A Framework of Distributed Affect in Text-Based Communication

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Abstract

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As a core human faculty, affect has been identified as a vital component of the communication and coordination practices of collaborative teams. Historically, the study of affect has been intimately tied to theories of cognition, and while there has been considerable work in recent decades to account for the cognitive properties and accomplishments of these coordinated groups, less attention has been given to affect—especially in fields related to human interaction with technology. Recent theories of human cognition are increasingly founded on an extended, distributed model. Likewise, some studies of affect have begun to show that it can be transferred and shared, but fall short of providing a richer accounting of its operation. While this work represents a turn towards acknowledgment and inclusion of affect in the study of these hugely important domains, there is still significant opportunity for elaborating on the nature of its function and significance in this setting.

It has been shown that socio-emotional interactions rich in affective expression are directly tied to creativity, problem solving, and desired outcomes for group functioning. However, these collaborative teams are increasingly non-co-located and rely on synchronous, text-based

communication to interact and carry out their work. While this mode of communication has distinctive benefits, it is also devoid of the rich, multi-modal, non-verbal cues that humans typically rely on for the expression and interpretation of affect. Records of this text-based interaction present a unique means of empirically observing and analyzing the expression of affect in the medium, and looking for evidence of the nature of its function. Initial explorations in this area have begun to suggest that affect too is best described as a distributed phenomenon that extends beyond the individual as the unit of analysis.

In this dissertation, I put forward a framework of distributed affect that is founded on the identification and characterization of five core features through which it operates: *transference, resonance, pervasiveness, persistence*, and *representation*. These features provide a set of descriptive components that moves the unit of analysis beyond the individual to account for interactions between people, their tools, their context, and their histories as part of a distributed system of affect. Grounded in the study of four years of longitudinal chat logs from an international astrophysics group, the framework of features I describe offers a unique analytic lens for the study of computer-supported group work, and a useful tool for framing questions about the continued study of affect in collaborative teams.

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DEDICATION

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“It's crazy how you can get yourself in a mess sometimes and not even be able to think about it with any sense and yet not be able to think about anything else.”

– Stanley Kubrick

"At the last dim horizon, we search among ghostly errors of observations for landmarks that are scarcely more substantial. The search will continue. The urge is older than history. It is not satisfied and it will not be oppressed."

– Edwin Hubble

Chapter 1. INTRODUCTION

Humans are inherently affective creatures, and our emotions, feelings, and moods play an integral role in almost everything we do—especially in how we communicate. Nowhere is this more apparent than when we are collaborating to do work, solve problems, or be creative together (Kelly & Barsade, 2011; Milliken, 2003). While modern theories of distributed cognition show how information coordination and sharing across a system of people and artifacts play an essential part in the cognitive properties and capabilities of a group (Clark, 2011; Hutchins, 1995), substantially less attention has been given to the crucial role of affect in this context. Likewise, existing complex systems models have helped researchers study the connections between affect and creativity at the group level (Aragon & Williams, 2011; Russ, 1993), but stop short of providing what could be considered a comprehensive framework for describing the mechanisms by which affect operates in such a collaborative setting.

As an increasing amount of said collaboration continues moving to computer-supported realms and is carried out by groups frequently not collocated in space or time, the typical channels of face-to-face communication are often being replaced by another means of transmission: text. Reliance on text-based communication is growing rapidly and carries with it unique and challenging opportunities for exploring and understanding how the communication of human affect operates in this context. Within this research and design space, there is a need for evolving and robust models for conceptualizing and describing how the expression of affect manifests through the novel mechanisms of text-based interaction and collaborative work (e.g., Aman & Szpakowicz, 2007; Aragon & Williams, 2011; Hancock, 2007).

McGrath et al. (2000) argue that complexity, adaptation, and dynamic cross-level interaction are essential characteristics of groups, referencing both Abraham's (1990) work in dynamical systems theory in the context of psychology, and complexity and chaos theory (Prigogine, 1984). A dynamical systems approach has been used in previous research to analyze communication patterns and affect. Arrow et al. (2000), studying the dynamics of concocted groups (i.e., built purposively), observe "the coordination network of an operating group connects members, tasks, and tools—both the tangible resources of hardware and money, and the intangible resources of knowledge and procedures—into a functional whole." I have observed these principles of dynamical systems at play in distributed group problem-solving and creativity, and this has informed my framing of distributed affect, particularly in relation to groups as "inherently dynamic systems, operating via processes that unfold over time [and] are dependent both on the group's past history and on its anticipated future" (McGrath, 2000); and what Arrow et al. (2000) call "affective" and "cognitive integration."

My dissertation research focuses on elaborating a framework of distributed affect to describe how affective states, through collaborative interaction in a dynamic system, extend beyond the individual as the unit of analysis, and influence things like group dynamics, creativity, and problem-solving. Text is the unique medium through which this framework is being derived and communicated, specifically because it has the unique properties of making the features of distributed affect empirically visible. My ongoing work in this area is directed at the analysis of affect found in the chat logs of the Nearby Supernova Factory (SNfactory), an international astrophysics collaboration that remotely controls a telescope to study a specific type of supernova. During operation of the telescope, critical decisions must be made quickly and collaboratively despite the group not being collocated. Online chat is the team's primary means of communication

during telescope operation, where the expression of affect is still a prominent and important occurrence (e.g., Aragon & Williams, 2011; Gill, 2008; Guillory, 2008). Their work has resulted in a chat log corpus with approximately 485,000 messages, which comprises the primary data set for my analysis.

1.1 MOTIVATION: AFFECT, DISTRIBUTED

The term *distributed affect* was first used by Edmondson in 2003. Edmondson briefly argued that affect could possibly be characterized in a way similar to distributed cognition, with the specific intention of exploring its implications for artificial intelligence (2003). Aragon and Williams (2011) later used the same term in 2011 when talking about group creativity in a dynamic systems model. They articulated the need to account for the affect seen in distributed collaborations and introduced distributed affect as a component of a larger model focusing on creative acts. In this dissertation, I focus and elaborate on the Aragon and Williams' definition of distributed affect through the construction of a framework for understanding how affective states, resulting from collaborative interaction in a dynamic system, extend beyond the individual in persistent and pervasive ways, and especially how the text-based medium has unique implications for this phenomenon.

As Hutchins illustrated in his seminal work on distributed cognition, *Cognition in the Wild* (1995), a great deal of the coordination of information required to achieve complex cognitive tasks is shared with the group via the "propagation of representational states across a series of representational media". This model of information sharing plays a crucial role in the problem-solving capabilities of a group, and is necessarily included in the unit of analysis when examining the cognitive properties of this system. Likewise, I posit that the sharing of affective states between

members of a group is similarly important. It has been well established that problem-solving is heavily influenced by affect, as well as how intimately tied this influence is to the cognitive (McLeod, 1989).

However, just as much of the study of cognition was originally tied to a unit of analysis that neglected to take the larger cognitive ecosystem of an actor into account, it is important that we also broaden the scope of what is considered where affect is involved. As previous studies, including the work on emotional contagion (Hancock, 2008), have shown, affect does not take place inside of a vacuum, detached from the environment and interactions with others—it is influenced by and distributed across them. This research moves beyond the bounds of emotional contagion, with its underlying assumption that affect exists inside individuals and is spread from one to another, to apply a unit of analysis beyond the individual. Aragon and Williams (2011) note that Hutchins focused his analysis of the cognitive system on knowledge that did not reside in any one person, but that his analysis "did not explicitly call out the emotional states that drove the collaborative problem-solving process". In contrast, I am taking steps to explicitly show the affective components observed in the data.

As will be demonstrated later it is possible to make this explicit distribution or propagation of affect visible by examining the way it is communicated between members of a distributed group. This communication of affect is being facilitated and made more overt through the ever-increasing prominence of computer mediated communication (CMC) (Aragon, 2009); and it is made even more explicit when affect is communicated via text where the spontaneous channel is greatly impoverished and the expression of affect must be re-routed through the cognitive channel and the manipulation of symbolic language. The text-based chat is indispensable as the SNfactory researchers carry out cognitively complex tasks such as troubleshooting problems with shared tools

and systems that are crucial for their work. These scientists rely heavily on each other's input and ideas to solve complex problems that no one scientist could solve on his or her own. As such, the cognitive accomplishments of the group as they work to resolve these complex problems in response to certain events is distributed between the SNfactory scientists over text-based chat as Hutchins' framework of distributed cognition would predict. In this dissertation, I posit that we can likewise characterize affect as distributed through an examination of expressions of affect communicated through text-based chat. I will support this argument with evidence from event-driven accounts of SNfactory scientists troubleshooting complex problems where the features of distributed affect can be empirically observed, analyzed, and evaluated in the context of the framework's implication for describing group dynamics.

