EXPLORING THE ROLE OF LINGUISTIC ABSTRACTION IN IDEA-GENERATION SESSIONS

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ABSTRACT

For many years, both academia and industry have been interested in increasing the efficiency of idea-generation meetings. Alex Osborne's (1953) rules for brainstorming are an early attempt to do so, and have extensively been used in engineering design, however their effectiveness has been questioned with recent research, and a need for fundamental research to establish which practices are useful arises. This study is an attempt in investigating linguistic abstraction in idea-generation meetings, in order to establish whether any best practices can be distilled from the language used. Engineering design group meetings were recorded and transcribed, and was analysed using a coding framework which was developed for analysing linguistic categories as well as the ideas that were generated during those meetings. More particularly, the study investigates the average abstractness/concreteness of speech throughout the duration of the meetings, as well as the switching between abstract and concrete language and vice versa while comparing idea-related discourse and non-idea related discourse switching. The coding framework proposed is considered robust enough to carry out further work.

Keywords: Creativity, Design practice, Design engineering

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1 INTRODUCTION

In the modern era, product design is becoming progressively complex as it becomes more interdisciplinary, being influenced by sales, marketing and other areas of business, and there is increased pressure on the engineering design process to become more efficient and productive. An attempt to increase the efficiency of idea-generation meetings lead to the use of 'brainstorming'. Through his influential book *Applied Imagination: Principles and Procedures of Creative Problem Solving*, Alex Osborne (1953) popularised the method called 'brainstorming', a group-creativity technique that involves problem-solving via spontaneous idea generation. This technique, originally developed for product marketing purposes, is frequently diverted from its original purpose and used by engineering designers as an effort to cope with their increased pressure to innovate efficiently. While this has shown to be useful in practice, it is not proven that the rules for efficient idea generation defined by Osborne in the context of product marketing actually apply to engineering design. For instance, contemporary research (Gómez-Jiménez 2013, Linley 2013) has found contradictory evidence in engineering design idea generation meetings to Osborne's tenet that criticism inhibits creativity. This poses a need for fundamental research in order to establish which practices would best promote creativity and idea generation both in quantity and quality of ideas generated, with a view to suggest some new guidelines for engineering design in the future. In order for this to be done, methods must first be developed to study brainstorming sessions in engineering design, which can then be deployed to create and analyse data sets. With statistically significant findings for engineering design, the research might eventually lead to propositions for new, specialist brainstorming 'rules' for engineering design.

Linguistic abstraction and generalisation are two candidates that may have an effect on the efficiency of idea generation meetings. Abstraction and generalisation have previously been studied within the context of the language used in the problem statement of design tasks. An example is Becattini, Borgianni, Cascini and Rotini's (2012) Hill Model, where they advise that the 'specific problem to be solved' should first be abstracted to a 'general problem' in order to generate an 'ideal solution', which will then decrease in level of abstraction as it is further defined into a 'specific engineering solution'. This is quite similar to Owen's (1992) 'ladder of abstraction'. However, this is only for the context of the problem statement, and does not address the abstraction throughout the meeting. Work on abstraction within the Theory of Inventive Problem Solving (TRIZ) has also been done by Kamarudin, Ridgway and Ismail (2016) who conclude that abstraction "is an absolute advantage in the conceptual design process", as well as Kokotovich and Dorst (2016) who note "one's capacity for varying the levels of abstraction is inextricably linked to the capacity for creatively mixing and re-mixing (1) Objects, (2) Experiences and (3) Concepts". Rodd, Gaskell and Marslen-Wilson (2000) have noted that linguistic 'ambiguity' as they term it, may provide advantages and disadvantages to cognition, and this poses an interesting area to study within the context of engineering meetings which require creativity for idea generation.

While existing literature indicates that levels of abstraction in thoughts and ideas may be potentially influential factors on creativity, no specific study to date has focused on how that abstraction manifests itself in the language used within engineering design brainstorming meetings. This research aims to address this particular gap and to investigate the effects of *linguistic abstraction* on the quantity and quality of ideas produced during engineering design meetings. As a first step towards this aim, this paper presents a new method to conduct in-depth analysis of the level of abstraction in peoples' language throughout the duration of idea generation meetings.

