ONLINE WAYS OF SHAREDNESS: A SYNTACTIC ANALYSIS OF DESIGN COLLABORATION IN OPENIDEO

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Abstract

This research aims to develop a language-based cognitive framework in order to evaluate the performance of virtual design communities. We leveraged two existing theories on the use of language as stimuli and constructive naming in developing a coding scheme, which we used to analyze the online collaboration communications of 9 teams in OpenIDEO. Successful teams used more noun phrases and verb-based syntax in the Idea phase, but less in the Refinement phase. This finding suggests that the successful teams were engaged in constructive naming and relied on verb-based syntax to express their ideas more than the unsuccessful teams early on in the design process. It also suggests that the unsuccessful teams attempted to "catch up" mid-process, but fell short. Despite the finding that the successful teams used more noun phrases in the Idea phase, their unique/non-unique noun phrase usage ratio was lower than the unsuccessful teams. This relationship was reversed in the Refinement phase. This finding suggests that expanding the concept space via constructive naming by unique noun phrases might not be sufficient for high performance, and that reusing those constructed names might also be necessary.

Keywords: Design Cognition, Collaborative Design, Open Innovation, Crowdsourcing, Constructive Naming

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1 INTRODUCTION

This research aims to develop a language-based cognitive framework to evaluate the performance of virtual design communities, and more specifically, how they construct shared understanding in online environments. The research builds on our knowledge of the development of shared understanding in collaborative design teams, and explores its applicability to large open collaboration interactions. As designers become increasingly connected to online collaboration environments, they are challenged to attend to a larger number of conversations and process information from a richer set of sources. We are interested in if and how the use of language characterizes design thinking performance in such a collaboration modality.

2 THEORETICAL FRAMEWORK

2.1 The relevance of shared understanding for design teams

Mathieu et al. (2000) defined shared understanding as the external representation of a problem or an aspect of a problem that is co-developed or accepted by a group of individuals working together towards a common goal. Shared understanding is also seen as a similarity in the individual perceptions of actors about either how the design content is conceptualized or how the transactive memory system works (Kleinsmann and Valkenburg, 2008). The individual perceptions are also known as mental models of individuals. When considering teamwork, the overlap between the mental model of the individuals who make up the team are referred to as shared mental models (Badke-Schaub et al., 2007). Shared mental models (SMMs) are characterized as knowledge or belief structures that are shared by members of a team and enable them to form accurate explanations and expectations about the task and also to coordinate their actions and adapt their behaviours to the demands of both the task and other team members (Cannon-Bowers et al., 1993; Klimoski and Mohammed, 1994). Team mental model contain knowledge about team members, their abilities, roles and responsibilities as well as how they interact with team members.

Shared understanding is recognized as a design team performance variable in design collaboration. Specific team interactions such as communication and coordination mediate the development of SMMs, and thus, mediate team performance (Johnson & O'Connor, 2008; Badke Schaub et al., 2007; Stout et al., 1996). Sharedness of mental models seems to have the most benefit to (team) performance in situations involving highly complex tasks, high workloads and/or limited communication.

Another salient issue in how mental models are conceptualized is the relationship between representations. How knowledge is structured and related seems to be more important than its completeness. Thus, mental models reflect individuals' tendency to categorize what they know and how this knowledge is organized (Badke Schaub et al. 2007). This point is critical to our analysis because of our focus on how knowledge is structured by virtual design communities (with language).

2.2 Shared understanding and performance in online design collaboration

Tang & Leifer defined workspace activity as the actions that occur in the shared space of collaborators working on a task (Tang and Leifer, 1988). They further observed that workspace activity is an important component of design activity. They found that such activities emphasized the importance of the workspace in the development of ideas, whereas previously the workspace was merely seen as a place to store ideas. This observation was critical in developing the notion that the workspace must be conceptualized as a resource for collaboration rather than a practical necessity.

