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ARGUMENTATION AND REASONING IN DESIGN: AN EMPIRICAL ANALYSIS OF THE EFFECTS OF VERBAL REASONING ON IDEA VALUE IN GROUP IDEA GENERATION

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1. Introduction

The early stages of product development comprising idea generation designates a key part of the on-going and successful design process [Cross 2001]. Idea generation often takes place in teams of people to ensure ideas are created and shared between different competences and perspectives on the task [Bucciarelli 2002]. Analysing the thinking and reasoning processes taking place in groups of designers during idea generation is therefore key to understanding and supporting design practice.

In individuals, reasoning is an activity that decides how to respond to situations in every aspect of their lives. Reasoning consists of trains of thought, including deliberation, arguing and logical inferences, the basis of which relies on the *mental model*(s) held in a context [Johnson-Laird 2006]. Mental models held between people is termed *team mental models* explaining a shared team cognition about relevant knowledge and goals [Cannon-Bowers and Salas 2001]. The quality of team mental models are suggested to be indicative of team performance [Badke-Schaub et al. 2007]. A commonly used method for determining team performance in idea generation is through the evaluation of the outcome ideas [Kudrowitz and Wallace 2012].

Reasoning in design is argued to be largely unconscious, but also exists in a verbal, argumentative form [Rittel 1987]. In the context of design, Rittel states that "*only at the micro-level can we identify patterns of reasoning corresponding to* [the design process]". Thus, the research presented in this paper seeks to develop a framework for empirically analysing patterns of reasoning as they are verbally realised between teams of people engaged in design activity. Specifically, the study aims to test the relationship between reasoning found in idea generation in groups and the effect on the quality of outcome ideas.

First, the paper reviews and presents existing theories and models of formal reasoning and reasoning design, resulting in the formulation of study aims and hypotheses. Second, the paper presents the data collection and analysis method. Third, the paper presents and discusses the results of the data analysis including contributions to theory and practice and directions for further research.

2. Theory and background

The following sections draws upon existing theories and models, as well as relevant empirical studies concerning reasoning in design which provide the motivation for the framework for the study.

2.1. Formal logical reasoning and models of design

When explaining design thinking, Rittel [1987] does not ascribe reasoning in design to a strictly formal character. However, recent contributions to reasoning in design define the activity from the perspective of formal logical reasoning. Therefore, the next section presents the formal types of reasoning and how they structure the thinking and reasoning of design.

Since the works of C.S. Peirce, logical reasoning types have been formulated as being of either *abductive*, *deductive* or *inductive* types [March 1976]. The types of reasoning define three fundamental ways of drawing conclusions from premises. Abductive reasoning is a process of conjecture that yields the best explanation to a course of events. An abduction is the preliminary estimate that introduces plausible hypotheses and informs where to first enquire by choosing the best candidate among a multitude of possible explanations [Magnani 1995; Schurz 2007]. Deductive reasoning is tautological as it allows to arrive at a conclusion from the logical implication of two or more propositions asserted to be true [March 1976; Magnani 1995]. Consequently, deduction is heavily justificational because the premises guarantees the truth of a conclusion [Schurz 2007]. Inductive reasoning is the process of deriving plausible conclusions that go beyond information in the premises [Johnson-Laird 2006]. Inductive reasoning is tautological like deductive reasoning because it infers concepts only from available data within a model or frame of reference [Schurz 2007; Magnani 1995].

Together, the reasoning types enter into three-stage process of inquiry [Fann 1970]. This process of inquiry is argued to be domain-dependent [March 1976]. Formal models of reasoning guide several studies of reasoning in design is existing literature. The formal models define design activity as an abductive process as it is the only type of reasoning able to suggest new concepts [Roozenburg 1993; Dorst 2011]. While above models of design are not empirically tested, a similar study by Dong et al [2015] analysed verbal protocols of reasoning processes between participants evaluating design ideas and concepts in terms of the formal deductive, inductive and abductive reasoning types and found that all three types of reasoning occur during design concept evaluation. Further, they find that abductive reasoning in evaluating ideas lead to fewer rejected ideas and deductive reasoning lead to more rejected ideas.

