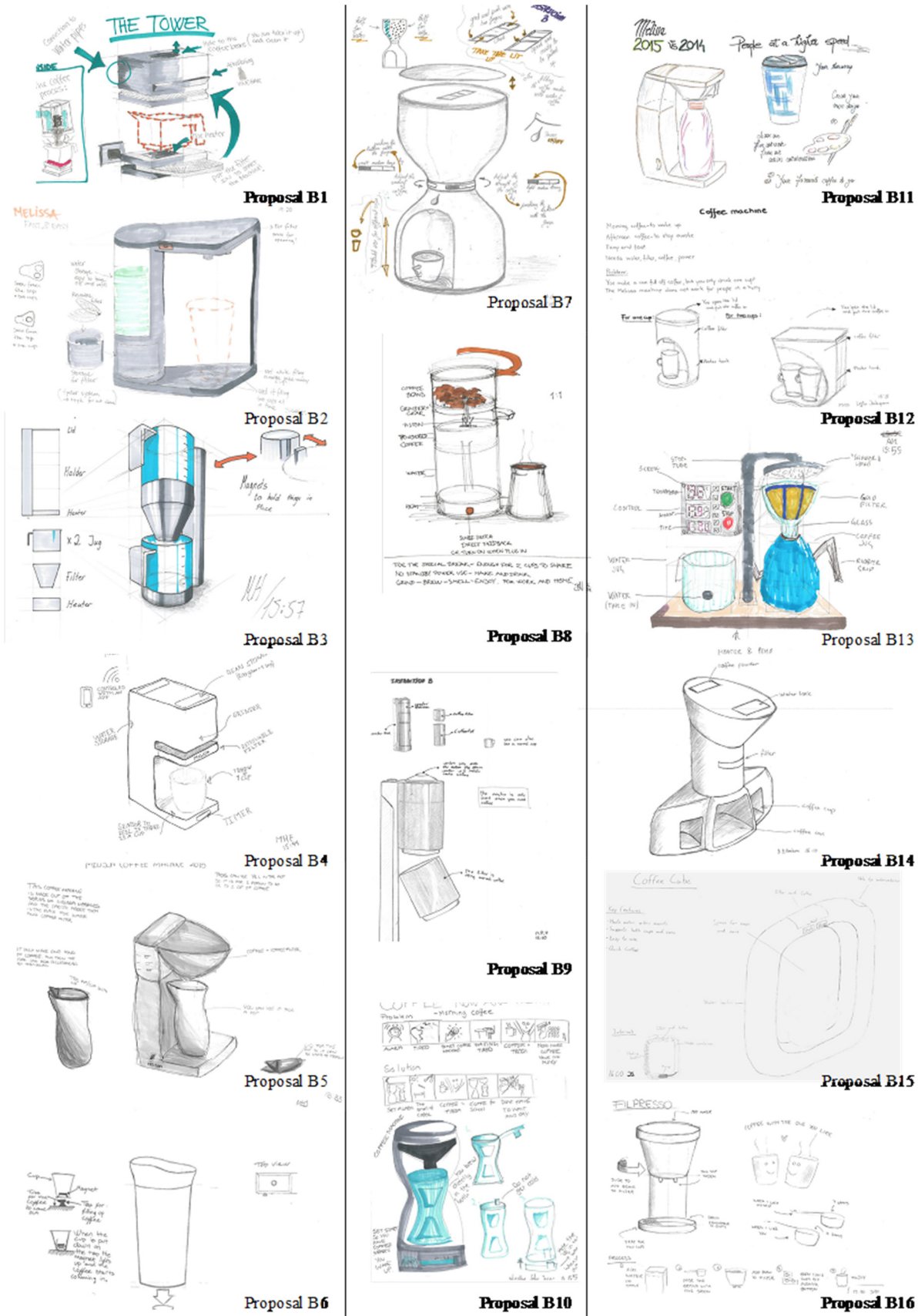

Figure 3.

Figure 4.

4.2 Group B

Examining the 15 variants of group B that looks significantly different from the reference coffee machine they are primarily focused on changing the use scenario (S.2), hence the experience and

interaction between the coffee machine and the user. They focused on designing for a different situation like coffee-to-go as B.2, 4, 10 and 11(Fig.4), or 1 cup for a single user as in B.7, 12, 14, 15 and 16 almost like capsule based coffee machine (S.1).