Since then, several tools and frameworks were developed to explicate the value of workspaces in collaborative design practices. Yin & Levett (1996) argue that the way companies organize large scale and multidisciplinary projects influences design activities. They studied large, complex projects to develop a Virtual Design Team (VDT) model, which was intended to address coordination issues. However, the incentives of the VDT model leveraged traditional variables such as cost, efficiency and policy. The increased need for such performance measures, together with the globalization of economies, have caused large companies to invest in new communication technologies that would enable them to manage complex collaborative projects.

Such communication tools have found their way into the other domains, and have enabled groups of individuals to access and exchange information. In education, Lorenzo et al. (2006) state that college students are constantly connected to information via online platforms—creating and re-creating it.

With a do-it-yourself open source approach, college students are now able to instantly interact with existing material and modify it to their needs. This 'web savviness' is illustrated in a study performed by the Online Computer Library Centre (OCLC), which highlighted college students' perceptions of libraries and information resources (De Rosa, 2006). Out of all college students, 72% ranked search engines as their primary choice for locating information, and 53% believed that information from search engines is as trustworthy as information found in libraries.

The positive and negative effects of online instant information exchange are under discussion in the literature. On one hand, online environments have enabled people to access more information and build virtual knowledge-bound groups. On the other hand, they have made the boundaries of knowledge more vague and enabled anonymity among actors. This method of information handling matters a great deal in collaboration because workspace activities revolve around the continuous exchange and interaction of knowledge between multiple actors.

In design practice, this new approach to workspace activities has led to emergence of online open-source innovation platforms such as OpenIDEO and MyooCreate. These platforms are often managed and facilitated by an external group of experts and are designed to integrate existing design methodologies. Therefore, such platforms are process oriented and follow predetermined convergent and divergent phases.

Recent research on such online design collaboration workspaces is limited. Paulini et al. (2011) describe frameworks for structuring and understanding the management of collective design processes and the roles of participants. They conclude that role of management is essential to the overall performance because such platforms employ a hybrid design process. Formulation, synthesis and evaluation are attributed to the community while technical and organizational aspects, such as bringing the product to market, are conducted by the mediating group of experts. This approach suggests that collective design in such platforms share aspects of a cognitive model that favours depth-first search (Maher and Tang, 2002).

2.3 The linguistic analysis approach to analyzing design collaboration

A segment of the research on collaboration in design teams utilized methods that build upon the concept of linguistic analysis. Natural language usage is influential in different parts of the design process: requirement specification (Burg, 1997; Nuseibeh & Easterbrook, 2000), concept generation (Segers, 2004; Chiu & Shu, 2007b,c), design representation (Pahl & Beitz, 1996; Stone & Wood, 2000), design retrieval and reuse (Stone & Wood, 2000; Yang et al., 2005), and outcome analysis (Mabongunje & Leifer, 1997; Dong et al., 2004). Linguistic analysis can help to measure the effect of language stimuli on design performance, to map utterance patterns, to develop contingency models, and to identify assimilation of knowledge through syntactical analysis.

Based on the assumption that online platforms mainly maximize the impact of ideation and conceptualization activities, some linguistic analysis methods and their contribution towards a better understanding of the task mental model in online environments have been discussed. Neumann (2012) characterized the sharedness of mental models by studying the utterances made by design teams. In his framework, a clear distinction between the different mental model categories exists, and different mental model categories and corresponding hypotheses are clustered. For some of the categories, an increase in the number of utterances is interpreted as an increase in sharedness of the team mental model whereas, for others, it is interpreted as a decrease in sharedness.

2.4 Language as design stimuli

Chiu & Shu (2007) argued that there was little work done on understanding the use of language as design stimuli. They presented the result of an experiment that used verbal protocols to elicit information on how designers used semantic stimuli presented to them as words related to the problem during concept generation. They were interested in the relationship between the word level of stimuli and the words and phrases used to produce new ideas. To model and measure these relationships, each of the utterances had to be coded as part-of speech classes (POS). POS describe the syntactical form of a particular word or phrase. They proposed a nomenclature that serves as taxonomy for the coding of utterances.