Problem solving theories and models of design emphasise that design thinking concerns (a) the notion something novel and useful which is (b) concretised and explored and (c) evaluated to amend the original notion or concept [Gero and Kannengiesser 2004; March 1976]. From the field of cognitive psychology, Johnson-Laird [2006:353] describes a generic problem solving cycle as the "…*use* [of] *some constraints to generate a putative solution, and other constraints, such as the goal of the problem, to criticise and amend the results*". Christensen and Schunn [2009] studied the role of mental simulations in design from protocols of concurrent verbalisation of design teams. The study found mental simulation, interpreted here as a primarily deductive reasoning process, to reduce uncertainty of a frame into approximate answers, hence suggesting that deduction is an integral part of reasoning in design activity.

Schön [1983] offers a different perspective of how to perceive the design process as a practice involving naming, framing, moving and reflecting in cycle converging towards problem understanding and moving towards a solution. Framing guides action by providing a way for individuals and teams alike to 'see' and shape design activity. An empirical study using the framework of Schön by Valkenburg and Dorst [1998] using protocol analysis found that the integration of solutions at different levels of complexity using framing is central to good performance finding empirical evidence for the importance of framing.

The study presented here combines the above theories and models to interpret reasoning in design as a three-stage process. The process involves; (1) reasoning that leads to a problem setting or perception through framing, followed by (2) reasoning that concretises and predicts a solution or effect under the framing, and finally (3) a reasoning process that evaluates by reference to principles or accepted facts, possibly 'outside' the frame. The process is not necessarily linear, but involve iterations at different levels of abstraction depending on the framing [Voss 2006].

2.2. Reasoning is argumentative

Addressing design activity directly, Rittel [1987] argues that there is no clear separation between problem definition, synthesis and evaluation. Rittel consequently goes on to define reasoning in design as a process of argumentation. Whether working alone or in groups, design involves issues and competing positions that are interconnected and 'open' simultaneously. When engaged in a verbal discourse, these divergent perspectives can appear as speculation, argumentation, trade-offs or negotiation [Bucciarelli 2002; Rittel 1987].

Taking the definition of reasoning in design as a *process of argumentation* at face value, the research field of argumentation theory and rhetoric offers useful models and theories to explain reasoning in teams of designers. Argumentation theory argues for argumentation as an integral part of reasoning [Mercier and Sperber 2011]. Thus, analysing conversation between groups of people engaged in design holds the potential to understand and explain verbal reasoning as the deployment of linguistic processes to satisfy the demands of a cognitive reasoning task [Polk and Newell 1995]. Such attempts at verbal reasoning derive their persuasiveness from their similarity to the formal types of reasoning [Perelman and Olbrechts-Tyteca 1969]. Verbal reasoning is therefore not identical to the reasoning types of deductive, inductive or abductive in the formal logical sense, but the characteristics of utterances have similarities to the reasoning types in their verbal deployment. Perelman and Olbrechts-Tyteca go on to express that the "*choice of terms to express the speaker's thought is rarely without significance to the argumentation*" [ibid.:149]. In a study of argumentation and rhetoric in design activity, Stumpf and McDonell [2002] argue that premises in design discourse draw on both existing understandings (facts) and on values. This process of argumentation creates frames that persuades and changes the perceptions and perspectives of all involved in a conversation. Hence, the study understands the reasoning in groups as an argumentative process in which the framing influences design outcomes. Hence, the first use of reasoning to propose an idea, the *framing*, is decisive of the idea evaluation. This is backed by the finding of Stumpf and McDonnell [2002] that framing potentially persuades and changes the perceptions and perspectives of those involved in a conversation. Likewise, the notion of primary generator underlying ideas supports that idea starts are important to the perception of said idea [Darke 1979].