1.2 DEFINITIONS

The following terms—especially the first—will be used frequently throughout this work. Not only are these terms used in a variety of fields of study, but may also have multiple usages within those fields themselves. Here I present concise (insomuch as one ever can) and contextually useful definitions expressly for the purposes of this dissertation.

Affect: I define *affect* as "a feeling state distinct from cognition" (Russ, 1993), and as a person's "capacity to affect and be affected" by other people (Anderson, 2014). Additionally, my conceptualization is further informed by Ekkekakis' definition of affect as a "broader concept than mood and emotion" (2013) which provides the experiential substrate upon which moods, feelings, and emotions are woven. This intentionally inclusive definition accounts for the wide range of affective phenomena that will be discussed and analyzed in later chapters, but that may not be

traditionally considered the interrupting neurophysiological experience and expression of "emotion" (Moore & Isen, 1990).

Cognition: Additionally, when discussing *cognition*, I refer to the trajectory (transmission and transformation) of information (Hollan, Hutchins, & Kirsh, 2000), and the ensuing mental processes that are involved in "memory, decision making, inference, reasoning, learning, and so on [sic]" (Hutchins, 2000).

Distributed: I will use *distributed* in two senses: to describe groups which span different physical locations, time zones, countries, languages, and cultures (Edwards, 2008); and when discussing specific attributes of those groups, including "distributed cognition" (Hutchins, 1995; Stahl, 2011) and "distributed affect" (Aragon & Williams, 2011; Scott et al., 2016). The former usage will typically be in reference to individuals that are non-co-located, while the latter will be used to describe specific theoretical or conceptual models.

Creative Problem-Solving: Some of the events and group interactions that will be examined in subsequent chapters will be discussed in terms of outcomes that relate to *creativity* and *problem-solving*. Given that there are two expansive and rapidly evolving related fields of study surrounding the usage of these terms (with about as much consensus on their definitions as one might expect), I follow Mayer (1989, 1999) to provide a functional definition of *creative problem-solving* as a novel or useful outcome of a time-based process that moves a situation from one state (i.e., problem state) to another state (i.e., goal state) for which the method is not previously known to the problem solver.

1.3 RESEARCH GOALS

Chapter 2 of this dissertation provides review of background literature on the study of affect, cognition, and text-based communication, including some of their more interesting and relevant overlaps. Chapter 3 outlines and discusses the methodological approaches that guided and informed the research presented in chapters 4 through 6 which explore the following research questions:

- **RQ1**: How can researchers effectively identify and label expressions of affect specific to text-based communication?

- **RQ2**: What are the features of distributed affect that can be empirically observed in the medium of text?

- **RQ3**: How do these features interact with one another, and how do these interactions contribute to the workings of a collaborative group?

As a result of addressing these questions, this dissertation makes three contributions:

1. A taxonomy of affect specifically formulated for application to text-based communication, as well as a presentation of the adapted grounded theory method approach used to create it.

2. The defining and description of five distinct features of distributed affect that illuminate the mechanism for understanding its operation: *transference, resonance, pervasiveness, persistence,* and *representation*.

3. An application of this framework to the examination of a collaborative group communicating via text, that exemplifies its usefulness and appropriateness as an analytic tool for the study of affect in such a context.

By leveraging the distinct properties of the text-based medium to provide a means of closely examining and evaluating affective expressions between members of a collaborative group, this dissertation conceives a framework that uniquely positions affect as being distributed between people, their environments, and their tools as part of a dynamic system. This research supports and amplifies existing claims that affect plays a vital role in aspects of group work such as creative problem-solving that are crucial to group success, and places affect centrally in the study of science and technology to more fully characterize the vital breadth of human experience in these domains. It offers scholars new tools for looking at affect in their own research.

1.4 Structure of Dissertation

This dissertation is grounded in a qualitative analysis of text-based communication as a means of empirically observing and analyzing affective expressions and interactions that suggest that affect is best characterized as a distributed phenomenon. **Chapter 2** provides a review of background related literature that are at the intersection of human faculties of cognition, affect, and creativity, as well as a discussion of their relationships to one another in the context of this work. **Chapter 3** summarizes important aspects of the methodological considerations that I explored in how to best approach a grounded and flexible exploration of the complex topic of human affect, especially where text is involved. This chapter also introduces and summarizes key aspects of the corpus of text data, taken from a longitudinal study of an astrophysics collaboration, that this research focuses on analyzing.

Chapter 4 explores the problem of finding an appropriate means of identifying and labeling expressions of affect that accounts for their unique manifestation in text. A novel adapted grounded theory approach is described, and then utilized to construct a taxonomy of affect in text-based chat. The resulting affect labels are presented, and their application to the data set is discussed. **Chapter 5** revisits key aspects of the relationship between affect, cognition, and group dynamics in the context of computer-supported cooperative work represented by the text-based collaboration in the data. This chapter presents the identification and definition of five distinct features of distributed affect: *transference, resonance, pervasiveness, persistence,* and *representation*. Each of the features is described alongside examples from the data, as well as supporting literature. The features are examined contextually in **Chapter 6** utilizing the computer mediated discourse analysis method to operationalize and analyze some of their interactions through the exploration of specific events the group encounters and works through. These vignettes highlight how these interactions contribute to group dynamics such as creative problem solving, and provide additional compelling evidence that an accounting for affect as extending beyond the individual provides new and useful analytic perspectives.

In **Chapter 7**, I conclude by discussing the contributions that my research on distributed affect makes through offering a unique means of structuring both the identification and analysis of affect in text-based communication, and a novel theoretical lens through which new questions about affect can be formulated. I also reflect upon its place in the continued study of core aspects of human-centered design through the highlighting of affect as a vital and intrinsic human characteristic.

Chapter 2. BACKGROUND

This dissertation is primarily informed by research on affect, cognition, and text-based communication, and especially their relationship to the field of computer-supported cooperative work (CSCW) and computer-mediated communication (CMC). The framework put forward by this research also draws on research related to creativity, problem-solving, and dynamic systems, to better understand the interactions and outcomes of affective expressions in a group context. This chapter provides a survey of the most relevant aspects of these interrelated fields of study, and will also highlight those connections which are most important and meaningful for understanding their impact on the overall conceptualization and theoretical articulation of the distributed affect framework, as well as a discussion of how this work is situated within the larger context of the continued study of CSCW.

2.1 AFFECT

The number of fields that have studied affect, emotion, and the human capacity for feeling in one way or another is no doubt comparable to the number of centuries it has been under investigation. Within the modern breadth of that scope, its study in the social and psychological sciences is the one that most researchers in HCI-related fields might concern themselves with, and the same is true for this work.

The study of affect, however, has moved well beyond psychology into a variety of disciplines where it has been shown to play an important, and often underexplored part in understanding the object under study within these domains. Anderson (2014) uses affect as a central point of focus to theorize about issues of identity and sociopolitical concerns associated with modern work in cultural geography. The merits of generating positive affective responses in readers as a means of

appealing to a wide audience has been examined by Sandelowski (2008) as it relates to the writing and presentation of mixed methods studies from a literary theory perspective. Brennan (2004) has followed similar paths by narrowing in on the physiological "transmission of affect" as a means to understand notions of identity and "crowds" by placing these affective considerations in dialogue with existing feminist theories. Recent thinking posits affect as more than a "non-rational phenomenon" (Anderson, 2014) emphasizing the importance of understanding the dynamics of affective life and affect's physiological aspects. Seeing affect as plural, rather than singular, Anderson suggests that affects are interwoven through all aspects of life, "organized and patterned as part of diverse socio-spatial formations" (2014). This brief sampling represents only a small cross-section of the various ways that the study of affect is being incorporated into active research and theoretical explorations in a diversity of domains.