2 LITERATURE REVIEW

As a fundamental feature of human thinking, abstraction has been addressed in a wide spectrum of fields from art, linguistics, design, to computer science, to name but a few. In order to research 'linguistic abstraction' for this study, two definitions of 'abstract' (given by the Oxford English Dictionary 2018) provided the starting point for the literature review. The first definition of abstract (noun) is "existing in thought or as an idea but not having a physical or concrete existence". This definition encompasses a variety of language expressions, and is the basis of Semin and Fiedler's (1988) levels of abstraction framework. Psychologists Semin and Fiedler propose that the following four linguistic categories exist within different levels of abstraction, in order of decreasing abstraction:

1. Adjectives e.g. friendly, outgoing
2. State verbs e.g. love, respect, abhor, trust
3. Interpretive action verbs e.g. encourage, mislead, cheat, flatter
4. Descriptive action verbs e.g. hold, visit, call.

The first category involves adjectives which are the most subjective and as such may have different meanings to different people. The second category, state verbs, encompasses abstract statements which are again subjective, “refer to mental and emotional states or changes therein as opposed to overt behaviour” and “cannot be verified objectively by an observer, have a hypothetical interpretive status, and refer primarily to psychological state of person” (Semin and Fiedler 1988). The third category of interpretive action verbs is less abstract as those verbs have a more objective descriptive function, but are also still open to some degree of interpretation. The final, least abstract category are the descriptive action verbs, including verbs that are purely descriptive and allow little room for subjective interpretation. A significant difference between action verbs and state verbs is that action verbs usually refer to an action with a clearly defined start and finish.

In addition, within each category, there are further levels of abstraction. For example, while ‘generous’, being an adjective, is at the highest level of abstraction, ‘tall’, being within the same linguistic category would be considered less abstract. This is because there are a smaller number of interpretations that are attributed to a things (e.g. people) being described as ‘tall’: because the physical height of a human exists within certain natural constraints, whereas how ‘generous’ a person can be is much more subjective and the limits are much wider, varying in interpretation from person to person.

The second definition of ‘abstract’ (verb) is “extract or remove [something]” (Oxford English Dictionary 2018). Although this definition is for the verb ‘to abstract’, it provides invaluable insight into what exactly ‘abstraction’ is, since formulating an abstract expression involves the removal of specific details. For instance, saying “we played a game” provides a certain amount of information regarding what activity was undertaken, but it does not provide specific details. By contrast, a more specific way of formulating that expression would be “John and I played two games of Monopoly”. This sentence provides further details as to which people played the game, and what game they played. Hence, an abstract statement may be classified as such when there is further information that could have been given, i.e. there is an element of subjectivity and uncertainty with regard to the meaning of the expression, varying from individual to individual. An abstraction, such as in the game example, is the product of the process of abstraction and produces concepts that may act as super-categories which give room for sub-categories of many related concepts (Langer 1953). In the case of the game example, the noun ‘game’ is the super-category, and the sub-categories involve all games that exist, such as Monopoly. In psychology, abstraction is studied in the context of abstract versus concrete language. Concrete language is defined as that in which referents (the objects being referred to) can be experienced through sensation or non-verbal perception i.e. dog, pond, tree. This means that there is little room for subjective interpretation, and the same referent is experienced in a broadly similar manner in different individuals. Abstract referents lack this attribute, e.g. love, truth (Paivio, Yuille and Madigan 1968), since subjective interpretation is inherent.

As ‘abstraction’ and ‘ambiguity’ are often presented as (almost) synonymous concepts, studying abstraction in language leads to studies on the role of ambiguity in language. In an experiment attempting to assess extraction of meaning from sentences containing ambiguous words by participants who listened to phrases through earphones (Lackner and Garrett 1972), it was found that “people may subconsciously consider more meanings than they are aware of” (Aitchison 2003). In another linguistic study by Swinney (1979) where participants listened to sentences containing lexical ambiguities and then performed a lexical decision task, it was similarly found that lexical decisions for words related to each of the multiple meanings of the presented ambiguous words were facilitated, even when certain meanings were inappropriate based on the contextual environment of those ambiguous words. The findings of these studies allude to the prospect that since ambiguous phrases may elicit multiple meanings in people’s subconscious, it may be possible that use of ambiguous (more abstract) words/phrases could increase creativity due to multiple meanings increasing the size of the idea space.

