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PLEASE CITE THE PUBLISHED VERSION

<http://dx.doi.org/10.1109/CHASE.2015.12>

PUBLISHER

© IEEE

VERSION

AM (Accepted Manuscript)

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Shreeve, Ben, Paul Sawyer, Pete Ralph, and Patrick K. Stacey. 2019. "Geographically Distributed Sensemaking: Developing Understanding in Forum-based Software Development Teams". figshare.
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Geographically Distributed Sensemaking: Developing Understanding in Forum-based Software Development Teams

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Abstract—Global software development is becoming increasingly popular. Working in geographically distributed teams affords advantages to both employer and employee alike. Despite this, distributed working remains a point of contention for many organisations, with some claiming it unsuitable for complex collaborative work. Many argue that the complex act of team sensemaking (the process by which a team develops an understanding of a situation or problem) can only effectively be performed in co-located environments. To investigate this assumption, we examine the communications of a geographically distributed game development team. This global team communicates entirely via forums, yet still manages complex sensemaking tasks asynchronously. We use thematic analysis to investigate how themes develop during online conversations, and use speech act sequences to explore how understanding is developed during these asynchronous conversations. Our findings demonstrate how collective sensemaking occurs within a real-world, geographically distributed team.

Index Terms—Sensemaking, Distributed Working, Distributed Sensemaking, Problem Solving, Forums, Geographically Distributed Working.

I. INTRODUCTION

Developing software in geographically distributed teams is becoming increasingly common; much of the software development process lends itself to such an organisational structure. A number of high-profile companies such as Mozilla Corporation, Canonical and Automattic allow their staff to work remotely. Despite this, many organisations remain unconvinced, e.g., Google and Yahoo actively discouraging distributed working.

The reasons for not embracing distributed working vary, from accusations that teams cannot be trusted, to criticisms that distributed teams cannot be as productive as their co-located alternatives [1]–[4]. Many hold the view that without casual interaction, teams only develop limited socio-cognitive

relationships; that is, how teams think together, share information and develop shared mental models. To this end, some recent research explores how distributed teams operate (e.g. [5], [6]). Here, we build upon this by focusing specifically on how sensemaking occurs in a geographically distributed team.

In a software project context, sensemaking refers to the process by which project participants develop understanding. It is often a collective process because no single team member has complete knowledge. The team therefore has to share, negotiate and test ideas and information to arrive at an understanding. Distributed sensemaking therefore refers to sensemaking where participants are physically separated. More formally, distributed sensemaking can be defined as *the process by which a team of individuals collaborating across geographic, organisational or temporal boundaries use communication tools to develop a collective understanding of a situation*. Whilst several papers have explored distributed sensemaking (e.g. [7]–[9]), we did not find an explicit definition. Furthermore, we refer to a collection of workers as a team (rather than a group) because team members rely upon each other to achieve their end goals [10].

Geographically distributed teams are only possible because of the communication technology that supports them. How they communicate is affected by the extent of their distribution. For example, organisations that are within the same, or similar time zones often choose to communicate synchronously, e.g., by videoconference. Meanwhile, those operating under significant time differences often rely on asynchronous forms of communication, e.g., emails, forums and project management systems to collaborate. Some use a mixture – asynchronous communication for the majority of their work, and synchronous communication when absolutely necessary.

This case study focuses on sensemaking within an open-source game development team that communicates via a forum system. We have focused on conversations that deal with

identification of and refinement of wicked design problems. These conversations exhibit collective sensemaking as participants seek to understand, and then to refine design ideas. Using speech-act theory we have identified the underlying sensemaking process within these conversations. The identification of this process and its characteristics should act as a first step in the identification of best practice for geographically distributed asynchronous sensemaking.

Next we summarize seminal research on sensemaking, distributed working, and distributed sensemaking. Section III introduces the research methodology, explaining the two stages of analysis (thematic analysis, and speech-act sequence analysis). This is then followed by the Results (§IV), Discussion (§V) and Conclusion and Future Research (§VI).

