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 [Magnani 1995], [Schurz 2007].

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 in 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]. Galle [1996] empirically analysed the reasoning used in design rationalisation by use of replication protocol analysis. He found patterns of inference corresponding to abductive and deductive reasoning and argues that deductive reasoning can be productive and introduce new elements to a design, as opposed to the theoretically based argument by e.g. Roozenburg [1993]. Galle [1996] further observes that design reasoning is occasionally opportunistic and based on beliefs, and therefore does not necessarily reach a strict formal logical conclusion as per the premises. A related study by Dong et al. [2015] analysed verbal protocols of reasoning processes between participants evaluating design ideas and concepts in terms of the 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 [March 1976], [Gero and Kannengiesser 2004]. 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 [Rittel 1987], [Bucciarelli 2002].

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 to controlled experimental conditions. In contrast, the present study concerns participants and design problems from industry and 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 [Ward and Kolomyts 2010], [Keshwani et al. 2013]. This results 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. The study uses the outcome idea value to the design process as an indicator to analyse the effects of patterns of argumentation and reasoning on design activity.

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]. H1 predicts 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 with a certain, deductive form are evaluated 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, H2 predicts that abductive reasoning leads to uncertain ways of proposing ideas requiring further investigation, and thus evaluated unfit for current development project, but potentially valuable for future projects, i.e. radical ideas rather than incremental ideas.

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 provides the data for this study. All companies were of SME size and were involved in a product development project. 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 and sometimes further idea generation by 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 four case companies evaluated the ideas generated. The evaluating groups counted at least the project leader and one design engineer for all companies. Two matrices determined 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 [Chi 1997], [Ahmed et al. 2003], [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 corresponding to the micro-level of design activity [Rittel 1987], segmentation was completed according to word phrases [Goldschmidt 1991]. Next, a two-step coding scheme analysed the segmented protocols.

The first coding step 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 [Voss 2006], [Badke-Schaub et al. 2007]. 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.

For the second coding step, definitions of the three types of reasoning, *abductive*, *deductive* and *inductive*, were derived from the literature review [Fann 1970], [March 1976], [Roozenburg 1993], [Magnani 1995], [Johnson-Laird 2006], [Schurz 2007], [Reichertz 2014]. 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. The scores are fair to 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.

The protocols counted 6518 segments of which 3866 segments were idea episodes (59%). Of the idea episodes, 3354 segments (87%) coded for reasoning. Table 2 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 2. 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 and evaluated 349 ideas. Of these, 291 (83%) had an identifiable idea episode in the protocols. Table 3 presents the distribution of how the 291 ideas were evaluated.

Table 3. 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 relationship between reasoning start and idea evaluation. The relationship is further analysed using independent samples t-tests to complete a pairwise comparison for the proportional differences across the pairs. Figure 1 illustrates the results and displays the calculated confidence intervals (to the 95% margin of error) of the proportional distributions, thus showing the differences between the reasoning types used to start ideas evaluated to be either 'Accept' and 'Put on hold'. This analysis tests the stated hypotheses.

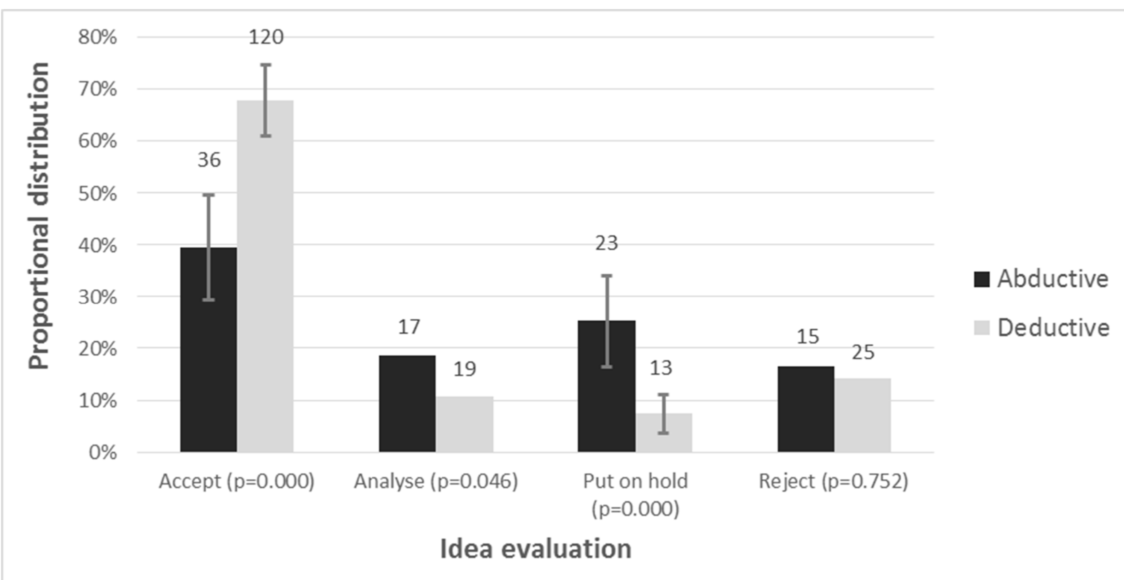

Figure 1. Proportional differences in reasoning type to start idea episodes by evaluation category. Numbers above each bar indicate number of ideas

The analysis significantly supports both H1 and H2. First, H1 hypothesised that ideas started by deductive reasoning 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 evaluated as ‘Accept’. 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).