These theories on linguistic abstraction and ambiguity have not been applied in the study of engineering design meetings. The first stage in assessing whether linguistic abstraction could be a useful contribution to design creativity research is to develop a method to characterise the level of linguistic abstraction within the context of engineering design meetings.

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3 METHOD

In order to characterise linguistic abstraction in idea generation meetings, recordings from three such meetings of three different groups of designers were collected. A linguistic framework was developed to characterise the language used, and the transcripts of the meetings were coded using that framework.

3.1 Ideation session recording

Data comprises recordings of idea generation meetings carried out by three groups of six senior engineering design students each (referred to as A, B and C). No rules or guidelines were imposed for their sessions. Each of the three sessions aimed to generate design concepts for a different project brief. Group A worked on an off-grid bamboo processing unit for engineering building materials, group B on a veterinary super operating theatre and group C on a CNC textile machine for textile research. The idea generation meetings were carried out in February 2017 and were part of the students' ongoing work for a semester-long design unit. Table 1 shows a list of the recordings, including the date on which they were taken, the group ID and the approximate duration of the recording.

Table 1: Recordings used

Date of Meeting	Group ID	Approximate duration
14/02/2017	A	45 minutes
15/02/2017	B	31 minutes
21/02/2017	C	39 minutes

3.2 Transcription

The recordings were transcribed manually and the speakers' names were omitted for anonymity. Certain periods of speech which were irrelevant to the study, e.g. expressions of humour, were not transcribed but described for clarity with the use of brackets, as shown in the transcript row in Figure 1.

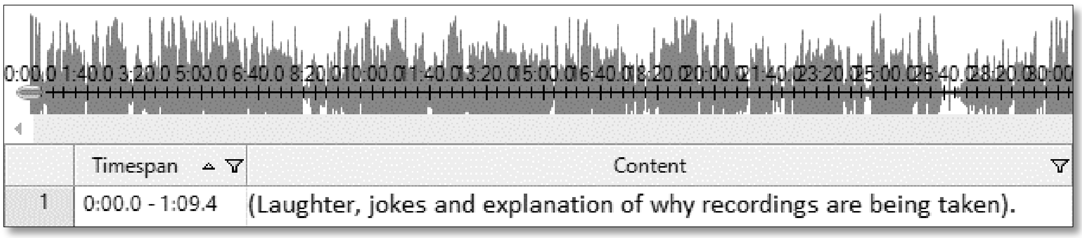

Figure 1: Screen shot of the transcript editor showing a spectrogram of the audio file being transcribed, as well as the first row of the transcript.

3.3 Coding framework

This section describes the coding framework which was developed in order to analyse the language used in the ideation meetings. The development of the main categories of the framework *ideas* and *linguistic abstraction*, are individually described in sections 3.3.1 and 3.3.2. The finalised coding framework is presented in section 3.3.3.

3.3.1 Ideas

The traditional, generic definition of an idea is 'a thought or suggestion as to a possible course of action' (Oxford English Dictionary 2018). Howard (2008) defines an idea within the context of engineering design as a 'creative output' and as a 'generative proposition linked to the function, behaviour or structure of a concept'. Combining the traditional definition with the engineering design definition, it is therefore possible to infer that an idea within this context must be a suggestion of a way of doing something, but more specifically it must be related to a concept for the product which is being designed. This effectively rules out non-product-related suggestions which would traditionally

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be classified as ideas, such as a suggestion on how to carry out a process. The notion of 'generative proposition' is also congruent with the findings of Sonalkar, Mabogunje and Leifer (2012), which have identified a "notion of possibility in a speaker's expression" when they are introducing a concept. Sonalkar *et al.* (2012) then move on to define concepts as "product solutions that were expressed through either a single idea expression or through an aggregate of idea expressions".
To summarise, the following three parameters need to be fulfilled in order for a speech portion to be classified as an idea expression: generative proposition, linked to a concept, related to the final product to be proposed.
To illustrate what would not be classified as an idea expression and what would, examples of transcript rows are shown in Figure 2 and Figure 3. Figure 2 shows a transcript row which poses a suggestion but which is not categorised as an idea due to the fact that the suggestion is unrelated to a concept, while Figure 3 shows a transcript row which would be classified as an idea expression because it involves a concept-related proposition.