II. RELATED WORK AND RATIONAL

A. Distributed Working

Distributed working explores how people work across cultural, language, organisational, geographic or temporal boundaries. In many cases these occur in combination. Offshoring, open-source and system support teams often have to work across these boundaries.

Geographic distribution takes many forms, starting as soon as collaborators are unable to communicate face to face. For many organisations this entails teams operating from multiple locations (partial geographic distribution). Some, like the team in our case study, are fully distributed with each team member operating from a separate location.

Approaches to collaboration change according to the extent of distribution. Teams can collaborate using synchronous communication tools (e.g. video conferencing) where the geographic distribution is within similar time zones (e.g. a French team collaborating with a South African team). Teams can often meet up when the geographic distribution is less extreme (e.g. different offices within the same country). However, synchronous communication breaks down as the time-difference becomes more extreme (e.g. a U.K. team collaborating with a New Zealand team). Asynchronous forms of communication (e.g. email, forums) tend to be used to work across these large time differences. Many teams use a mixture of synchronous and asynchronous communication tools. Collaboration is still possible even with extreme geographic and temporal distribution [11].

Many existing studies focus on developing communication and collaboration tools to support distributed teams (e.g. [12]-[16]). Fewer studies examine teams in situ to understand how they cope with distribution [1], [17]-[20]. Of these, even fewer focus on how socio-cognitive processes occur in distributed teams [5], [6], [21]. Socio-cognitive processes happen through social interaction and affect the way a group thinks, for instance, when a team shares information and reviews it during sensemaking to reach a consensus.

B. Sensemaking

Sensemaking is the cognitive process by which we (as individuals) develop an understanding of some new stimuli or situation. In a team situation, the sensemaking process is

further complicated; team members have to share information and opinions, and deliberate to achieve consensus. Software design activities, from problem understanding through requirements formulation to solution synthesis are quintessentially sensemaking [22]-[25].

A number of existing studies explore the sensemaking process itself [9], [26]-[31]. Russell et al. [27] introduces the notion that sensemaking consists of a series of iterative loops. Each loop represents the understanding at a specific time-place. New loops form when new information is provided that alters the understanding.

Weick [28] proposes that sensemaking is a continuous process; that when we encounter something new, we attempt to develop a mental model which explains this new stimulus. As we learn more about it (through testing, researching, talking about it with others, etc.) this mental model is constantly being refined. As such, our understanding is purely transitory; it is only our understanding at that moment in time. He suggests that sensemaking is a social process, whereby we learn through explaining and gathering other peoples insight.

In expanding Weick's ideas to consider their implications for teams, we can see how complex collective sensemaking is. Team members must not only make sense of their situations but also explain their understanding to the rest of the team, whilst simultaneously attempting to understand their teammates' understanding. Where an individual's model of understanding differs from their teammates', confusion and disruption can occur. More effective teams develop social systems that help them negotiate these conflicts [5], [17], [18].

Sensemaking occurs throughout the software engineering process. Weick's [28] work suggests that it is likely to occur where there are complex situations, with no clear answer such as wicked problems. In software engineering we often encounter these situations when identifying requirements and designing systems. During these activities many options need to be considered, and information gathered and refined. By understanding this process, we can work to support it better.

C. Distributed Sensemaking

A small community subset of researchers are now focussing on distributed sensemaking. This term applies to collective sensemaking in any form of distribution (e.g. cultural, language, geographic, temporal, organisational).

Some research explores organisational distribution through case studies [8], [32], [33], while others consider distributed sensemaking more generally [7], [9].