2.3. Idea evaluation

Approaches to evaluate the quality of ideas have similarities across literature, for example *usefulness* (value to user), *feasibility* and *novelty* [Amabile 1996; Kudrowitz and Wallace 2012]. These contributions have in common that the evaluation of creative or innovative ideas is through a combination of these factors and have often been applied when students are the participants of the study. In contrast, the present study, with participants and design problems from industry, applies a method for evaluating ideas that categorises ideas according how to valuable and useful they are within the context of the on-going development project. Thus, the evaluation focuses on a consensual rating of each idea according to practicality of meeting the needs at hand [Keshwani et al, 2013; Ward and Kolomyts, 2010]. This result in an evaluation system consisting of four idea categories that favour ideas that are implementable within the development projects in the companies. The evaluation categories of 'Accept', 'Analyse', 'Put on hold' and 'Reject', define the fitness of an idea according to the value the idea brings to the project in a timeframe of months, the categories are described in detail later in the paper.

3. Empirically analysing reasoning effects on idea value

Departing from the intention to understand the patterns of reasoning in design, the study aims to complete an analysis of utterances that resemble the three types of logical reasoning in their syntactical form. The study investigates how utterances that can be categorised within these reasoning types appear in a context of argumentative dialogue between groups engaging in design activity. As presented in the above, the argumentative form of verbal utterances entails that assumptions, values and other biases are part of the utterances. To analyse the effects of patterns of argumentation and reasoning on design activity, the study further uses the outcome idea value to the design process as an indicator.

3.1. Hypotheses

The study formulates two hypotheses to test the relationship between reasoning and idea value.

H1: Ideas evaluated as 'Accept' are more likely to be started by deductive than abductive utterances.

As reported earlier, a study of reasoning in design found that abductive reasoning during evaluation leads to a higher degree of acceptance [Dong et al. 2015]. H2 assumes an opposite direction because of the criteria set for evaluating ideas. The case in Dong et al describes the evaluation of ideas for an innovation context, while the evaluation criteria in the present study of 'accept' favours incremental ideas, i.e. those that can be implemented within the time frame and resources of the development project. Thus, ideas started a certain, deductive form are perceived to be implementable and consequently accepted.

H2: Ideas evaluated as 'Put on hold' are more likely started by abductive than deductive utterances.

A previous study using the same coding scheme found indications that conditions fostering abductive reasoning lead to more ideas evaluated as 'Put on hold' [Cramer-Petersen and Ahmed-Kristensen 2015]. Therefore, H1 assumes that abductive reasoning leads to ideas that suggest value to the project but in an uncertain way requiring further investigation, and thus evaluated unfit for current development project, but potentially valuable for future projects, i.e. radical innovation rather than incremental.

4. Method

This section describes the data collection source and methods and presents the coding scheme used to analyse the data.

4.1. Data collection

Idea generation and evaluation workshops in four companies providing the data for this study. All companies were involved in a product development project, were an SME in size, and the idea generation and evaluation took place in a workshop with company participants from several departments working on real world problems. For all companies there was a project milestone for completed concept prototypes within six months of the idea generation workshops. Table 1 summarises company details.

Table 1: Details on companies used for data collection

Company and product type	*Number of employees*	*Participant roles in company*	*Team size*
1. Construction tools	*~10*	*Project manager, design engineer (2), industrial designer*	*4*
2. Waste management equipment	*~80*	*Head of development, design engineer (2), production manager, purchasing manager, mechanical engineering consultant (2), sales manager*	*8*
3. Food refrigeration	*~200*	*Technical support manager, design engineer (2), production manager, production/assembly (2), production planning, R&D manager, product manager*	*9*
4. Agricultural machinery	*~350*	*Project coordinator, design engineer (2), purchasing (2), technical assistant, workshop manager, marketing manager, production/assembly, technical development manager*	*10*

The workshops were audio and video recorded, and facilitated to allow the participants to generate many, quick ideas documented on post-its as keywords and/or sketches. Brief verbal presentations to other participants accompanied all ideas. The workshop consisted of 3-5 rounds of idea generation, for total durations between 90-120 minutes, with focus on (a) ‘open’ brainstorm, (b) cost reduction and (c) user and improved functionality.