Affect has also been identified as playing a central role in the creative process (e.g., Amabile et al., 2005; Csikszentmihalyi, 1996; Russ, 1993). Amabile et al. (2005) describe a model that accounts for the cycle of creativity in an organizational setting. In this model, positive affect is linked to cognitive variation, which, after an incubation period (which may be as short as overnight, or as long as several weeks or months), leads to a creative act. This creative act in turn provokes affective reactions from others in the organization, which can then precipitate the next cycle of creativity. Similarly, Russ (1993) identified affect-laden thoughts as being closely related to divergent thinking (akin to cognitive variation), which promotes thinking that goes off in different directions that aids in generating a variety of solutions to a problem.

Against prior views of emotional expression as merely inappropriate disturbances within a work setting, an increasing number of studies in recent years have documented a renewed interest in understanding affect in the workplace (Ashforth, 1995; Barsade, 2002; Grandey, 2008). Numerous

studies have shown that affect and emotion influence interactions and performance in cooperative work environments (Amabile, 2005; Ashforth, 1995; Mentis, 2010; Milliken, 2003). Similarly, this "awakening of interest in emotion in CSCW" (Mentis, 2010) can support the evaluation and design of affect-aware information systems in these and other settings.

In their discussion of affect in within the context of interactive systems, Dourish and Bell (2011) raise salient points that very strongly echo this position. Firstly, they note that cognition is not disembodied or cut off from the breadth of human experience, and that emotion plays a key role in the ways that humans carry out cognitive acts such as decision-making (Dourish & Bell, 2011). Secondly, they draw on ethnographic accounts by Abu-Lughod (1986), which discuss affect not occurring as a purely private and internal phenomenon, but rather as closely related to social and cultural contexts. They go so far as to note that "emotion is not a precursor to action; emotion, as a cultural object, is produced through concerted action" (Dourish & Bell, 2011).

2.2 COGNITION

Recent work in the study of cognition acknowledges the importance of characterizing cognition as a distributed phenomenon and has focused on the differences between the "extended" and the "brainbound" mind (Clark, 2011). Hutchins' concept of distributed cognition (1995), "extends the reach of what is considered *cognitive* beyond the individual to encompass interactions between people and with resources and materials in the environment" (Hollan et al., 2000), and where "interaction [is] a source of novel structure" (Hutchins, 2000). Cognitive processes thus extend beyond the individual to other members of a social group, involving coordination between people and their environmental context, and are capable of being distributed temporally so the outcomes of earlier events impact later events (Hollan et al., 2000).

In this sense, our cognition and our mindfulness emerge from the interactions of our brains and bodies with the socio-cultural world around us, including artifacts and cultural constructs (Hutchins, 1995). As Rogers points out, "[t]his distinction is critical for the distributed cognition approach, emphasizing again the importance of focusing on the distribution of cognition through analyzing the interactions between the different 'components' (i.e., the changes in representational state) of the system over time and place." (2012). Additionally, Hutchins has demonstrated through various ethnomethodological studies that the traditional unit of analysis for studying cognition, the individual, fails to accurately capture the richness of elements that must be considered to account for high-level cognitive accomplishments (Hutchins, 1995; Hutchins, 2010). Shifting the unit of analysis to include the physical environment, tools and artifacts, other individuals, and even culture, reveals how these systems that extend beyond an individual may have cognitive properties that cannot be accounted for by solely studying the individual. This perspective would urge us to consider that combinations of people and tools are capable of forms of cognitive agency that are unique to these distributed systems.

The distributed cognition perspective also acknowledges that life is lived in complex social environments that are filled with cultural artifacts (Hutchins, 1995; Hutchins, 2010; Giere & Moffat, 2003). Activity in the nervous system is linked to high-level cognitive processes by way of embodied interaction, and as a result high-level human cognition depends on these culturally organized material and social structures. The products of these interactions not only accumulate in the brain, but also in the *cognitive ecology*. We practice "cumulative epistemic downstream engineering" and "human cognition is rooted in the reliable effects, on developmentally plastic brains, of immersion in a well-engineered, cumulatively constructed cognitive niche" (Hutchins, 2010). In other words, the way we think and act in the world is a part of the cultural-historical

process of building and living in the world around us. It is this aspect of the distributed cognition perspective that is perhaps most consequential for moving towards thinking of affect as also being distributed.

Most importantly to note here is that many recent attempts to account for the complex and high-level aspects of human cognition have moved away from the individual (i.e., stopping at the barrier of the brain), and extending what is accounted for to include the mind-body interaction, embodied interaction within a context filled with artifacts, and socio-cultural constructs that indeed extend well beyond the individual in both time and space. My research builds upon such previous work on cognition (e.g., Arrow, 2000; Hutchins, 1995; Stahl, 2006), postulating that these approaches to group cognitive dynamics apply equally to affect, and that an affective ecosystem of dynamics between group members and their environment can be empirically observed in the data serving as a record of those interactions.

2.3 TEXT-BASED COMMUNICATION

Despite a widely-acknowledged impoverishment of the non-verbal cues that humans have always depended on for recognizing, attending to, and interpreting the multi-modal aspects of face-to-face communication, the widespread adoption and proliferation of text-based forms of communication continues to grow rapidly. Synchronous online chat differs from other online text-based communication media, such as email, in several significant ways. Since conversations can take place in real time, they capture some of the synchronicity that is associated with face-to-face or voice communication. This synchronicity can greatly enhance the effectiveness and efficiency of this mode of communication by allowing for real-time interaction. Unlike other real-time modes of communication, text-based chat also has benefits associated with asynchronous communication.

Messages can be replied to at the convenience of the correspondents or as dictated by the circumstances of the tasks being performed. Additionally, all the messages can be logged, providing a persistent record of the conversation. In these regards, this kind of text-based online chat can offer positive aspects of both synchronous and asynchronous forms of communication.

Contextually relevant aspects of the use of text as a means of human communication will be explored extensively throughout the rest of this manuscript, but the following subsections detail just a few elucidating examples of the approaches employed by HCI researchers to account for verbal and non-verbal cues in text. While by no means exhaustive, this list provides some context for the more commonly discussed and agreed upon features that are of importance when considering this aspect of my research.

2.3.1 Verbosity and Phrasing

Hancock et al. (2007) conducted a study using 40 dyadic interactions that concluded that users are readily able to communicate and distinguish between positive and negative valence emotions in text. One of their key findings was that, relative to negative expressers, participants expressing positive emotion used significantly more words (verbosity), with an approximately 29% increase in the number of words produced. They also found that positive affect users expressed disagreement far less frequently. Although positive affect users reported trying to agree more frequently with their partners, the data showed that it was the frequency of the occurrence of disagreement that was a better indicator of positive or negative expression of affect.

2.3.2 Punctuation

A key component of any form of text-based communication is punctuation, and the medium of chat can affect this element in key ways. Zhou and Zhang (2005) note that while chat provides a

means for multiple users to simultaneously communicate in a flexible and convenient way, that it is also often prone to errors in punctuation. They posit that punctuation can be said to indicate the components of prosody typically found in face-to-face communication, including changes in tempo, pitch, volume, and emphasis. Similarly, Hancock et al. (2007) noted that one of the primary strategies of chat participants in their study to express positive emotion was an increased use of punctuation. This was especially true for the use of exclamation points, with positive affect expressers using up to six times as many exclamation points as negative expressers.

2.3.3 Emoticons

Emoticons have been shown in several studies to play an important role in how messages are interpreted from an affective standpoint (Derks, 2007). They have become well-known and fairly ubiquitous components in many of the text-based forms of communication we are familiar with. However, emoticons may not be as useful as one might expect them to be. In a study conducted by Walther and D'Addario (2001) it was found that overall, verbal message content was more important in interpreting the affective expressions it contained. They also claim that messages containing emoticons did not generate different emotional interpretations than messages without emoticons, and were also not effective in contradicting the emotional content of the accompanying verbal message.

2.4 HIGHLIGHTING CONNECTIONS

When surveying a broad section of research in CSCW, Mark Ackerman (2000) has identified what he refers to as the "socio-technical gap": the fundamental divide between what we know to be rich, flexible, and highly contextualized settings of human activity and the technical systems that we design to support them. As a whole, in this view, technical systems are relatively inflexible and

only offer a fairly narrow set of solutions to problems which, when addressed in an offline setting, often necessitate a rich and multimodal means of collaboration and coordination to solve. While this is framed in terms of a problem that must be addressed in CSCW research, Ackerman (2000) is also quick to point out that it is likely misguided to consider the solution to be a closing of the gap, especially if this is done through a series of fairly unconscious decisions which can lead to undesirable consequences.