According to Chiu & Shu (2007), a possible gap exists between how people may tend to think, e.g., in terms of nouns, and how new ideas may be more frequently introduced e.g., through verbs and noun modifiers. They found that using the stimuli as verbs enabled the participants to produce more new ideas than when using stimuli as nouns. Based upon their findings, they argued that that both verbs and noun modifiers introduced the highest proportion of new ideas. However, they also argued that noun modifiers might be harder to exploit since they occur infrequently.

2.5 Constructive naming

Constructive naming often takes place when we construct new functions (e.g. designing), and is different from associative naming. As more words are used to describe a phenomenon, they acquire more meaning, which leads to a consideration of the words' denotative and connotative meaning (Mabogunje, 1997). Moreover, Mabogunje & Leifer (1997) observed a correlation between constructive naming by noun phrases and design performance in project documentation. Woodward-Kron (2008) examined how undergraduate primary education students incorporated so-called specialist language in their writing as their disciplinary knowledge increases. She observed that students explicate their thoughts with a higher level of technicality with time. The higher achieving students used more abstract generic utterances than the lower scoring students. Thus, comprehending knowledge involves adopting terminology as well as coming to terms with the abstract dimension of discourse (Woodward-Kron, 2008).

3 THE RESEARCH STUDY

3.1 Hypothesis

Previous research indicates that the syntactical form of language can provide knowledge about conversations in design practice. Neumann (2012) measured the development of SMMs through the number of utterances related to a specific SMM category. He mapped how utterances either increase or decline over time for each of the different categories. His hypotheses are based upon the assumption that certain categories benefit from a decrease of utterances and others do not.

In this research, we argue that Neumann's approach cannot fully explain the relationship between language use and design team performance. Based on Chiu & Shu's work (2007), we argue that the syntax of the expressed utterances can provide deeper insights in the cognitive process of design teams—especially with respect to constructive naming. Moreover, Chiu & Shu show that the syntactical form of utterances is time-related. In the early phases of the design process, designers respond to stimuli and consider the problem, requirements, and ideas. In the later phases of the design process, they consider specifications.

Therefore*, we hypothesize that, in design projects carried out in online collaborative environments, the frequency and timing of noun and verb based utterances related to design tasks contribute to the development of shared task-related mental models and design performance.*

3.2 The Case: OpenIDEO as an online design collaboration environment

We used OpenIDEO as a case study to explore out hypothesis. OpenIDEO is an online innovation platform run by the global design consultancy firm IDEO. It has become one of the largest online platforms for co-creation with over 50000 participants. Past partners have been the European Commission, Unilever, Amnesty International and the Haas Centre for Public Service at Stanford.

Projects in the OpenIDEO platform start with the announcement of a societal challenge, which is often sponsored/brought in by an external partner, but also sometimes by IDEO. An example of a challenge is "How might we establish better recycling habits at home?" which was sponsored by Coca Cola. Anyone above the age of 13 can contribute to a challenge by signing up on the website.

The OpenIDEO process consists of seven stages: Inspiration, Ideas, Applause, Refinement, Evaluation, Winners Announced and Impact (as the OpenIDEO is continuously refined, this phase structure might have changed after the execution of this study). An idea is posted by an individual as a response to the challenge (and the inspiration) and then openly and collaboratively improved on the platform. Almost all ideas are developed by a team; the individual who posts the idea is free to add as many members to the team as he/she wants. Moreover, any platform participant can comment on a posted idea and contribute to its development.

The challenge we examined in this research is "How might we inspire young people to cultivate their creative confidence?" which was sponsored by IDEO. This challenge was suitable as a case both due to the large number of people that have contributed to it and the large number of ideas (609) that were generated during the Idea phase. 22 of those 609 ideas progressed into the Refinement phased and were considered by the platform moderators during the Evaluation phase.

3.3 Data collection

The online comments made during the Idea, Applause, Refinement and Evaluation phases of 9 of the 22 ideas that progressed into the Refinement phase constituted data for the study. The 9 ideas were randomly selected from the 22. The 1091 comments associated with the 9 ideas were imported into a spreadsheet for analysis via a post-hoc procedure; by the time this research started, the challenge was completed and the winning ideas were announced.