A smaller group of the participants from each of the workshops held for the four case companies evaluated the ideas generated from this idea generation workshop immediately after idea generation was completed. These groups counted at least the project leader and one design engineer for all companies. The evaluating groups used two matrices to determine the value of the ideas. The first matrix evaluated a high/low *fit to project* and a high/low *value to user*. Ideas scoring low on *value to user* went into the ‘Reject’ category. Ideas scoring high on *value to user* but low on *fit to project* were put into the ‘Put on hold’ category. Ideas scoring high on both *value to user* and *fit to project*, moved to the second matrix for further evaluation. The second matrix evaluated ideas according to high/low *fit to company portfolio and strategy,* and low/high to the *risk and resource investment required*. Ideas scoring high on *fit to company portfolio and strategy* and low (positive) on *risk and resource investment required* went into the ‘Accept’ category. Ideas scoring high on *fit to company portfolio and strategy,* and high to the *risk and resource investment required*, and vice versa, went into the ‘Analyse’ category.

4.2. Data analysis

Data was analysed using protocol analyses of concurrent verbalisation. Protocol analysis of design activity is a way to understand underlying cognitive processes, e.g. reasoning, with minimal interruption of the recorded process [Ericsson and Simon, 1993; Christensen, 2009]. Consequently, verbal protocol analyses of real life industrial development projects is relevant and expected to be highly representative of design cognition found in practice [Ahmed et al., 2003; Chi, 1997; Christensen, 2009]. In this case, as the observations were in groups, no additional verbalisation were required, hence there is a minimum of interference with thought processes.

The transcripts of the idea generation workshops resulted in the protocols. To break these down into segments, segmentation was completed according to word phrases [Goldschmidt 1991]. Next, a two-step coding scheme was used to analyse the segmented protocols. The coding scheme is summarised in table 2 and described in detail in the following sections.

Table 2: Coding names and steps used to code protocols

Coding step	***1 – identifying ideas***	***2 – classifying reasoning***
Code list	*IDEA*	*ABDUCTION*
	IDEA ASPECT	*DEDUCION*
		INDUCTION

First coding of the protocols involved the coding for presence of idea and idea aspect. Design activity in groups result in ideas that are contributed to by more than one person [Badke-schaub et al. 2007; Voss 2006]. Hence, ideas form idea episodes consisting of both a first mention of the idea (coded *idea*) and follow up utterances related to the same idea (coded *idea aspect*). Henceforth, *idea episodes* denote segments that include related idea and idea aspect utterances.

Definitions of the three types of reasoning, *abductive*, *deductive* and *inductive*, were derived from the literature review [Fann 1970; Johnson-Laird 2006; Magnani 1995; March 1976; Reichertz 2014; Roozenburg 1993; Schurz 2007]. The definitions used were oriented towards the suggested role or function that the three types of reasoning serve in reasoning processes. Generally, the codes interpreted the reasoning types as: (a) Abductive reasoning conveys uncertainty and possibility, (b) deductive reasoning conveys certainty and definitiveness and (c) inductive reasoning conveys preference through evaluation or generalisation. The coding of reasoning types was restricted to the idea episodes coded in the first step of the coding process.

Cohen's weighted Kappa was calculated for inter coder reliability after each of the coding steps [Cohen 1968]. The first author coded the all protocols, while the second author coded 460 segments for idea and idea aspect, reaching a Kappa of 0.71, and 353 segments for reasoning, reaching a Kappa of 0.61. Both scores are good and justify the validity of the coding scheme.

5. Results

This section presents and discusses the results of the data analysis. In addition to the quantitative analyses of the data to test the hypotheses, the section presents a qualitative analysis using examples and observations from the protocols to interpret and discuss the results.

5.1. Quantitative analysis

The protocols counted 6518 segments of which 3866 segments were idea episodes (59%). Of the idea episodes, 3354 segments (87%) coded for reasoning. Table 3 below presents the proportional distribution of all reasoning codes. The table also presents the proportional distribution of the type of reasoning first appearing (reasoning start) in idea episodes.