We must be mindful of how the technical solutions we implement can result in fairly "invisible" practices that become commonplace and can have lasting impact. Rather, Ackerman urges us to think of the identification and focus on this socio-technical gap as a core contribution of CSCW in and of itself (2000). In other words, simply knowing it is there and recognizing that there are consequences for how we design for it, is hugely important. For instance, if we view the gap as an opportunity for us to adapt to our technology and become more rational and predictable in our behaviors, we run the risk of unknowingly shedding desirable human behaviors in favor of closer alignment with our technology (a sort of neo-Taylorist point of view which strives for efficiency and effectiveness over all else) (2000). There also exist coevolutionary arguments which position the gap as a matter of adapting the resources in our environment to our needs, and that if these adaptations are beneficial enough, then we in turn evolve our social practices accordingly. Ackerman admits that this type of evolution and adaptation is difficult to dismiss outright, but maintains that a "rounding of the edges" of coevolution is necessary in order to be sure that we are not falling prey to an unwitting sacrifice of our human capacities when addressing the gap (2000).

The recipe for this dissertation has all the ingredients necessary to identify and explore the very human aspects of the space under study, as well as a distinctive acknowledgment of the technical solutions being implemented as means of "closing" the gap—and the way this is shaping

behaviors. The above review of literature clearly demonstrates that there are widely accepted formulations characterizing cognition as a distributed phenomenon (e.g., Clark, 2011; Hutchins, 1995) and of affect as being a crucial component in communication, acts of creativity, and problem-solving (e.g., Barsade, 2001; Csikszentmihalyi, 1996; Russ, 1993). Likewise, both these areas of research have historically played an important role in the design and study of computer-based systems (theoretical, technical, and socio-cultural) that support collaboration and the carrying out of complex and creative work (e.g., Aragon & Williams, 2011; Derks, 2008; Hollan et al., 2000). These systems, while obviously not exclusively reliant on text, continue to be predominately built around modes of text-based communication in all its myriad forms (Herring, 2002; Olson, 2008; O'Neil, 2003). Therefore, it is not difficult to see how these related elements connect to provide a landscape well-positioned for continued study. While this is clearly not an under-explored area of inquiry by any means, a survey of this literature motivates my research aimed at formulating a theoretical tool to more clearly articulate the role of affect as a distributed phenomenon, and a focus on text as a unique and highly appropriate medium for this inquiry. This is especially true as it relates to the unique opportunity that examination of text affords the researcher in terms of being able to focus on a specific empirically and directly observable means of interpreting the distributed nature of affect, rather than relying on the inference of an internal state or difficult-to-carry-out accounting of the myriad signal channels in an unfolding face-to-face context.

Aragon and Williams (2011) originally propose the concept of distributed affect as just one part of a dynamical systems theory addressing how affect helps maintain and accelerate creativity across a distributed group through the creation of what they term creative resonance. They propose a distributed dynamical system that describes how "[t]he affect within the system makes the

connections between ideas and between people stickier" and how when local dynamics (Arrow, 2000) are tuned to develop socio-emotional links with other group members "there is a greater possibility of distributed affect creating the [creative] resonance that drives and grows ideation." They suggest "the information to be transferred must include the two strands of cognition and affect. Thus, we have not only distributed cognition but also distributed affect." I maintain that while the former strand no doubt plays an integral role and has been rightfully been explored in-depth, the latter strand warrants additional exploration and elaboration to catch up with its more "intellectual" cousin.

Chapter 3. METHODS AND DATA

Below, I introduce and summarize key aspects of the methodological approaches used during various stages of this research as a means of foregrounding the work described in subsequent chapters. A contextual discussion of these methods will be presented alongside their application in Chapters 4 through 6. However, the following sections will offer an opportunity for me to include - commentary on decisions related to interpretations of methodological norms and their appropriateness for addressing my research questions.

This research is substantially predicated upon its grounding in a large corpus of longitudinal text data. While that statement may seem expected and mundane given the topic of this dissertation, the data itself and what it represents are far from mundane. As such, the first part of this chapter elaborates on some of the more noteworthy aspects of this corpus, the records of human interaction that comprise its contents, as well as the greater purpose behind those interactions.

3.1 DATA: THE NEARBY SUPERNOVA FACTORY

In 2007, the Nearby Supernova Factory (SNfactory) was an international astrophysics collaboration of approximately 30 core members, with about half of the scientists located in the U.S. and the other half in France. These scientists are studying Type Ia supernovae, a specific type of stellar explosions that have a consistent brightness, allowing their distances to be effectively measured over time and thus trace the expansion history of the universe (Aldering, 2002). This work has garnered the group and its affiliates world-wide recognition for their groundbreaking discoveries and techniques for measuring this expansion, and showing that it is indeed accelerating—a finding which has significant consequences for our understanding of some of the most fundamental aspects of the cosmos.

Distributed collaborations of scientists who work toward a common goal and share instruments are called shared-instrument collaboratories. A *collaboratory* is defined as "an organizational entity that spans distance, supports rich and recurring human interaction oriented to a common research area, and provides access to data sources, artifacts and tools required to accomplish research tasks" (Olson, Zimmerman, & Bos, 2008). Significant work has been done to describe the circumstances under which such groups thrive, including such social aspects as cultural norms and common ground, as well as technical considerations related to communications costs and technology training. All of these factors play a part in the group's "collaboration readiness" (Olson et al., 2008), which I posit also have significant affective consequences for the group.

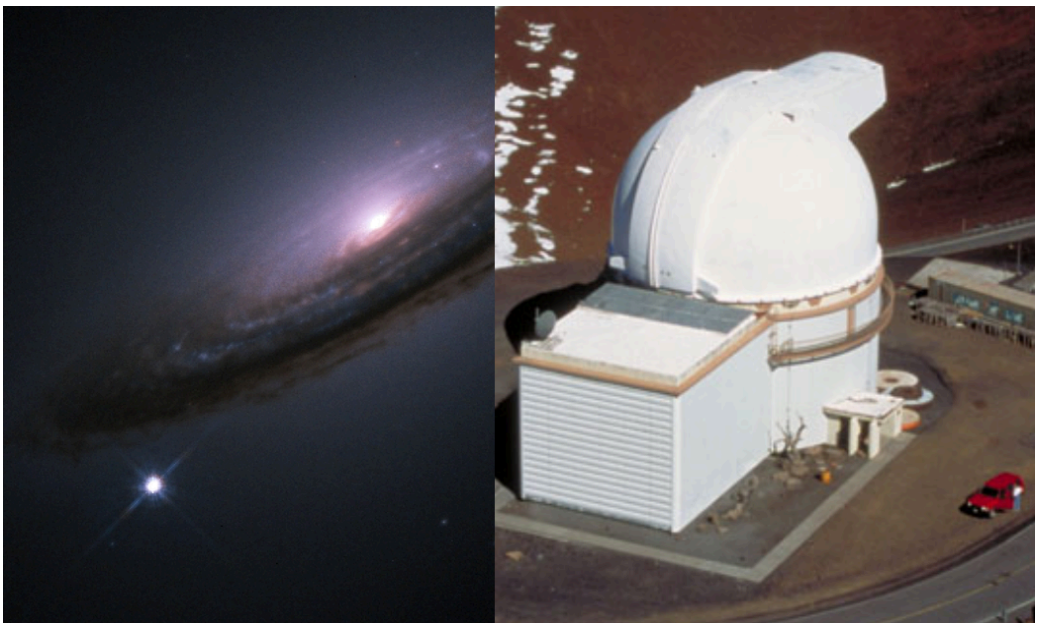

Figure 3.1: Type Ia Supernova[1] and University of Hawaii 2.2-meter telescope[2].

The primary instrument for celestial observation the group used at the time the corpus I examined was collected, is the University of Hawaii 2.2m telescope on the summit of Mauna Kea pictured in Figure 3.1. The group operated this telescope remotely three nights per week; during such

[1] Supernova 1994D visible as the bright spot in the lower left. Image credit: High-Z Supernova Search Team.
[2] Image Copyright 2005, Richard J. Wainscoat.

operation, numerous decisions must be made quickly and collaboratively even though many of the team members come from differing cultural backgrounds, are separated by an ocean, and may have never even met one another face-to-face. These situational factors shape the team members' expression of affect as they carry out their work and communicate with each other.