3	0:19.3 - 0:21.5	So we decide on it as we go through each one...

Figure 2: A transcript row showing a suggestion which would not be classified as an idea.

112	11:07.3 - 11:29.1	Yeah, I think the disinfecting solution, we have something similar here. Where what happens in like, when you, you can store the tools here, and when the operation's finished actually, then the fluid kinda like rises up and then cleans everything after some time, and then once again drains, something like that. We can have like evaporating system something to make it dry and things like that.

Figure 3: A transcript row showing a speech portion classified as an idea expression.

Useful ideas
Ideas were then categorised as 'useful' if they have carried through to the final design of the product. This was assessed by analysing the deliverables of the project, which were the individual technical reports written by each group member, business plans which were written by the group as a whole, and the accompanying technical drawings submitted by the groups. To ensure that all useful ideas were identified, interviews with group members were carried out, outlined in section 3.4.

3.3.2 Linguistic abstraction

Linguistic abstraction was categorised using the *abstract versus concrete* spectrum. Since the ideation meetings involved heavy use of technical language, it was not possible to use Semin and Fiedler's (1988) framework in exclusivity to perform the analysis, due to its very narrow focus on parts of speech, e.g. verbs and adjectives. As such, the abstract and concrete categories were instead formulated through an iterative process of comparing a variety of speech expressions for the degree of ambiguity they exhibited. In this process, a variety of categories were identified such as expressions of equipment, materials or scientific phenomena. Each category was found to have different levels of abstraction. For instance, in the equipment category, some expressions involved saying 'a machine' and others saying '3D printer'. It can be observed that there is a different level of abstraction in each statement, since '3D printer' leaves little room for ambiguity for what the referred to equipment is, but 'a machine' is a super-categorical expression which has a larger scope for different interpretations. Therefore, expressions were assessed on their abstraction level depending on the context of the expression as well as the words used. In this way, portions of speech were categorised as 'more towards the abstract side of the spectrum' or 'or more towards the concrete side of the spectrum'. These go on to be referred to in the rest of this paper as 'abstract' and 'concrete' respectively.

3.3.3 Final coding framework proposed

The analysis process involved implementing the framework into NVivo. This was done creating 'nodes', which represent categories in which transcript rows may be placed in. Transcript rows may be added to categories via a simple drag-and-drop method. Three main nodes were created to characterise the general categories in sections 3.3.1 to 3.3.2. The main nodes were Abstract Language, Concrete Language, and Idea and were used as top-level descriptors rather than nodes in which text was actually coded into, with the exception of Idea. Sub-nodes were created to indicate cases of each general

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category. Abstract language was sub-divided into Analogy, Vague material, Vague placeholders, Vague size or shape or quantities and Vague terminology while Idea was used as a node in itself rather than just a top-level descriptor, with Useful idea being a sub-node. Note that referenced expressions in the Idea and Useful idea nodes are not necessarily discrete ideas, i.e. two or more references in the Idea and/or Useful idea nodes might relate to the same concept. Finally, Concrete language was sub-divided into Specific materials, Specific size or shape or quantities and Specific terminology. This is summarised in Table 2.

Table 2: Node names and descriptions used in the coding framework. Node names in bold are top-level nodes and succeeding ones are sub-nodes of the preceding bold node.