Table 3: Total counts and proportions of reasoning types and reasoning to start idea episodes

		Abductive	**Deductive**	**Inductive**
Coded reasoning	Count	435	2472	447
	Proportion	13%	74%	13%
Reasoning start	Count	125	227	18
	Proportion	33%	63%	4%

The coding found a high proportion of deductive reasoning and even amounts of abductive and inductive reasoning. However, when analysing the reasoning that starts idea episodes a higher proportion of abductive reasoning (33%) and lower proportions of deductive (63%) and inductive reasoning (4%) compared to overall reasoning proportions was found.

The workshops generated 349 evaluated ideas. Of these, 291 (83%) had an identifiable idea episode in the protocols, others were simply stated. Table 4 presents the distribution of the 291 ideas suitable for testing the hypotheses.

Table 4: Total counts and proportions of idea evaluation

Idea evaluation	**Accept**	**Analyse**	**Put on hold**	**Reject**
Count	168	39	40	44
Proportion	58%	13%	14%	15%

Ideas accepted for further use accounted for more than half of all ideas, while ideas not accepted evenly distributed across the other three categories.

To test the two hypotheses, a one-way ANOVA analysis was completed for the effect of reasoning start on idea evaluation, yielding ($F(2, 288) = 6.308$, $p = 0.002$). Hence, there is significant dependency of reasoning start on idea evaluation. The relationship is further analysed using independent samples t-tests to complete a pairwise comparison for the proportional differences across. Figure 1 below also displays the calculated confidence intervals (to the 95% margin of error) of the proportional distributions, thus illustrating the actual differences between the reasoning types hypothesised to start 'Accept' and 'Put on hold' idea evaluations.

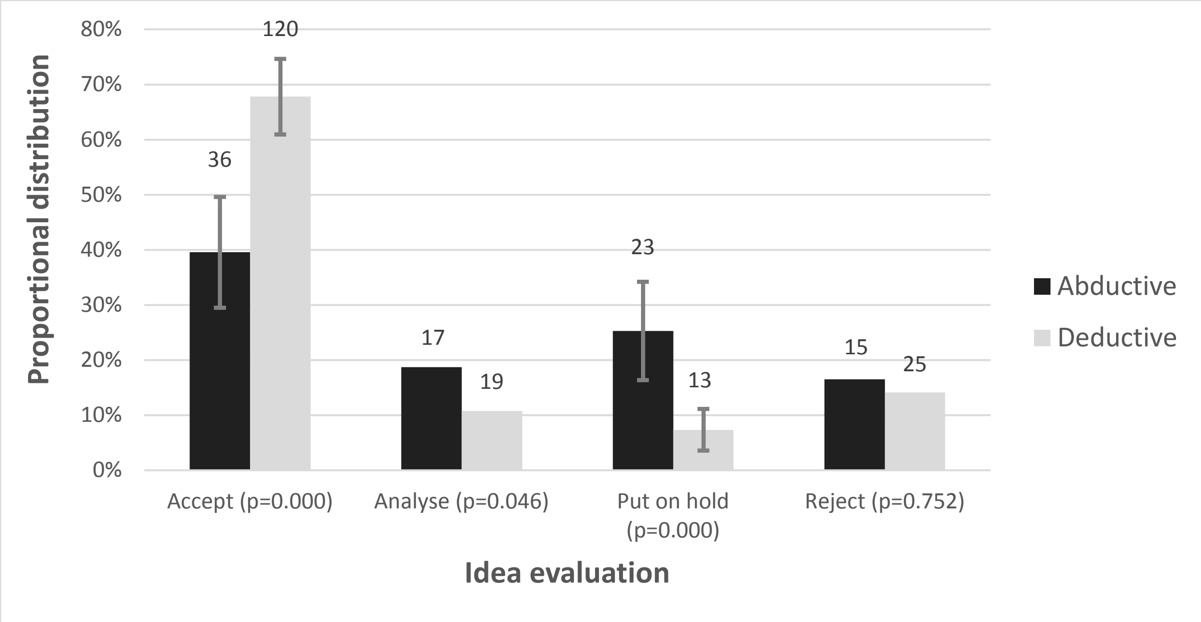

Figure 1: Proportional differences in reasoning type to start idea episodes by evaluation category. Numbers above each bar indicate number of ideas