3.4 Data analysis

We analyzed the data with a coding scheme which includes both a semantic and syntactical layer. The coding procedure was based on a coding scheme developed by existing definitions from the literature, contributing to the consistency and reliability of the research.
After coding, we conducted descriptive analysis to plot the distribution of the syntactical categories over time. In order to test statistical patterns between the observations and performance, we ran a Pearson's Chi-Square test among winning and non-winning teams across the relevant OpenIDEO phases.

3.4.1 Semantic layer screening for the task-related mental model

Since we are particularly interested in the utterances related to the task mental model, we used the semantic categorization by Neumann (2012) as an initial screening procedure to select the relevant utterances in the data. According to Neumann, there are four categories in the task mental model: Problem definition, Analysis & Evaluation, New ideas and Explanations. The first and second authors examined the semantic layer associated with the comments and identified the relevant data. Prior to that, randomly selected comments were coded to check for reliability. In an initial test, percentage agreement between the two coders for identifying task mental model utterances was 45%. Upon discussing the differences, the agreement increased to 75%, which was deemed satisfactory.

3.4.2 Syntactical layer coding

After excluding the utterances that do not contribute to the task mental model, the first and second authors coded for the syntactical layer. We used a coding scheme consisting of four categories of syntax that have particular relevance to constructive naming, which builds on Mabogunje's (1997) and Chiu and Shu's work (2007). *Noun phrases* have a noun or pronoun as their head word. *Verb phrases* contain both the verb and either a direct or indirect object (the verb's dependents). *Verbal nouns* are nouns that are derived from verbs. The last category is when a *verb phrase serves as a noun phrase*. The application of this coding scheme resulted in 2686 valid data segments that could be considered noun or verb based utterances. When checking for reliability, there was initially 84% agreement between the two coders. Upon discussing the differences, the agreement increased to 95%. Table 1 provides an example of each category. The data excerpt from which the examples were extracted is presented below the table for additional context.

Table 1. Examples of the four syntax segments extracted from data

1. Noun phrase	the mobile SelfStyle Engine
2. Verb phrase (verb-based syntax)	will include a website version updates with community challenge, encouragement from role models, highlights from the community
3. Verbal noun (verb-based syntax)	to keep it simple to include an influencer blog
4. Verb phrase serving as a noun phrase (verb-based syntax)	embedding it within the app linking for the SEQ bit

"Thanks X and Y. Yes, definitely will include a website version. I've been starting with the mobile to keep it simple – plan on doing a few illustrative pages for the website soon. Great idea about the blog Y. I am planning to include an influencer blog called the SelfStyle Engine that updates with community challenges, encouragement from role models, highlights from the community, etc. Hopefully, by embedding it within the app, we can get lots of engagement, and linking for the SEO bit. Y, can't wait to hear what you think about partners and grants!"

4 RESULTS

4.1 Descriptive analysis of noun and verb based utterances

The incidence of the four noun and verb based utterance types across the four phases follow a similar pattern with two peaks in the idea and refinement phases (Figure 1). However, the phases differed in duration. We used the timestamps on each of the project pages to account for the duration of each phase (not all ideas were initiated at the same time during the Idea phase), and normalized the utterance counts for time (Figure 2). The normalised data plots show a more even distribution of utterances across the four phases with a slight increase over time (see Figure 2).