Node Name	*Description*
Idea	Generative proposition linked to the function, behaviour or structure of a concept.
Useful idea	Generative proposition linked to the function, behaviour or structure of a concept, which was used in the final design.
Concrete language	
Specific materials	Specific descriptor of a material and material families e.g. cotton, bamboo, ABS, epoxy, anti-inflammatories.
Specific size or shape or quantities	Size, shape or quantities expressed in an explicit manner, e.g. five meters, two ideas.
Specific terminology	Includes specific scientific principles, effects, processes, properties, equipment, methods, and other engineering terminology e.g. biomass energy, modular construction.
Abstract language	
Analogy	Comparing or likening something to another, usually for the purposes of explanation e.g. “like an angle poise lamp”, “it could look like a hand”.
Vague materials	Generic descriptor of a material e.g. metal, plastic.
Vague placeholders	Includes simplifications of what is being explained, e.g. calling something a ‘thing’ or ‘stuff’.
Vague size or shape or quantities	Size, shape or quantities expressed in a vague manner, e.g. big animal, lots of hinges.
Vague terminology	Includes vague scientific principles, effects, processes, properties, equipment, methods, and general terminology e.g. machine, value, sustainable energy development.

3.4 Interviews

In order to ensure that useful ideas were correctly identified, interviews with one member of each group were carried out. A copy of each member’s group meeting transcript was given to them with the portions of text coded in the Idea node highlighted. By labelling the ideas which were useful using an asterisk and some notes, they confirmed which ideas should be in the Useful idea node. Moreover, they were also given the opportunity to flag any idea that was expressed in the transcript but was mistakenly not identified by the researcher.

3.5 Linguistic analysis using the proposed framework

A spreadsheet was created where each instance of abstract or concrete language in each transcript row was identified, by placing a ‘1’ in the corresponding column. Since several instances of each type of language might occur within the same transcript row, each row was split into parts e.g. 1a, 1b, 1c, as required. A third and a fourth column were also created, corresponding to ‘idea’ and ‘useful idea’. Thus, the transcript rows which corresponded to a certain idea were identified, by placing a ‘1’ in the appropriate column, and then enclosed in a dark outline (‘idea box’) for ease of viewing. This way, the different idea instantiations are clearly visible on the spreadsheet. This is demonstrated in Figure 4 which shows an excerpt of the transcript with an idea box. Rows 2a-7 involve speech corresponding to an idea and the first four rows involve abstract and concrete language instances, while the blank abstract, concrete and useful idea cells represent the fact that those elements were not observed in those transcript rows. Specifically for the abstract and concrete columns, it means that either those transcript rows did not include language which could be classified as either, e.g. speech portions like

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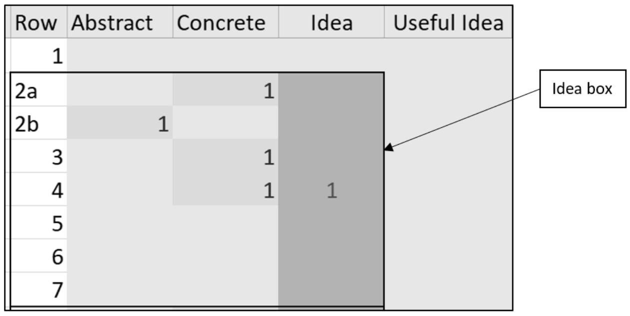
‘Yes’ and ‘OK’, or involved non-meeting-related speech, such as the example in Figure 1 (which is not the case when the row is enclosed within an ‘idea box’).



Row	Abstract	Concrete	Idea	Useful Idea
1				
2a		1		
2b	1			
3		1		
4		1	1	
5				
6				
7				

Figure 4: Excerpt of the spreadsheet showing a representation of the transcript.

The instances of abstract language occurring within 20 consecutive spreadsheet rows were added and then divided by 20. This gives an indication of the average ‘abstractness’ of the language in those 20 rows. This was carried through for the whole spreadsheet, e.g. for rows 10-20, then 11-21, then 12-22, and so on. In this way, a number in the range of 0 to 1 was calculated for each 20-row portion, which enabled the creation of graphs representing the level of abstract language variation throughout the progression of the meeting. This was done for concrete language as well.