The SNfactory group used text chat (AOL Instant Messenger) as their primary means of synchronous communication to jointly make scientific and operational decisions about the telescope they were remotely and collaboratively operating (Aragon & Poon, 2009). A typical computer display might look something like what is pictured in Figure 3.2 for an SNfactory member while going about their work.

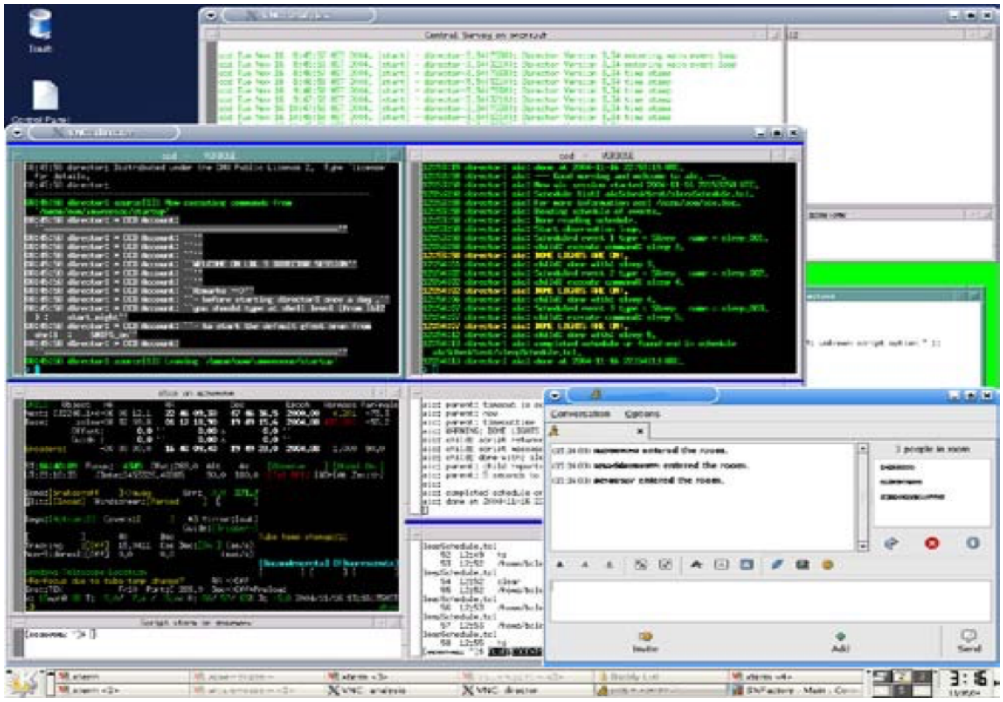

Figure 3.2: VNC telescope control window with chat client.

During the four-year span of these chat logs, conversations range over excitement at new findings, frustration with faulty software or hardware, confusion with incoming data, and many other affective states. There are a total of 485,045 chat messages, sent over the course of four years, in the corpus. Many of these messages were also produced by automated programs ("bots") using the chat protocol to relay changes in the state of the world (sunrise/sunset, weather, telescope status/settings, etc.), and to assist the scientists with running scripts and carrying out other various tasks.

The typical number of people engaging in the chat on any particular night was 4-6 (although this can vary from 2-10). Given the nightly and cyclical nature of the scientists' work, the chat is organized into 24-hour periods that I will refer to as separate "logs" in rest of this dissertation. At present, over 67,000 lines of the corpus have been manually coded for affect using a taxonomy that will be detailed in Chapter 4, and it is these coded portions of the logs that form the primary basis for my analysis.

3.2 Phases of Research

This research is carried out in three phases, each in dialog with a specific research question, and with each phase employing its own respective methodological approach as briefly noted below.

- **Phase 1** presents the use of an adapted grounded theory approach to the creation of a taxonomy specifically formulated to account for expressions of affect in the text-based medium. This work is presented in Chapter 4 and serves to answer **RQ1**: *How can researchers effectively identify and label expressions of affect specific to text-based communication?*

- **Phase 2** consists of the formulation and definition of the five features of distributed affect as arrived at primarily through a grounded analysis of the coded chat logs. This work is presented in Chapter 5 and is in service of addressing the primary research question motivating this work, **RQ2**: *What are the features of distributed affect that can be empirically observed in the medium of text?*

- **Phase 3** consists of the operationalization and examination of the five features in the context of specific salient events in the chat logs through the utilization of the computer-mediated discourse analysis method. This phase, discussed in Chapter 6, addresses **RQ3:** *How do these features interact with one another, and how do these interactions contribute to the workings of a collaborative group?*

The resulting framework that emerged from these inquiries and the contribution it presents will then be reviewed and discussed in Chapter 7. Limitations of the current work, as well as opportunities for future research, will both be addressed.

3.3 Flavors of Grounded Theory

The grounded theory method is traditionally described as a "qualitative research method that uses a systematic set of procedures to develop an inductively derived grounded theory about a phenomenon" (Corbin, 2008). It has seen widespread use among scholars to study a plethora of topics in the social sciences, and has even been lauded as the "paradigm of choice" for qualitative researchers (Miller & Fredericks, 1999). Grounded theory (GT) has undergone various revisions, transformations, and evolutionary steps in the last 50 years. Most notable of these was a schism that formed between its two creators, Barney Glaser and Anselm Strauss, which resulted in two *flavors*—the first of which is often referred to as "classical" and is attributed to Glaser, with the

second taking on the moniker of "Straussian" which was co-developed with Juliet Corbin. It would be folly to attempt to do justice to the eventual number of cited differences between the two, but it has been succinctly condensed by others down to a fundamental disparity between the former's emphasis on induction and natural emergence vs. the latter's more prescriptive and highly analytical approach (Kenny & Fourie, 2014).

Of comparable notability has been the work of Kathy Charmaz over the last two decades to reformulate grounded theory from a distinctly constructivist point of view (e.g., Charmaz, 2000; 2006) that emphasizes the value of flexible strategies and an acknowledgement of the role that interactions play in the knowledge work that researchers produce (Kenny & Fourie, 2014). These interactions—be they between researcher and data, researcher and subject, researcher and worldview, or even interactions between emergent concepts—are all an inseparable part of how they construct meaning (Charmaz, 2006). In regard to all of these qualities of GT, Charmaz very neatly encapsulates the core aspects of her constructivist stance as:

- The grounded theory research process is fluid, interactive, and open-ended.
- The research problem informs initial methodological choices for data collection.
- Researchers are part of what they study, not separate from it.
- Grounded theory analysis shapes the conceptual content and direction of the study; the emerging analysis may lead to adopting multiple methods of data collection and to pursuing inquiry in several sites.
- Successive levels of abstraction through comparative analysis constitute the core of grounded theory analysis.
- Analytic directions arise from how researchers interact with and interpret their comparisons and emerging analyses rather than from external prescriptions.

These guidelines (2006, p. 178), and the way of thinking about GT they promote, lend themselves to this *flavor* finding substantial and successful application in a wide variety of fields such as

education, healthcare, social work, and design (e.g., Razavi & Iverson, 2006; Pidgeon & Henwood, 1996; Sarker et al., 2000; Furniss et al., 2011). These oftentimes complex, nuanced, and ever-changing contexts of research are especially well-suited to the flexible and interpretive approach favored by this constructivist stance. These areas of study are also rich with human interaction, and thus promote the researcher to integrate these relationships and perspectives into their emerging concepts.

In addition to incorporating the lessons learned from a close reading of Charmaz, the research presented in later chapters moves to fully embrace the notion that GT's capacity for extensibility is quite substantial indeed. In particular, the method was shown by Furniss, Blandford, & Curzon (2011) to be a very appropriate means of crafting a taxonomy or generating a theoretical framework in the context of HCI and information technology research. They assert that even an openly admitted deviation need not warrant the preclusion of confidently stating one's work to have employed grounded theory, noting that "methods' labels encompass their history, process and properties, which can be reflected on and critiqued" (Furniss et al., 2011).