Vlaar et al. [6] explore the distributed sensemaking processes between client and offshoring group. This study provides an important insight into how two organisationally and geographically distributed teams work to understand and refine a software project's requirements. They discuss how the difficulties of time difference, introduced by the geographic distribution are managed. They propose that actions of sensegiving (explaining), sensebreaking (confusing) and sensedemanding (questioning) occur as sub-processes during sensemaking. This differs from the present study in that Vlaar et al. [6] studied a partially distributed team (i.e. working

between several co-located offices) while we study a fully distributed team.

Tausczik et al. [34] provide a recent study of how understanding is developed in a forum. Their study focuses on the interactions between members of a maths forum (mathoverflow). They seek to explore the relationship between number of responses and quality of the solution. They differentiate between direct contributions (solutions) and indirect contributions (actions that refine the problem understanding). The present study differs in the type of questions addressed, focussing on wicked design questions as opposed to math questions.

III. METHODOLOGY

This study sets out to understand how sensemaking occurs within geographically distributed teams. The focus is on the identification and refinement of requirements during software development. The study aims to investigate how language is used in this process. In doing so we provide a first step in the creation of good practice guidance.

A. Case Study

The source of data for this research is an open-source game development forum. The developers are creating a fan-based (unofficial) Star Trek game called STExcalibur (www.stexcalibur.com). The developers are located in multiple geographic locations, spanning multiple time zones. Their primary form of communication is via a forum. The forum is split into a private developers-only section and a more general public section.

Forums are a popular method of asynchronous collaboration, providing an online community for participants to discuss areas of interest. Forums allow participants to put questions to a wide and often specialised audience, or to contribute to others' conversations. The asynchronous and open nature of these forums means that conversations and replies are listed in chronological order with the opening comment leading the conversation. The conversation can then meander in much the same way that face-to-face conversations do. Participant contribution varies – some may contribute a lot, others a little; some express strong opinions and others no opinion.

Developing understanding is much more complex in asynchronous forms of communication, like forums. Because asynchronous communication tools lack the immediate feedback provided by physical proximity, ambiguity is common. For example, a person's body language and tone of voice will indicate if someone is asking a question when talking face-to-face. However, these nuances are often missing or limited in asynchronous communication. Conversations in forums are therefore often longer and more complex as participants seek to remove ambiguity.

Sixty conversations concerning the design of the game were read to give an idea of the breadth of discussions on the forum. As design conversations these tended to deal with broad queries (with no definitive conclusion) as opposed to specific technical queries. Of these, we selected the six conversations

that contained the most extensive sensemaking for detailed analysis. Three of these conversations are publicly available:

1. www.stexcalibur.com/forum/index.php/topic,5028.html
2. www.stexcalibur.com/forum/index.php/topic,6777.html
3. www.stexcalibur.com/forum/index.php/topic,4752.html

To identify these six we had to first establish criteria to identify conversations that did not demonstrate sufficient sensemaking. These were conversations where a clear outcome to the conversation was expected; e.g., a technical query where the originator is seeking a solution. These conversations demonstrate limited sensemaking for the most part as other participants seek to understand the problem and identify the solution.

Conversations that exhibited complex sensemaking were more open ended. They tended to be design related conversations. Typically these conversations start with a suggestion that is then queried and refined through a large number of responses. These conversations do not tend to have a conclusion, unlike technical queries, which have definitive solutions. One conversation demonstrating complex sensemaking sought to explore how the virtual environment should react to damage. Participants discussed this at length, comparing how other games operate and debating the merits of a wide range of possibilities.

Further to this, we sought to select conversations that contained a minimum of three participants. It has been suggested that three participants are the minimum number necessary for team characteristics to develop [35], [36].

The six conversations selected for analysis demonstrate complex sensemaking as prescribed. We utilised purposive sampling, selecting three conversations from each area of the forum. The shortest of these conversations is 7,613 words in total, consisting of 58 responses from 15 different participants. The longest conversation is 15,571 words long, with 50 responses and 10 participants.