The analysis significantly supports both H1 and H2. First, H1 hypothesised that deductive reasoning start ideas would be more likely to be accepted than those started by abductive reasoning. The paired bars to the left in figure 1 shows that 68% of deductive vs. 40% of abductive started ideas are accepted. This result is significant as shown by the p-value of the t-test (p=0.000). Second, H2 hypothesised that abductive reasoning is more likely to start 'Put on hold' ideas than deductive reasoning. The paired bars third from left in figure 1 shows that 25% of abductive vs. 7% of deductive ideas are 'put on hold'. This result is significant as shown by the p-value of the t-test (p=0.000).

5.2. Observations and interpretations

In the following section, an example and observations from the data interpret the above results. First, table 5 presents an example idea episode. Next, the episode is analysed and interpreted along with general observations from the protocols.

Table 5: Example idea episode from protocols. Translated from to English from Danish

Speaker	*Segment*	*IDEA*	*IDEA ASPECT*	*REASONING TYPE*
A	if you could minimise the entire pulley	*x*		*ABDUCTION*
A	or then just have a reel or a caster	*x*		*ABDUCTION*
A	that you find on the American solutions,	*x*		*DEDUCTION*
A	but then you just do a pre…	*x*		*DEDUCTION*
A	use a bit more to prepare	*x*		*DEDUCTION*
A	so you drive it to the window,	*x*		*DEDUCTION*
A	in the right distance mount it	*x*		*DEDUCTION*
A	and then you just have to lift it 3-4 cm	*x*		*DEDUCTION*
A	and then you have the adjustment and lift it again	*x*		*DEDUCTION*
A	so you minimise the entire phase of pulling and lifting	*x*		*DEDUCTION*

A	so you just do it manually	*x*		*DEDUCTION*
B	It could also be that you used the pulley to drive the wheel,		*x*	*ABDUCTION*
B	so you extend it and attach the hook		*x*	*DEDUCTION*
B	oh wait no, but, well…		*x*	
B	it is silly as it is now		*x*	*INDUCTION*
B	but it could be with the same motor		*x*	*DEDUCTION*
B	when it is attached to the cart base		*x*	*DEDUCTION*
B	then there is some sort of gearing to the wheel,		*x*	*DEDUCTION*
B	same engine drives and pulls…		*x*	*DEDUCTION*

The idea presented in the above example shows how abductive reasoning frames the idea by proposing to minimise or remove a product component. Following this is a range of deductive utterances seeking to explore possible solutions to the framing. After that, a second person contributes to the idea, thus triggering an aspect of the idea and abductive reasoning by re-framing the solution by suggesting alternative uses for the component sought minimised or removed in the previous framing. An instance of inductive reasoning also occurs as a subjective attitude to an existing solution. Investigating the form of the argument in the exemplified idea episode and drawing on the analysis of multiple episodes in the protocols, six observations stand out. First, abductive reasoning conveys possibility and intention in an uncertain form that invites to exploration of what it proposes. Second, and in contrast to abduction, deduction reasoning conveys certainty in a definitive form. This form often occurs when producing a sequence of statements that simulate a solution or consequence, as shown in above example. Third, inductive reasoning generally occurs at later in idea episodes and takes a form of decision or subjective attitude towards the idea. Fourth, reasoning types occur in different sequences, and thus do not follow a strict abductive-deductive-inductive process of inquiry as suggested by prescriptive models of design [March 1976]. Fifth, all types of reasoning can start idea episodes. While abductive reasoning is more likely to start episodes rather than appear in them (33% vs. 13%, refer to table 3), a majority of ideas (63%) are started by deductive reasoning. Different to the example above, ideas started by deductive reasoning often takes the form of an existing solution mentioned in a certain way, leaving little room for questioning or discussing the appropriateness of the idea. Sixth, the analysis shows that only 2% of all idea episodes did not include deductive reasoning, underlining the importance of deductions as a means to propose and simulate solutions, which is central to progress the design process [March 1976; Christensen and Schunn 2009].