Contrasting this enthusiasm for extolling the method's virtues and the extent to which it can be interpreted, adapted, and extended, it has also met with its fair share of criticisms throughout its life stages (see Dey, 1999 for a summary). Perhaps most notable of late was the unabashed and particularly indicting critique by Gary Thomas & David Janes that scrutinizes and roundly rejects the method at what can only be called a fundamental level (2006). Not only do they call into question the method's use of the term "ground" as a misnomer, they go on to strike down the primary assertion that the method can produce anything that should be considered "theory" (Thomas & Janes, 2006). While their critique was largely focused on classical and Straussian formulations, and was supported by considerable evidence and citing of other detractors, the

critique failed to fully address the constructivist approach, and was at times dismissive of it, stating "although there is a new kind of constructivist grounded theory it is unclear what this can add to such accounts [of researchers] indeed, it may even subtract from them" (Thomas & Janes, 2006).

It is not my intention to spend any additional amount of time here summarizing and comparing these varying schools of thought on the method, nor to try and tackle a contrasting of their specific methodological functioning. Rather, in looking retrospectively at the body of work that this manuscript captures a portion of, it is worth taking stock of the various flavors of GT that have found their way into my research, and to openly and rightfully acknowledge that aspects of them have been adapted, borrowed, or interpreted according to the needs of the questions being asked at the time. You will certainly see these approaches at play in the chapters that follow—examples of researchers digging through the proverbial "methodological toolbox" to find the right tool for the job at hand. It is my hope that this will be seen as pragmatism in the face of what is now largely understood to be the "mess" of research, rather than as any shrugging off of the methodological rigor that can certainly (and rightfully) be ascribed to the grounded theory method.

3.4 Computer-Mediated Discourse Analysis

The SNfactory chat logs represent a rich and storied account of both the technical coordination and socio-emotional interactions of the participants. As such, it was imperative for phase 3 to employ a method that would be well-suited to addressing both aspects, and the interplay between the two as they related to the goals, means, and outcomes of the group interacting through the chat tool. After surveying the multiplicity of methods available to investigate phenomena in such interrelated fields as human-computer interaction, computer-supported cooperative work, and online communities—

one stood out as being especially well-suited to the aims of accounting for the features of distributed affect.

Computer-mediated discourse analysis (CMDA) is a recently developed method by Susan Herring that bridges the gap between traditional methods of discourse analysis (typically aimed at written or vocal) and the more recent development of computer-mediated communication (CMC), largely textual, that shapes a growing majority of our communication practices (see: Herring, 1997; Herring, 2001; Herring et al., 2004). CMDA applies "methods adapted from language-focused disciplines such as linguistics, communication, and rhetoric to the analysis of computer-mediated communication… [and has] at its core the analysis of logs of verbal interaction" (Herring et al., 2004), thus takes advantage of the unique qualities of online discourse that occur in our chat logs.

Additionally, Herring points out that when following the CMDA approach, one should have an open-ended research question that can be addressed empirically through the examination of textual evidence (2004); in this case that question being related to how the features of distributed affect interact and influence group dynamics. Of key importance here is that CMDA is specifically formulated to apply to the examination of five levels of language, and through an accounting of the phenomena that occur at each of these levels, one is able to identify features for further analysis. These levels are: structure, meaning, interaction, social behaviour, and participation patterns. In some ways, these levels are akin to the key functional elements of turn taking, adjacency pairs, and repair identified by Goowdin when discussing conversation analysis (1990), although they have been adapted to the text-based medium and are also attempting to account for other factors not specifically considered in a traditional conversation analysis approach (Herring, 1997). In Chapter 6, these levels of language will be discussed in more detail, and will ultimately be used to

operationalize the features of distributed affect in terms of how they can be observed in the text-based medium.

Finally, referring back to the points raised in Chapter 2 concerning the socio-technical gap, it is useful here to note that Ackerman has also pointed to CMC (such as the implementation of chat used by the SNfactory) as a *first-order approximation*—a term he borrows from fluid dynamics to describe "tractable solutions that partially solve specific problems with known trade-offs" (2000). In other words, we acknowledge that some given design is doable within a certain set of constraints, but we are careful to identify and be mindful of the impact this has within the context the solution is deployed. In this sense, we are acknowledging the socio-technical gap, and exploring its dimensions in more detail to avoid the pitfall of ignoring or making these trade-offs invisible. Far from ignoring them, CMDA can be used to directly examine this first-order approximation in the records created by using text-based chat as a partial solution to not having access to the typically rich, multi-modal forms of expressing and interpreting affect available to us. Through the employ of the framework of distributed affect features in conjunction with the CMDA method, phase 3 of this research represents a realized example of this acknowledgment.

Chapter 4. A TAXONOMY OF AFFECT IN CHAT

In the previous chapters, I have established and elaborated some of the connections between affect and cognition, group work, and text-based communication. In the literature surveyed in Chapter 2 and the related data and methods discussed in Chapter 3, it was demonstrated that in a variety of both personal and work settings, communication technologies support non-co-located groups that rely heavily on text-based forms of communication to achieve their collective goals. As a result of the widespread adoption of these ubiquitous and ever-evolving communications tools, a significant portion of research in related fields has focused on their design and usage. In his 2011 assessment and history of the Association for Computing Machinery's Special Interest Group on the Design of Communication (SIGDOC), Brad Mehlenbacher noted that the field of communication design has expanded to include numerous diverse research areas such as human-computer interaction, computer-mediated communication, interaction design, and collaborative systems. These areas are "united by a common interest in the relationship between text and technology" (2011).

The role of communication technologies in creative, distributed collaborations, such as the previously described SNfactory, has been of particular interest in recent creativity research (e.g., Aragon & Poon, 2009; Aragon & Williams, 2011; Csikszentmihalyi, 1997; George, 2002), and it has been established through these and other studies that affect plays a crucial role in these types of creative collaborations, especially as influencing communication between group members (e.g., Aragon, 2011; Fitzpatrick, 1996; Hancock, 2007; Kraut, 1988). As groups work, conversations can range from excitement and confusion to frustration and annoyance, as well as a wide range of other affective states and expressions. To investigate this link between affect and the rapidly evolving

communication-supporting technologies that shape social dynamics, researchers need the right analytic tools to investigate online text-based communication in this domain.

A primary concern of many qualitative studies is centered around the researcher's ability to effectively code their data as a means of labeling and organizing it in the service of being able to analyze it further—sometimes as part of the initial stages of analysis itself. This process of coding data is an important step in beginning to truly gain a better understanding of the structure, patterns, and meaning contained therein. Equally important is the consideration given to how useful and good of a "fit" there is between the codes being applied to the data, and the data itself (Miles & Huberman, 1994). Our desire for our coding scheme to have good fit with the data was of major importance to us when coding affective interactions in the medium of text. This was in no small part predicated on our aim of imbuing the often-messy world of human emotion with an equally structured and appropriate layer of meta data that was perhaps more suitable for something approaching objective analysis. After collectively carrying out an initial exploration of other existing taxonomies of emotion and not finding a suitable candidate for our purposes, my colleagues and I decided on the path of creating our own.

The impetus for creating this taxonomy was initially predicated on a multiplicity of research questions that my collaborators and I intended to explore as part of a directed research group. Some of those questions fell by the wayside as we defined and refined our scope of inquiry, while others became separate veins of research that my collaborators pursued on their own—but they all shared one thing in common: a desire to better articulate how we as human-centered researchers can expand and refine our understanding of the hugely important role that affect plays in our interactions with and through technology. This work was a major stepping stone in being able to carry out my subsequent work; and will provide a clearer understanding of the novel

methodological way we arrived at the affect codes that were applied to the SNfactory data set, what those codes are, and the contribution they represent in relationship to the distributed affect framework.

4.1 ACKNOWLEDGMENTS

Substantial portions of the work presented in this chapter were carried out collaboratively, with significant contributions from Katie Kuksenok, Daniel Perry, Michael Brooks, Ona Anicello, and Cecilia Aragon. Parts of this chapter were previously published as "Adapting Grounded Theory to Construct a Taxonomy of Affect in Collaborative Online Chat" in the 2012 ACM International Conference on Design of Communication (Scott et al., 2012). This work has been edited and revised by the author for inclusion in this dissertation.