B. Data Analysis Procedure

Analysis consists of two parts: theme identification, and identification of speech-act sequences. Theme identification serves to highlight the broad structure of conversations. The analysis of speech-act sequences then helps explore how themes develop, and what happens during the transition between themes.

1) Thematic Analysis

This method is based on open coding - it helps to identify core areas of interest within a conversation. Forum conversations usually start with a specific purpose, often to seek clarification from the community. However the conversation can vary substantially from the original topic raised.

Themes are based around keywords. The opening comment introduces the first keyword, the response usually incorporates this keyword, or a word closely associated with it. Responses that relate to this theme utilise this keyword, or an associated word. A new theme occurs when a new keyword is introduced to the conversation that does not relate to the prior keyword.

By identifying the recurrence of key words, phrases or associated words and phrases we have been able to trace themes in the conversation.

2) *Speech Act Sequences*

We utilise speech act sequences as a lens for analysing the development of understanding within themes, and consequently the conversation as a whole. Speech act sequences are: "A series of oral or written actions performed by a speaker (or writer) (e.g., a student's email request to a professor; a narrative; a news report) or a communicative exchange, between two or more interlocutors, embedded in a situated context (e.g., a conversation; news interviews; chat)." [37].

Speech act sequences have been developed from speech act theory; this derives from the idea that we use language to perform actions in everyday communication. Speech act theory was originally suggested by Austin [38] who proposed that speech acts consisted of three components: 1 - the locutionary act, that is the form of the language itself; 2 - the illocutionary act, that is what the speaker is trying to achieve; and 3 - the perlocutionary act, the effect this has on the listener.

It is these performative utterances or speech act sequences that allow us to explore how understanding is developed within a conversation. Through analysis of the conversation and relying on our own experience, we can identify whether a perlocutionary act is occurring; e.g. the speaker is asking for advice. We can then see if the expected response is made; e.g., a listener responds with an opinion. A breakdown in sensemaking can be identified where there is disruption or disconnect of themes (e.g. a request is made but nobody responds to it, or acknowledges it).

Our analysis categorised sections of speech based upon the intended act of the speaker. We have based our coding on Searle's [39] classification of illocutionary acts:

- **Representatives** - speech acts which commit the speaker to the truth of the proposition e.g., stating, testifying in court. An example from the forum: "this is a tricky one I have studied....".
- **Directives** - speech acts which attempt to get the hearer to take a particular course of action e.g., requesting, questioning, suggesting and informing. An example from the forum: "it would be great to command....your fleet to target....one or multiple ships in the enemy fleet".
- **Commissives** - speech acts which commit the speaker to a future course of action e.g., promising. This speech act occurs rarely on the forum.
- **Expressives** - speech acts which express a speakers attitudes and emotions towards a proposition e.g., thanking, apologising, agreeing and disagreeing. For example from the forum: "that example was excellent".
- **Declarations** - speech acts which change the status of the proposition in question e.g., 'I name you king', 'I pronounce you Husband and Wife', 'You're fired' etc. No examples of this speech act have been found in any of the forum conversations studied.

Classifying each statement within a conversation helps identify a participant's intended action, e.g., where a participant is asking a question. The expected response to this would be an answer, or an acknowledgment of some kind. By identifying the actions and appropriate responses we are able to see how understanding is developed.

IV. FINDINGS

A. *Thematic Analysis*

The thematic analysis of our selected conversations suggests that multiple themes are often prevalent in conversations exhibiting complex sensemaking. This is based on the conversations analysed; this could be a result of the sensemaking itself or due to our sampling strategy. Each of the conversations analysed contains between 7 and 9 themes. Themes are usually related in some way. They provide an indication of the collective understanding developed during the conversation. None of the conversations remain on the initial theme for long. In most cases there are 4 or 5 responses to the initial question during which forum members attempt to ascertain their understanding of the initial question raised. Therein, new themes are developed as the forum-members attempt to identify the best answer or develop understanding of the question or issue raised. The team of developers is relatively small, and they know each other well. This familiarity should help the developers avoid and interpret ambiguity during sensemaking. They should be better at recognising questions and confusion in each other's responses. However, the developer conversations still display multiple themes..