4 RESULTS & DISCUSSION

4.1 Levels of abstractness and concreteness

A sample of the results of the method described in section 3.5 are shown in Figure 5 below. Highlighted in light grey and dark grey are ideas and useful ideas respectively and all are numbered (i.e. ideas 1 to 23 are shown), and the average concreteness is represented by a dark line while the average abstractness with a lighter line.

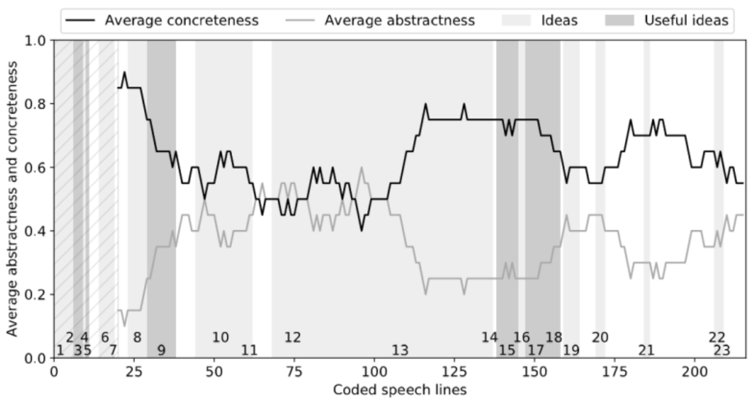


Figure 5: Average abstractness and concreteness during the meeting of Group B.

Taking all the graphs obtained (groups A, B and C), it was found that there is a higher proportion of concrete language during idea discussion. In the few idea instances where the proportion of concrete language is not higher than that of abstract language, the two proportions are actually very close (e.g. see idea 12 in Figure 5).

4.2 Switching between abstract and concrete language

Figures 6 and 7 show a portion of the discussion of Group B, where they discuss the idea of having sensors built in the veterinary operating theatre which would notify the surgeon if too much force is being applied or the animal starts moving. Figure 6 (left) shows that in row 109 a detailed description is given about how that system would work, and Figure 6 (right) shows that the speaker used several instances of both abstract and concrete language. Then, the speaker in row 110 summarises the concept previously described as ‘real-time read-out’, which is considered concrete language as shown in Figure 6 (right). It is possible to conclude that the level of abstraction of idea content (real-time

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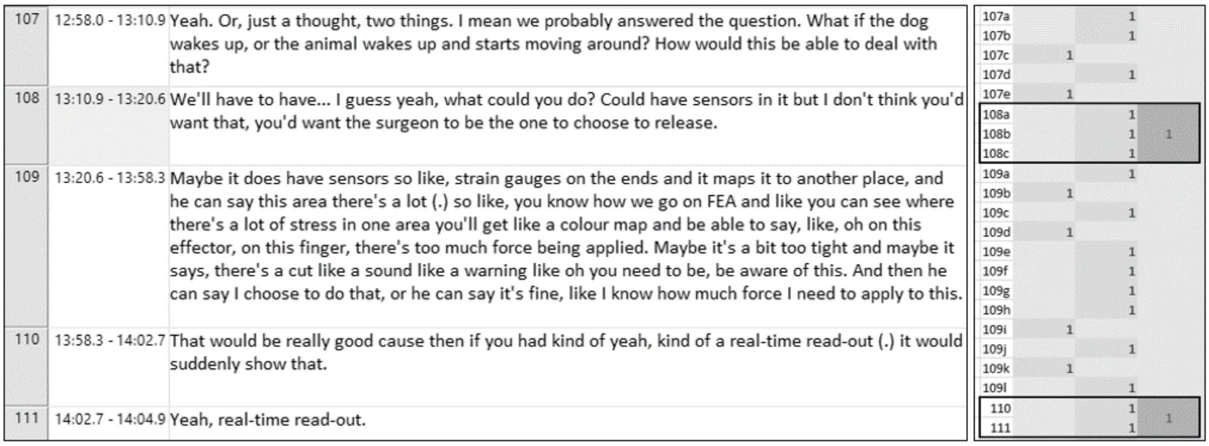
read-out in row 110 is more abstract with regard to the idea space than the detailed description given in row 109) is not necessarily related to the linguistic abstraction, since real-time read-out is considered concrete linguistically, while many of the descriptors used in row 109 are considered abstract, even though the ideas discussed are less so within the context of the idea space. Examples like these show that there is an interesting distinction between linguistic abstraction and idea abstraction - as understood in engineering design research. The topic merits further research.