A significant relationship exists between the type of reasoning used to start ideas and the resulting evaluation. Additionally, observing of the idea evaluation system in use by the companies revealed that accepted ideas tended to rely on existing solutions while ideas categorised to be 'put on hold' tended to entail the generation of radically new functional principles. Therefore, the study shows a link between the innovativeness of evaluated ideas, given the interpreted forms and function of the reasoning types in the data, inferring that accepted ideas are more likely to be incremental and generated with a reasoning process beginning with deduction while 'put on hold' ideas are more likely to be radical and likely to be started with an abductive reasoning process.

6. Discussion and conclusions

First, supported by both hypotheses, we find that there is a significant relationship between how ideas start and how they later add value to the design process. This result shows the importance of how people argue for their ideas, as it is a factor that influences framing and consequently other people in a context of group idea generation. The result thus agree with similar studies [Valkenburg and Dorst 1998; Stumpf and McDonnell 2002; Darke 1979].

Second, from the result of H1 that deductive reasoning leads to more incremental ideas, we argue that the definitive form of deductive reasoning constrains the remaining reasoning sequence to be less 'open' to redefine the initial framing. We attribute this with the certain and definitive form of deductive reasoning [Fann 1970]. This is evident because deductive reasoning starts idea episodes 63% of the time and that 58% of 'Accept' ideas do not contain any abductive reasoning while the number is 8% for 'Put on hold' ideas, 29% for Analyse ideas and given the evaluation system favouring the acceptance of incremental ideas. In contrast with the result from H2, abductive reasoning leads to more radical ideas, we argue that the uncertain and 'open' form of abductive reasoning leads to a higher likelihood of more abductive reasoning appearing in the development of the idea, entailing new perspectives and ways of 'seeing' the problem, signifying more radically different ideas [Roozenburg 1993]. Hence, ideas started by deductive reasoning risk missing out on alternative solutions and ideas started by abductive reasoning risk having less change of being accepted due to ideas unfit for the constraints set by e.g. a product development project. Therefore, the study finds that analysing the form of verbal reasoning present is a way to diagnose whether an idea generation workshop, or similar design activity, is progressing in a productive way by producing appropriate and valuable ideas [Kudrowitz and Wallace 2012].

Third, owing to other factors that influence how ideas are evaluated, we propose that analysing the form verbal reasoning is combined with other methods for understanding design activity. Another important factor to consider is the content of utterances, i.e. what an utterance proposes. While the present study has mainly investigated the form of arguments made, other studies in design concern analysing and modelling how 'design' ideas develop, e.g. concerning function, behaviour and structure [Gero and Kannengiesser 2004; March 1976]. Thus, integrating such analyses with the analysis method applied in present study holds potential to understand reasoning in design progresses along with the co-evolution of problem and solution [Dorst and Cross 2001].

6.2. Contributions and future research

Concluding, the study presented the analysis of reasoning in groups for both generation of ideas and their evaluation on four real world problems.

Main contributions include: (a) The development of a reliable coding scheme for identifying verbal reasoning, (b) showing a significant relationship between reasoning to start ideas and the evaluated value of the idea and (c) demonstrating that verbal framing is decisive for the further development of an idea in terms of how existing perspectives on problems and solutions change. Combined, the contributions contribution to the understanding of design as a complex activity involving technical and social considerations, and provide a platform for further research on:

- The identification and analysis of other factors influencing verbal reasoning and idea value alike, e.g. the content of reasoning in idea generation
- Analysing individual differences in reasoning to support team composition and performance

From the perspective of design practice, the study has shown the importance of verbal reasoning as a tangible aspect of design activity. By being aware of the verbal form used when proposing ideas practitioners can influence others to accept ideas or to emphasise new perspective, etc. This is a point of further research through the development and testing of:

- Tools for diagnosing design activity in practice
- Design methods or similar to influence the verbal reasoning of design teams

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