The majority of conversations rapidly depart from their starting topic. This progression demonstrates how the forum environment supports the elicitation and refinement of requirements as the team shares knowledge to arrive at a collective understanding. One of the conversations analysed opens with a question about how the weapons on space ships will be affected by the ships' speed. The theme of weapon accuracy is responded to in the first and second replies. But by the third response a new theme is introduced related to how mass affects movement in space. Eventually the conversation does return to the initial theme, but not until much later. The earlier themes are still useful; the third theme about ship movement in space helps to inform participants. The suggestions made when the conversation returns to the original theme are able to make use of this information, refining the suggestions further.

Themes, in summary, show how online conversations develop, and get side tracked much the same as face-to-face conversations. Speech-act analysis helps to identify the mechanics behind theme development.

B. *Speech Act Sequences*

With the broad themes identified, we were able to focus on the individual utterances within each conversation. By identifying the illocutionary act performed by each utterance we were able to identify whether the anticipated response occurred. The majority of conversations on the forum start with

a question, which is a directive form of illocutionary act. For example, there are only so many expected responses to a question: an answer, a question seeking further detail, a statement of fact, an opinion, or a mixture of all four. However, readers may not realise it is a question and offer an unexpected type of response, jarring the conversation and forcing it to change.

Our analysis of speech act sequences has helped to identify where misunderstanding occurs within the group and a new section of sensemaking occurs. In most cases theme development is dialectic (See Figure 1):

Figure 1: Dialectic theme development

This process continues as participants develop both their knowledge (by sharing information), and their understanding of each other's opinions and priorities. However, sometimes the flow of development is interrupted (See Figure 2):

Figure 2: Theme disruption

There is no acknowledgement of the prior theme at all. It is not that Participant 2 has misunderstood the previous conversation. In these situations participants still acknowledge the previous theme, and the other forum members correct their misunderstanding. In the situation outlined, the existing theme stops and a new one begins. The new theme tends to relate to the previous one however the transition between the two is not via development of the previous theme.

The same process of theme disruption occurs in both developer and public conversations, suggesting that familiarity between participants is not important. If anything this disruption appears to represent a key component of sensemaking within this context.

This process of theme development and disruption demonstrates how important information is introduced to a conversation. The same process of introducing new disruptive information (and changing the direction of a discussion) occurs in face-to-face conversations. However, in an online environment the introduction of disruptive information can be

more severe without the clarification of meaning afforded by body language and tone of voice.

In summary, conversations develop with fewer questions when the speaker clearly indicates what they expect from a response. New themes are introduced where the dialectic process of theme development is disrupted. This disruption is the point at which radically new information or perspectives are introduced to the conversation. This can increase the quality of decision making as a wider range of information is considered.

V. DISCUSSION

The sensemaking in our case study differs from Weick's [28] characteristics of sensemaking in a number of ways:

1. The forum environment enables participants to review and consider their responses before committing them.
2. The number of social interactions possible is much larger, with access to a wider range of information and opinions.
3. The forum environment archives contributions, aiding retrospective sensemaking.

The first difference pertains to the idea that people affect their environment. Weick [28] suggests that people affect the environment they are attempting to make sense of. In online environments participants have the ability to draft responses before committing them. They have the ability to consider the impact their response will have on others. Face-to-face conversations are often impromptu with little preparation possible.

The second difference relates to the social aspect of the sensemaking process [28]. Social interactions gather a range of perspectives and sources of information. In a co-located environment however, the range of participants is limited to those invited to the meeting, or within the immediate vicinity. By contrast, anyone with a computer and the Internet can access and contribute to a forum. With access to a greater number of participants there are more contributions and therefore longer and more complex conversations.