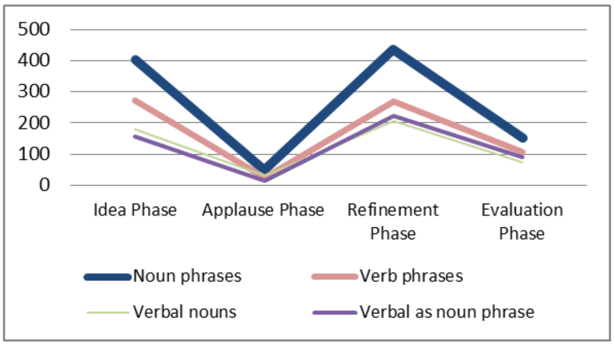

Figure 1. Total number of utterances per phase

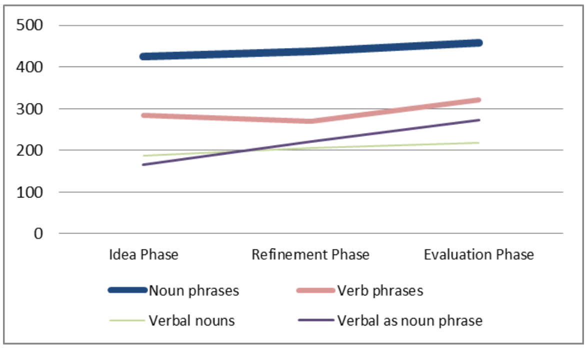

Figure 2. Normalized number of utterances

4.2 Comparative analysis of the utterances of winning and non-winning teams

Out of the 9 coded projects, 4 were selected by the OpenIDEO moderators as "winning" ideas after the evaluation phase. In our analysis, we considered the developers of the winning concepts to be higher performing teams, and constructed two performance conditions: 4 winning and 5 non-winning teams. The total number of coded utterances was 1414 for the winning condition and 1272 for the non-winning condition, which justified nonparametric statistical testing. We also merged the three verb based utterance categories into a single cluster, named "verb-based syntax."

4.2.1 Noun phase and verb-based syntax utterances

We performed a chi-squared test of independence to check if the count differences between the noun phrase and verb-based syntax utterance categories across the phases in between the performance conditions constitute statistically significant deviations from expected values based on the overall occurrence probabilities of the utterance categories. The test revealed that the observed utterance counts were significantly different than expected utterance counts overall between the two performance conditions, X^2 (7, 2686) = 93.1, $p<0.001$. Analysis of the adjusted residuals revealed that the observed noun phrase and verb-based syntax utterances in winning projects were significantly higher than the non-winning projects in the Idea phase ($p<0.001$ and $p<0.001$ respectively, two tailed). The analysis of the adjusted residuals also revealed that the observed noun phrase and verb-based syntax utterances in winning projects were significantly lower than the non-winning projects in the Refinement phase ($p<0.01$ and $p<0.001$ respectively, two tailed). Analysis of the adjusted residuals did not reveal any other differences. Figure 3 displays the results.

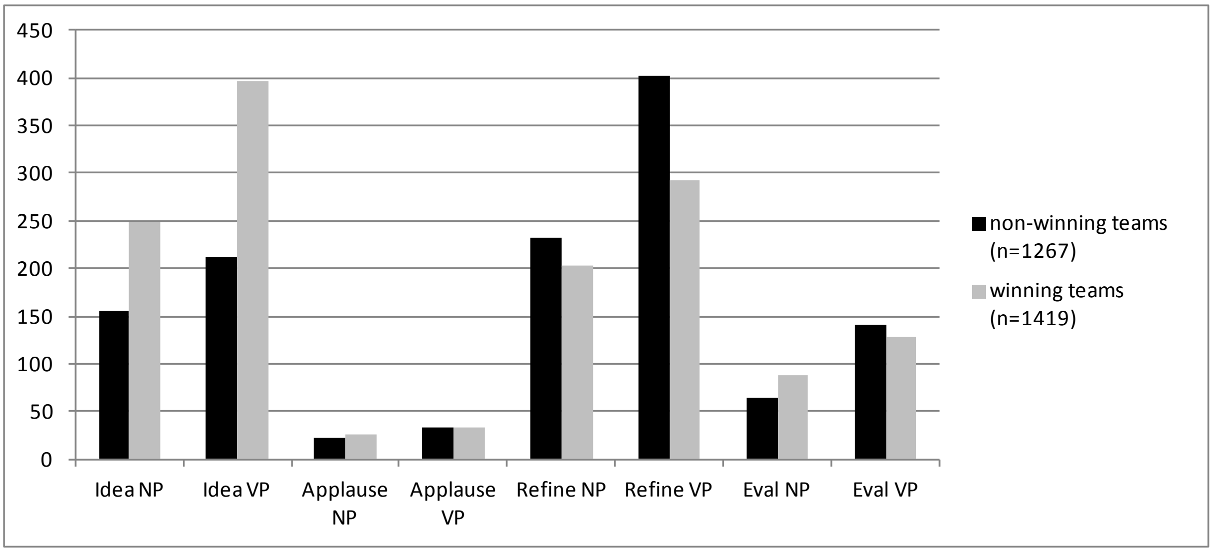

Figure 3. Total number of noun phrase and verb-based syntax utterances per performance condition per phase