Others add new functionality and coffee production methods changing and deleting components and adding new ones in the product architecture (S.3) to change the experience of use (S.2). E.g. B.6 (Fig.4) where the coffee rises up from the bottom of the cup which creating a new and surprising effect and experience and B.8 where the process of making coffee becomes a tangible effort by turning the top of the machine to churn the coffee beans (S.2) before pressing the piston (S.1 and S.3).

Two proposals stand out as visual resemblance to a more traditional filter based coffee machine, proposals B.3 and B.9 (fig.3). But at closer inspection B.9 involves a change in the functionality (S.3) that allows the machine to dispense coffee like a tap. This leaves B.3 as the only one without any significant changes in the sociocultural meaning.

5 ADDITIONAL FINDINGS

Besides the analysis to identify which proposals produced significant new meaning or not other patterns were observed. Firstly it was evident group B, which were forced to go in a deep process in general had more text on their final proposal than group A. This we ascribe to the briefing, which forced them to initially write down ambiguity and discrepancy. This process might have triggered two things. Firstly whereas the first group used a visual language to communicate, the initial writing might have started a process, were text is used as a communication tool. Thus it might just be a sheer way of communicating. However going into the actual text on the sketches it becomes apparent, that the text is used to comment and reflect upon the drawings. It is almost like an internal conversation is put down on the paper, a dialogue between the drawing and the text. The student has drawn something and reflected in the text. This is an example on reflective practise in action and on action: *"In a good process of design, this conversation with the situation is reflective. In answer to the situations back-talk, the designer reflects in action on the construction of the problem, the strategies of action, or the model of the phenomena, which have been implicit in his moves."* (Schön 1983, pp79). Accordingly it can be argued the briefing to seek ambiguity and discrepancy in the coffee machine and the coffee drinking situation (and note it down) triggered a reflection, which was not only apparent in the sketches (development), but equally significant in the final product proposal. Thus the explanation of the final product proposals were richer in group B than group A, in terms of explanations of functions, use scenarios etc.

6 DISCUSSIONS AND IMPLICATIONS

Our study makes several important contributions to literature. Firstly distinguishes between two different kinds of concept development processes: a process where participants go straight to proposal creation and a process where participants seek ambiguity and discrepancy before going into proposal mode. Second it shows the result from such two processes differ significantly in term of outcome. The straight proposal creation process results in proposals, which focus on restyling in terms of colour, shape and functions. Thus they stay within the same product category and accordingly keep the initial socio cultural meaning. This also means these proposals are closer in product architecture, thus more technical clarified compared to the other group. Whereas the deep concept creation process results in proposals that move further away from the starting point, it focus on changing the use scenario and accordingly the sociocultural meaning. This kind of process creates more radical solutions, which are also technical less clarified. Third it questions the implicit assumption in innovation literature, that fuzziness should be removed from the early phases. This study proposes that certain parts of what are experienced as fuzziness; the ambiguity and discrepancy are actually inherent parts of deconstructing a problem (the solution space) and become drivers of the concept development. Thereby it serves as fuel to the sense-making process, which create novel sociocultural meaning. Thus by avoiding ambiguity and discrepancy in concept development (the straight proposal creation group), the experience of 'fuzzy' is avoided, but this also majorly leads to conceptual styling.

Altogether the study provides more knowledge of the performance of different types of concept development process, investigating what role ambiguity and discrepancy have. Coupling the literature of innovation, with knowledge within the design field. Making it explicit, why it is important in some development projects to embrace and utilize ambiguity and discrepancy in concept development.

In future studies it could be interesting to explore if the results may be similar for experienced designers, or if they unconsciously because of their training would go into a deep concept development process. Additionally future research could explore more of which dimensions influence the performance of a concept development process. It could be interesting to compare this approach, with other popular approaches, e.g. as previously mentioned extant creativity and innovation research focus on a broad variation and selection approach. These studies thus build on the implicit assumption that a broad approach of quantity creates quality. By introducing this deep approach, we call upon studies that challenge this assumption. Future studies could compare a deep concept development process with a broad variation-selection, to explore how the different methods affect the outcome.

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