107	12:58.0 - 13:10.9	Yeah. Or, just a thought, two things. I mean we probably answered the question. What if the dog wakes up, or the animal wakes up and starts moving around? How would this be able to deal with that?
108	13:10.9 - 13:20.6	We'll have to have... I guess yeah, what could you do? Could have sensors in it but I don't think you'd want that, you'd want the surgeon to be the one to choose to release.
109	13:20.6 - 13:58.3	Maybe it does have sensors so like, strain gauges on the ends and it maps it to another place, and he can say this area there's a lot (.) so like, you know how we go on FEA and like you can see where there's a lot of stress in one area you'll get like a colour map and be able to say, like, oh on this effector, on this finger, there's too much force being applied. Maybe it's a bit too tight and maybe it says, there's a cut like a sound like a warning like oh you need to be, be aware of this. And then he can say I choose to do that, or he can say it's fine, like I know how much force I need to apply to this.
110	13:58.3 - 14:02.7	That would be really good cause then if you had kind of yeah, kind of a real-time read-out (.) it would suddenly show that.
111	14:02.7 - 14:04.9	Yeah, real-time read-out.

107a		1	
107b		1	
107c	1		
107d		1	
107e	1		
108a		1	1
108b		1	
108c		1	
109a		1	
109b	1		
109c		1	
109d	1		
109e		1	
109f		1	
109g		1	
109h		1	
109i	1		
109j		1	
109k	1		
109l		1	
110		1	1
111		1	

Figure 6: Transcript rows (left) coded transcript rows (right) 107-111 of Group B.

The histograms in Figures 7, 8 and 9 below show the switching rates between abstract and concrete language (switches from the former to the latter and vice versa, divided by the number of rows) for portions of speech involving ideas (left) as well as those that do not (right), for each group. The highest switching rates were observed during idea-related discussion for groups A and B, and the opposite was found for Group C. It must be noted that a limitation for this data was the fact that some ideas were expressed only in one single sentence, and hence no switching could be observed, so those ideas were not taken into consideration for the histograms.

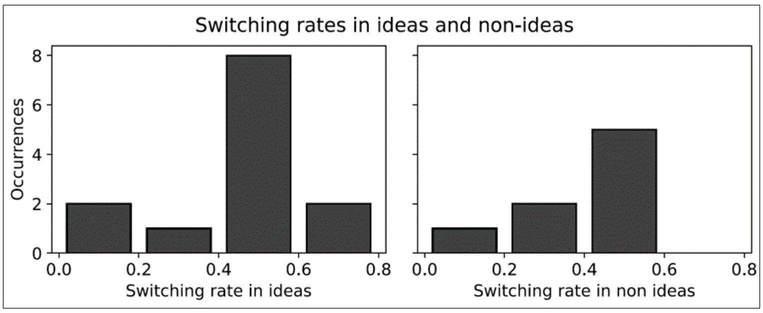


Figure 7: Histogram of switching occurrences for Group A.

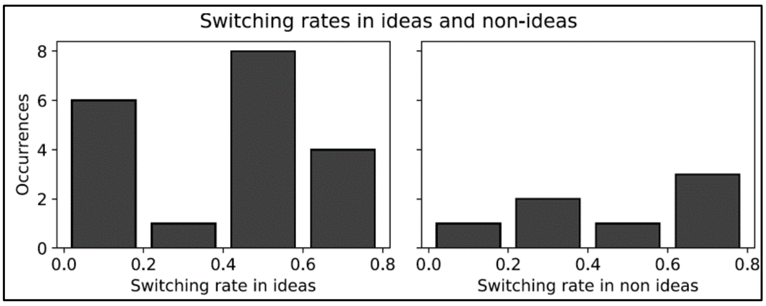


Figure 8: Histogram of switching occurrences for Group B.