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 evaluated to be ‘Put on hold’ tended to entail the generation of radically new solutions or principles, as expected in the hypothesis explanations. One case company was even jokingly re-naming the ‘Put on hold’ to the ‘patent’ category. While not tested statistically, the result suggest a link to the innovativeness of ideas, given the interpretation of the reasoning types in the data that deductive utterances signify certainty and the opposite for abductive utterances. Thus, certain framings of ideas that are accepted infers that they are more likely to be incremental and generated with a reasoning process starting with deduction and certainty e.g. stemming from existing knowledge or existing solutions. To the opposite, ideas evaluated to be put on hold are more likely to be framed by uncertainty, inferring radical ideas often started by an abductive reasoning process because the person arguing for the idea invents new solutions.

An additional result from the analysis shown in Figure 1 shows that 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 2), a majority of ideas (63%) are started by deductive reasoning. This suggests that idea generation does not always rely on abductive reasoning, as suggested by theories and models of design [March 1976], [Roozenburg 1993], but that the use of purely deductive processes are able to generate new ideas, as also found by Galle [1996].

Next, an example and following observations from the data further illustrates and discusses the results. Table 4 presents the example idea episode.

Table 4. 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, five 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 points in idea episodes and takes a form of decisions 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, 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].

6. Discussion and implications

The results presented in the above found support for both of the stated hypotheses. In sum, the results showed a statistically significant relationship between the reasoning types used to start arguments for ideas and the later evaluated value of ideas, where deductive and certain ideas tended to be accepted while abductive and uncertain ideas tended to be potentially valuable, but not presently acceptable. We thus argue that the verbal form of reasoning is indicative of the type of ideas that is being proposed, which allows for a very direct way of diagnosing how an idea may be later evaluated to fit an on-going product development project.

A different interpretation of the results is possible through the observation from H1 that deductive reasoning leads to more incremental ideas. As earlier stated, the framing of ideas is found to influence and guide activity [Stumpf and McDonnell 2002]. Consequently, 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]. 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. Likewise, the result of H2 that abductive reasoning leads to more radical ideas makes it possible to 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 determine 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].

Finally, the results of the study indicates in important relationship between how ideas are framed and how they lead to more of the same type of reasoning. For example, we observe that abductively started ideas tend to lead to more abductive reasoning later on and similar for deductive reasoning. While not directly analysed in present study, the result suggests that the way people argue for their ideas influences, frames and consequently influences and persuades other people in a context of group idea generation.

Similar studies support this finding [Darke 1979], [Stumpf and McDonnell 2002], , and thus provide the possibility of a different explanation to above result that e.g. a majority ideas started by deductive reasoning only contain other deductive reasoning. If accepted ideas are at the same time incremental, and thus not bringing much new to the way of perceiving the design space, it is of interest to investigate how reasoning patterns when arguing for ideas can be changed to allow for new (abductively inferred) perspectives on solutions, etc. The same could be said to bring radical, abductively started ideas, to a more appropriate level befit to the constraints set by the design task, etc.

7. Conclusion

The study presented the analysis of reasoning in groups for both generation of ideas and their evaluation on four real world problems. The results of the data coding showed a significant relationship between reasoning to start ideas and the evaluated value of the idea and demonstrating that verbal framing is decisive for the further development of an idea in terms of how existing perspectives on problems and solutions change.

7.1 Limitations and future research

Two limitations of the study frames the extent of the contribution and sets directions for future research. First, the analysis is limited to the verbal arguments accompanying generated ideas and the form in which they are proposed. While this method of analysis allows comparing arguments in terms of how they are framed and started, the analysis does not allow to quantitatively compare to the content of ideas, e.g. the knowledge used or the kind of solution proposed by the idea. By investigating the relationship between form and content of ideas, an improved understanding of how the design process unfolds can diagnose and influence design activity.

Second, the study did not quantitatively analyse how the different types of reasoning used to start ideas influence the following sequence of reasoning. Such an analysis would shed more light on the extent of framing effects acting through the use of language or rhetorical styles in design activity. Furthermore, this analysis holds the potential to analyse how verbal behaviour in a context of design leads to influence on e.g. other people engaged in a collaborative design activity and the kind and value of resulting ideas.

In combination, the study contributes to design research by showing a significant relationship between the verbal framing of ideas and the resulting evaluated value of the same idea. 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 future research through the development and testing of:

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

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