4.2.2 Unique and non-unique noun phrase utterances

The next part of the analysis was focused on accounting for the repetition of noun phrases. Our intent was to identify the number of unique noun phrases expressed in the online conversations by differentiating them from the repeated instances of the noun phrases in the utterance counts. Measuring the frequency of unique noun phrases can provide a more accurate description of the range of the constructive naming behaviours of the teams in each performance condition. On the other hand, the frequency of non-unique noun phrases provides insight into the extent to which the unique noun phrases were reused in the discussion.

In order to make this differentiation, the two coders went through all the coded noun phrases again while discussing their resemblance to each other. This created subsets of identical and similar noun phrases. The coders then added all the subsets together with the leftover noun phrases, resulting in the final number of unique noun phrases. To calculate the number of non-unique noun phrases, we subtracted that number from the total amount of noun phrases. We excluded the applause phase from the analysis because it entailed a small number of comments (and coded utterances).

We performed a chi-squared test of independence to check if the count differences between the unique and non-unique noun phrase utterances across the phases in between the performance conditions constitute statistically significant deviations from expected values based on the overall occurrence probabilities of the utterance categories. The test revealed that the observed utterance counts were significantly different than expected utterance counts overall between the two performance conditions, X^2 (5, 1004) = 11.5, $p<0.05$. Analysis of the adjusted residuals revealed that the observed non-unique noun phrase utterances in winning projects were significantly lower than the non-winning projects in the Refinement phase ($p<0.01$, two tailed). The analysis of the adjusted residuals also revealed that there is trend for the observed non-unique noun phrase utterances in winning projects to be higher than the non-winning projects in the Idea phase ($p=0.057$, two tailed). Analysis of the adjusted residuals did not reveal any other differences. Figure 4 displays the results.

This observation can also be illustrated by computing the unique/non-unique noun phrase ratios in each phase for the two performance conditions. The ratios were .51, .57 and 1.16 in the Idea, Refinement and Evaluation phases for the winning teams, whereas, they were .63, .49, and 1.08 for the non-winning teams.