The third major difference from Weick's description pertains to the retrospective nature of sensemaking. He suggests that we can only identify sensemaking in retrospect. Retrospective analysis is one of the main methods utilised in sensemaking studies [8], [32], [33] which all seek to understand sensemaking after the event. Data tends to rely on recollections from participants, who are inevitably biased. A forum however captures every question and response, providing a cognitive aid and reducing the risk of bias. Having every response available makes forum conversations very different from face-to-face conversations. Participants are able to review all past replies and quote previous comments in their responses. The quoting mechanism allows participants to highlight a section of a previous comment they want to respond to, which is then copied into their response.

Our analysis has highlighted a number of other interesting aspects of sensemaking in a forum environment. In particular

there were some notable differences between conversations in the public and developer-only sections. Replies tend to be much longer in the public side of the forum. These replies often incorporate responses to multiple prior comments. These long, complex responses introduce more ambiguity. It is not always apparent which response belongs to which comment.

This leads to confusion, often resulting in slower collective sensemaking in terms of the number of responses needed for a conversation to reach a conclusion. By contrast, the developers seem to work differently, perhaps because they are familiar with one another. This would tie in with research into transactive memory systems in distributed teams [5]. This is illustrated by how the developers tend to deal with only one theme in each response. Developers also use more quotes. This means that it is much clearer to see which prior comment is being addressed, and much more succinctly. Responses in the public side of the forum tend to be far longer by contrast, often dealing with multiple themes. This is perhaps as a result of unfamiliarity and inexperience of participants. It is also possible that such responses are written at a later point in time where the commenter is responding to multiple individuals at once.

Ambiguity in forum responses appears to stem from ineffective signposting of intent. In face-to-face communication this signposting is aided by body language and tone of voice; it does not take long when talking face-to-face to recognise when another person is asking a question, making a statement or making a joke. However, without these subtle nuances, clarity is sometimes lost in text conversations.

Finally, our analysis has shown how themes are developed and disrupted. This process of:

Theme → Development → Disruption → New Theme

fits Russell et al.'s [27] view of sensemaking as a series of iterative loops. Each theme represents another loop, a further development in the collective sensemaking process. This thematic development during a conversation helps to demonstrate how sensemaking happens in geographically distributed teams. But it is not clear why this disruption occurs. These disruptions may indicate the extracted cues that Weick [28] describes; that is, the triggers which prompt someone to see new connections between a range of information. This represents the key part of sensemaking.

VI. CONCLUSION

Our analysis of sensemaking through theme development and disruption in forum conversations provides insight into how distributed sensemaking can be structured. Further to this our analysis contributes to the existing sensemaking literature by exploring public sensemaking. That is, the sensemaking that occurs during mass collaboration, where the number and diversity of participants is unknown.

Sensemaking is shown through the development of existing themes, and the creation of new themes. The development team operates in a way that limits confusion during their conversations. Responses are shorter in length and use quotes

from previous statements to indicate the subject matter precisely.

There are several opportunities for future research. It would be beneficial to repeat this analysis on a wider range of forums to further our understanding of theme-disruption. There are also a range of more complex social aspects that are not considered in this study, such as power-dynamics amongst team members, and areas of expertise and responsibility. Follow-on research could augment our methodology with interviews of conversation participants. There is further opportunity to explore how further types of distribution (language, cultural and organisational) affect the sensemaking process. Finally, it would be interesting to see if there is a link between number of disruptive moments in a conversation and the quality of sensemaking.

This paper develops and utilises a speech-act based methodology. It provides an initial overview of how sensemaking occurs in forum environments, which should be utilised as a first stage in the development of a best-practice guide for forum working.

ACKNOWLEDGMENTS

We would like to thank John Hardy for his help in the creation of this paper. This work is funded by the Digital Economy programme (RCUK Grant EP/G037582/1), which supports the HighWire Centre for Doctoral Training <http://highwire.lancaster.ac.uk>.

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