4.2 BACKGROUND

During face-to-face meetings in which the members of a collaborative team are co-located in both space and time, both verbal and nonverbal physical cues play an important role in the way that communication is carried out and processed by the members of the group (John-Steiner, 2000; Kraut, 1988). However, with the widespread growth in the last few decades of technologies that enable new and increasingly robust modes of remote communication, collaboration is now just as likely to take place between members of a distributed group that do not benefit from the affordances of face-to-face communication (Kraut, 1988). A large portion of this communication takes the form of text, including emails, text messages, and instant messaging chats. These online, text-based forms of communication have become ubiquitous and constitute one of the most important means of contact between members of many distributed groups.

The trace created by using text-based chat communication to mediate creative problem solving can be studied to better understand collaboration. The expression of affect still plays an important role in these text-based forms of communication, but it takes on forms that are distinct from those found in face-to-face communication (O'Neill, 2003). Affect-laden words, emoticons, special abbreviations, deformed spellings, punctuation, and interjections are just a few of the many ways in which the expression of affect has been adapted to text-based forms (Hancock, 2007; Kraut, 1988; Liu, 2003). These signals, embedded in a detailed trace over time, can help us measure the quality and quantity of affect expression in text-based communication between members of a distributed group. The utility of this measurement for further analyses depends on how robust the analytic lens is to the effects that the specific communication medium has on the character of affect expression.

Existing taxonomies of affect and emotion focus primarily on classifying psychophysiological responses to internal states and environmental factors (Barrett, 2006; Ekman, 1992; O'Neill, 2003). There are several conflicting theoretical models of affect and emotion in multiple fields. Examples include the dimensional models of Russell (1980), the emotion wheel of Plutchik (1980), and the distinction between basic and complex emotions (Barrett, 2006; Ekman, 1992). Emotion is often measured via facial expression, vocal features, and body posture as the physical "expression" of emotion (rather than focusing on internal "state") (De Silva, 1997).

Researchers interested in understanding how we express and perceive emotions rely primarily on analyzing these physical forms of expression (De Silva, 1997). This is not possible when attempting to measure the expression of affect in text-based communication from a chat log. Furthermore, the affordances of the medium can lead to individuals adjusting communication practices to express affect via text in ways that they would not do using the spoken word and thus

are not well accounted for in existing taxonomies. Our work bridges the gap between research that considers the measurement of affect, and the design of communication media that can fundamentally shape human expression.

4.3 Adapting Grounded Theory

As detailed in Chapter 3, the goal of the grounded theory method is to generate a theory that emerges from the data being comparatively analyzed, rather than the application of an existing theory to answer a research question (Corbin, 2008; Glaser, 1967). The method is especially well suited to producing theories of interactions between different social units, and is widely used in many social science fields (Charmaz, 2006). Throughout many sections of this chapter, a significant portion of original ideation and writing done at the time of the research described is left largely intact as a means of more fully demonstrating the critical reflection and process of extending or adapting more "traditional" aspects of the grounded theory method. Although this produces some redundancy with some of what was discussed in Chapter 3, it is integral to the work presented here, especially in terms of embracing the flexibility and adaptability of GT as commented on by Furniss et al. (2011), and as one of the contributions of this phase of the research.

In order to analyze the data and build a theory that is grounded in it, Strauss and Corbin suggest three types of coding activities: open, axial, and selective (2008). While they are generally carried out in sequence, they are also often used iteratively as the research progresses, taking advantage of the emergent and reflexive properties of this method (Charmaz, 2006). These procedures form the core of this methodological approach and are the main processes by which the data is used to generate a theoretical framework.

4.3.1 Open Coding

During open coding, text data, such as field notes or interview transcripts, is examined line-by-line, the main concepts and categories are identified, and their properties and dimensions are initially captured through the use of memos that discuss the researchers' ideas behind the codes. The concepts captured in these memos can be seen as the core units of the theory being developed. The similarities and differences between data points are examined, then named and recorded in the memos. This phase of coding is an open process during which all pieces of data are of interest to the researcher, and few if any restrictions are placed on what data gets coded and how it is conceptualized.

4.3.2 Axial Coding

During axial coding, categories, concepts, and codes are related to one another by linking them around the axis of a single category at the level of their properties and dimensions. In order to understand how these categories and codes relate to one another, Corbin and Strauss (2008) suggest the use of a "paradigm model" that takes into consideration the relationships between conditions, context, actions/interactions, and consequences. The basic idea of this model is to systematically propose linkages between these aspects and then look back to the data for validation. This paradigmatic model is then used to link sub-categories with their respective categories in a way that reveals an underlying structure of the codes produced during open coding. Generally, axial coding proceeds until a level of "theoretical saturation" is reached whereby gathering or examining new data does not lead to the emergence of substantially new structure.

4.3.3 Selective Coding

The first major goal of selective coding is the formulation of a core variable or category to which all other categories and codes can be related. At this point, open and axial coding processes cease, and only those categories and variables that can be related to this core variable continue to be coded as the formulation of the theory proceeds. Strauss and Corbin point out that this core category should be able to explain variation as well as contradictory evidence found in the data. The core variable represents a type of narrative that is grounded in the data by which the categories identified during axial coding are linked.

Finally, as a means of refining the theory produced through the selective coding process, Strauss and Corbin suggest that the researcher review the theory to check for internal validity and logic; attempt to account for underdeveloped categories; eliminate any excess categories; and to validate the theory (as might be accomplished through a high-level comparison with the original data).

4.3.4 Grounded Theory in Context

Qualitative data analysis methods grounded in data enable the discovery of emergent themes, rather than focus empirical investigation on pre-specified hypotheses. These methods have been critical in constructing and refining theories of social phenomena, including in human-computer interaction topics. Schoonewille et al. used GT to better model and understand developer comprehension of software documentation and then validated their model using a cognitive theory of multimedia (2011). Power and Moynihan used an adapted GT approach in constructing a framework to explain the situational variety of styles of requirement documentation, as well as a three-part scheme for classifying these requirements that was a direct result of their GT coding (2003). Finally, Razavi and Iverson produced a theory of end-user information sharing behavior in

a personal learning space using grounded theory methods that were enacted in a similar fashion to our own (2006).

In research of human interaction with information systems, grounded theory methods are used not only for construction of a theory, or as part of a mixed-method case-study approach, but also as a means to refine an initially hypothesized theory (Matavire, 2008; Sarker, 2000). In this case, the initial theory can be modified, refined, or further informed by themes that emerge from the application of open, axial, or selective coding to qualitative data. Our adaptation of this approach, on the other hand, takes the route of treating GT as an intermediate analytic step that results in a taxonomy to be used in subsequent analyses. Our expectations for this taxonomy extend beyond the construction of a theory, including, for instance, the need to automatically detect instances of codes in a large-scale dataset and perform statistical analyses. The goal of using this taxonomy for a purpose not typically part of the GT method led to the adaptations we propose.

The primary characteristic of the analytic processes of GT is closeness to the data. In studying affect in text-based communication, nuanced means of communicating and expressing affect are of key interest to research, and pose challenges to existing taxonomies of affect which are not amenable to the peculiarities of text-based, distributed expression (Barrett, 2006; De Silva, 1997; Ekman, 1992; O'Neill, 2003). Not only do these taxonomies rely on implicit physical characteristics not present in text for classification, they are also not ideal for capturing subtle affective states such as confusion or agreement, which we saw occurring frequently in our data. These other forms of affect are just as important as classical categories of emotion when attempting to account for all of the factors contributing to the dynamics of the group. The capacity to systematically extract previously unacknowledged themes is inherent in the GT methodology

and is crucial in this task. Nevertheless, the direct application of GT traditionally results in a theory or model of the data, which is not the purpose for which we want to use these methodologies.

4.4 Taxonomy of Affect in Chat

One of the primary concerns when developing our taxonomy was to account for the nuanced and specific ways that affect is communicated and expressed in a text-based medium, and specifically the SNfactory chat logs. We found that many existing taxonomies were created to characterize affect predicated on implicit physical representations such as facial expressions or tonal inflection (Barrett, 2006; De Silva, 1997; Ekman, 1992; O'Neill, 2003). This stands in stark contrast to much of the expression of affect in text-based communication which relies heavily on explicit statements of emotion and text features such as emoticons and punctuation (Hancock, 2007; O'Neill, 2003). Our application of GT was specifically intended to develop and refine a taxonomy that captured these types of affective expressions. Although this construction of a taxonomy for coding is not a typical use of GT, an appreciation for the method's closeness to the data as well as the method's ability to identify and group themes made it an ideal candidate for adaptation to our needs. Whereas the codes generated and applied during grounded theory are generally used to provide structure and inform the development of a theory, we were specifically refining these codes into a taxonomy that could be used as a coding scheme in its own right for the further analysis of our data.