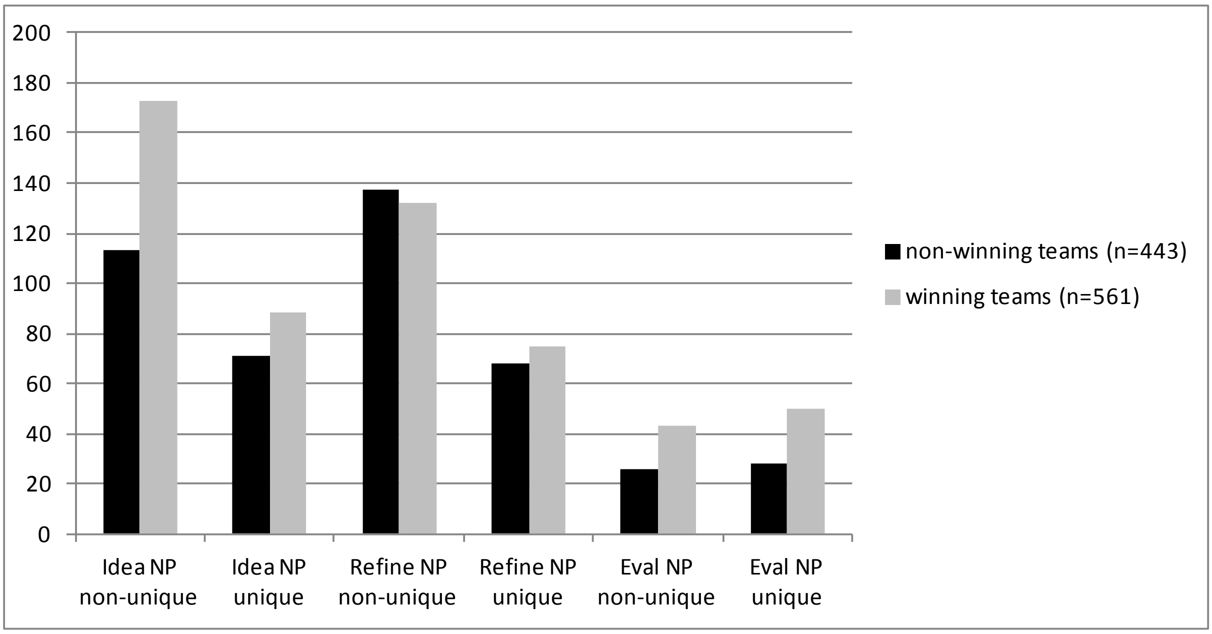

Figure 4. Total number of unique and non-unique noun phrase utterances per performance condition per phase

5 CONCLUSIONS AND IMPLICATIONS

5.1 Conclusions

First, we were able to identify repeated use of the four syntactic utterance categories derived from the work of Chiu and Shu (2007) and Mabogunje and Leifer (1997) in an open online design collaboration environment, and to observe differences between successful and unsuccessful teams. This further strengthens the position that the existing linguistic frameworks provide meaningful measures for analysing textual data in design discourse. However, as can be seen in Figure 2, the time-normalized incidence of those task-related utterances did not decline over time, which is contradictory to Neumann's findings that the task mental model will initially experience a high frequency of information exchange, which then decrease as the project proceeds (2012). This raises the question if online design collaboration—especially when executed in an open format in large loosely organized teams—might require more time for the task mental model to be shared.

Second, we identified a difference in the use of noun phrases and verb-based syntax between winning and non-winning projects across the OpenIDEO process phases. The successful teams used more noun phrases and verb-based syntax in the Idea phase, but less in the Refinement phase. This finding suggests that the successful teams were engaged in constructive naming and relied on verb-based syntax to express their ideas more early on in the design process. It also suggests that the unsuccessful teams lagged behind the successful teams, and attempted to "catch up" mid-process, but fell short. In other words, this is an indicator of the successful teams doing more conceptual design work when they are supposed to.

Third, we also identified a difference in the use of unique vs. non-unique noun phrases between winning and non-winning projects across the OpenIDEO process phases. Despite the finding that the successful teams used more noun phrases than unsuccessful teams in the Idea phase, their unique/non-unique noun phrase usage ratio was actually lower than the unsuccessful teams in that phase. This relationship was reversed in the Refinement phase. This finding suggests that expanding the concept space via constructive naming by unique phrases might not be sufficient for superior conceptual work, but that reusing those constructed names might also be necessary. We speculate that such repetition might be directly coupled with the development of shared understanding around the concepts that have been named with unique noun phrases.

5.2 Implications and limitations

The findings can benefit both online design collaboration platform participants and moderators. For the participants, real-time analysis capability of the syntactical form of the posted comments can be used as a basis of recommendations for regulating them and contributing to the development of SMMs. For moderators, translating the findings of the research into metrics that can potentially predict project success and act as a basis for intervention to improve collaboration performance. Particularly, predictive algorithms can prompt moderators to ask questions that can trigger the noun phrase and verb-based syntax usage behaviour appropriate for the project phase.

A significant limitation of our research is that it does not take into account communications that might have taken place between the participants outside of the online collaboration environment. Any such communication would have affected the process of constructing shared understanding. Another limitation is that we relied on the platform moderators' judgment to determine which projects were successful. Given they were intimately involved in the process, they might not have been as objective as external expert judges. And, of course, the true test of design performance is the real world response and impact. Also, a more accurate determination of sharedness could have been made by identifying the author of each noun phrase and verb-based syntax utterance, and determining how shared their usage was exactly among the team members.

Finally, a more elaborated and multi-faceted approach would entail an in-depth analysis of the topics discussed within the comment threads. Specifically, it would be revealing to test if unique verb-based syntactic utterances evolve into unique noun phrases.

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