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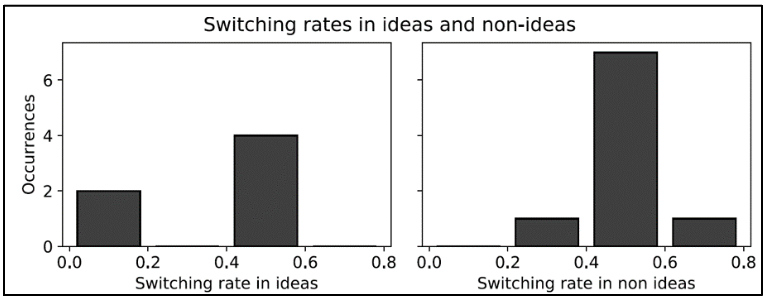

Figure 9: Histogram of switching occurrences for Group C.

4.3 Other observations

Although the primary topic of study is the effect of linguistic abstraction on idea generation, since the coding framework enables the identification of ideas and useful ideas within each meeting, it is possible to observe the time-efficiency of each meeting, whereby time-efficiency is defined as the portion of time spent discussing ideas with respect to the total meeting duration, i.e. a meeting that was not very time efficient included large portions of speech unrelated to idea discussion. The first finding was the expected heterogeneity of the meetings; each meeting had different numbers of ideas present, portions of non-idea related speech varying in length in between each idea expression and as such different time efficiency, as well as different volumes of concrete language. Variations in time-efficiency may be attributed to various factors. For example, the meetings which had a 'looser' agenda show fewer ideas and large portions of non-idea related speech. However, other unpredictable factors may contribute, such as familiarity and rapport between group members. This poses a limitation, if all groups had an equivalent agenda (focused brainstorming) we would have seen more idea-related discussion and consequently we would have had more data to study efficiency. Another interesting phenomenon observed was that of 'unexplored' ideas. There were a few instances where a person would offer an idea which was not discussed at all.

4.4 Inter-observer reliability check

To establish the reliability of the proposed method, it is suggested to perform an inter-observer reliability check using agreement on individual occurrences by interval sampling, as described by Caro, Roper and Young (1979). As a preliminary test before doing such a check, an independent observer was given a portion of un-coded transcript to code using the framework. The nodes required for the analysis were also given. The observer was given a briefing on the categories (nodes) for which transcript rows had to be classified, as well as how to use the required software. In addition, a demonstration was given to them by showing them an already coded portion from a different transcript section. It is important to note that the observer was not asked to identify useful idea expressions, since that would involve them having to read the three groups' deliverables. It was found that there was more than three quarters agreement on the observer's and the authors' transcripts, showing promise that the method would do well in an inter-observer reliability check.

5 CONCLUSIONS

The presented study links the effects of linguistic abstraction to the ideas produced during engineering design meetings. It is a first attempt at studying the level of linguistic abstraction throughout engineering meetings. It does so by characterising language within the context of engineering idea generation meetings, using a novel coding scheme. The coding scheme was developed with foundations from linguistics and psychology and was found to be easy use in the coding process.

It was observed that more abstract-concrete switching occurs during idea-related discussion. This might be explained by a phenomenon where abstraction levels tend to vary as a person attempts to explain a difficult/unknown/novel concept, and therefore requires a large array of language. Some other interesting observations were also made: e.g. the linguistic behaviour in the teams varied and the coding scheme might be able to provide a measure of time-efficiency. In addition, there was a higher proportion of concrete language during idea discussion. And finally, the transcript and coding scheme showed a disjunction between linguistic abstraction and idea abstraction. The findings of this preliminary study were not strong enough to recommend changes to people's language during design

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meetings nor to create new brainstorming rules for engineering design. However, the method developed is the first step in doing so. The proposed coding framework is robust enough for further studies in linguistic abstraction and further work is needed on a larger data set of meeting transcripts. Other suggestions for further research include conducting controlled studies to explore the link between linguistic abstraction and brainstorming session efficiency in terms of output quantity and quality. This would require having multiple equivalent groups; keeping the design task, information and design stage the same; and having a set time.

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