During traditional open coding, data is initially organized into concepts and themes (Corbin, 2008). Using this approach, we explored the data in an unrestricted manner through a careful line-by-line reading of portions of the chat logs. Given that this stage of the GT method is specifically geared towards openness, the need for adaptation was minimal. We initially coded anything and

everything that was of interest, not just affect, but also accounted for instances of creativity, collaboration, and other events significant to the group. Due to the scale of our data, it was not possible to perform open coding on the entirety of the data set, so we strategically sampled areas that contained high volumes of interaction between the participants in order to maximize our chances of finding significant and interesting phenomena.

Axial coding enabled us to focus the scope of what we would account for in our taxonomy. In addition to this substantive dimension, we also began to explore the inclusion of two other separate axes. As we related the instances of affective expression to one another, we found it useful to note their intensity (high or low) as well as their valence (positive, neutral, or negative) as is commonly done in sentiment analysis. These measures provided an additional fine-grained characterization of our substantive codes as well as a means to resolve ambiguities when applying codes that were not explicitly positive or negative depending on the context. Along with the substantive axis, the intensity and valence axes formed the overall paradigmatic model by which the codes produced during open coding were grouped and refined around a central set of codes.

Selective coding involves the formulation of a core variable or category to which all other categories and codes can be related to in a sufficiently significant way to be considered a substantial part of the final theory being developed (Corbin, 2008). For us, this core variable took the form of an "affect" category to which all of our codes in the taxonomy were being related. One primary difference between the traditional GT approach and ours was that we still continued an iterative approach to open and axial coding during our selective coding. This was done because through our selective coding process, we continued to encounter new and significant points of interest in our data. As these new codes were identified and defined, they were combined into the selective coding process as part of our attempt to reach the theoretical saturation that generally

signifies the completion of this phase in traditional GT (Glaser, 1967). This selective coding process was also an opportunity to explore the internal validity of our taxonomy by evaluating how well it accounted for affective expressions in our data.

4.4.1 Plutchik's Wheel of Emotion

After selectively coding our data, we were left with a core category (affect) to which we had related all of our other variables in order to form a theoretical frame that could account for affective expression encountered during open coding. We had also begun the process of validating, expanding, and trimming our codes through the iterative application of our categories to the data in order to check the internal validity of our coding scheme and the resulting taxonomy. At this point in the grounded theory process, it is generally accepted that relevant literature will be reviewed in order to better situate the emerging theoretical model within the existing body of research in that area (Glaser, 1967). This step in the grounded theory method was well suited to the creation of a taxonomy of affect without replacing or reinventing existing taxonomies. We hoped to account for the shortcomings of taxonomies that were not specifically capable of addressing the variations of affect expression that are present in text-based communication mediated by online chat.

Through our review of existing taxonomies of affect and emotion, we found that Plutchik's Wheel of Emotion (1980) was closely aligned with what we had been seeing and coding for in our data. Although we have been careful to make a distinction between affect and emotion, they are still closely related. In fact, not only were there numerous codes in our taxonomy that were not present in the Plutchik wheel, there are several emotions from Plutchik that were not in the taxonomy we had created but were still found to be applicable to our own data. Additionally, the inclusion of the

Plutchik emotions also ensures that our own work builds on and extends existing theories of affect and emotion.

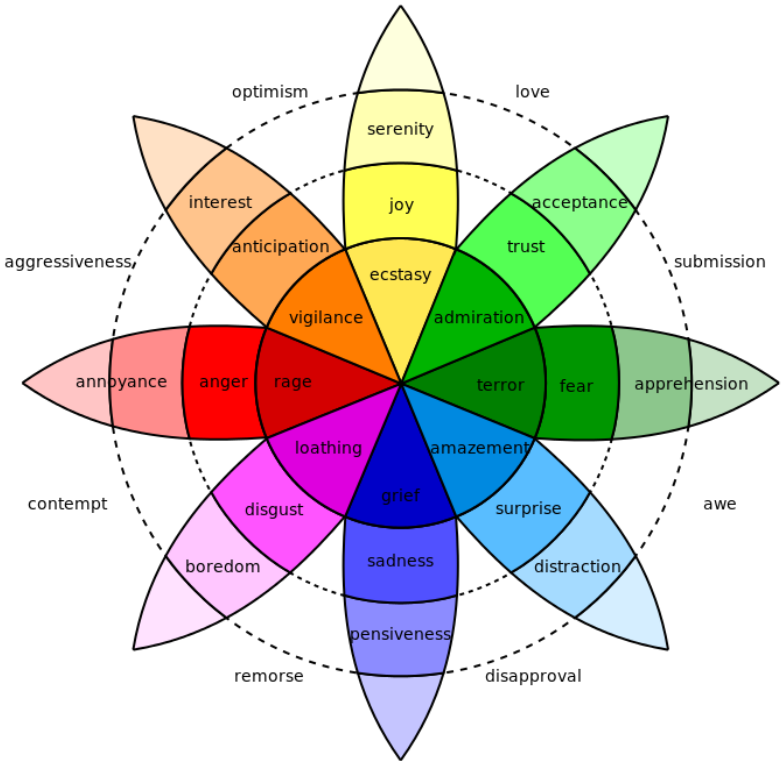

Figure 4.1: Plutchik's Wheel of Emotion

Ultimately, the application of this adapted grounded theory approach was our solution to the problem of attempting to translate a very large body of work on affect and emotion into a more appropriate and useful analytic lens. This lens can then be used to examine the specific types of affective expression present in our data because it accounts for the distinct ways in which these expressions are molded by the text-based medium.

4.5 The Taxonomy In Use

Over the course of several months, five members of our research team iterated on developing a coding scheme as part of the adapted grounded process we have described. The resulting taxonomy

includes substantive codes reflecting affect state expression (listed in Table 4.1 below), as well as valence codes relating to how "positive," "negative," or "neutral" a message is overall, and intensity codes for "low" or "high" expression intensity (where "neutral" valence does not call for an intensity code). Substantive codes are not mutually exclusive, and can be combined with valence and intensity labels for greater flexibility. For example, a sarcastic comment can express nuanced affect in this context, including "frustration/negative/high" during particularly stressful periods, and "amusement/positive/low" during less demanding times (see Table 4.1 below for examples).

Less Intense	→	**More Intense**
pride serenity	amusement joy	ecstasy
agreement acceptance	supportive trust	gratitude admiration
tired distraction	disbelief surprise	amazement
considering interest	relief anticipation	excitement vigilance
apologetic pensiveness	embarrassment sadness	grief
apathy boredom	disgust	frustration
disagreement apprehension	confusion fear	terror
annoyance	impatience anger	rage

Table 4.1: Taxonomy of Substantive Affect Codes

Messages could also be coded as "no affect" to systematically distinguish messages that had been coded and identified as expressing no identifiable affective state, and those which were yet to be coded. We coded approximately 5% of the total chat log data with the final taxonomy, utilizing a team of three primary coders and five additional coders, all part of the research team. For several weeks, coders focused on applying substantive codes and "no affect," and then the additional

intensity and valence axes were added to the affective coding scheme. Of 35,614 messages coded at the time, 15,942 (45%) were coded as "no affect" by at least one person—although, as the second example in Table 4.2 shows, "no affect" can be plausibly incident with more neutral affect codes, depending on interpretation.

Time	*Speaker*	*Message*
05:58:41	Alice	ok, so where was the SN on the image? #1: interest / anger / high / negative #2: annoyance / confusion / low / negative #3: interest / frustration / high / negative
05:58:55	Alice	was it the bright blob? #1: interest / anger / high / negative #2: considering / low / negative #3: interest / neutral
05:59:03	Ben	5876 absorption is much wider than the H alpha in v space #1, #2, #3: no affect
05:59:18	Ben	Oh hmmm. #1, #2, #3: considering / neutral
05:59:28	Ben	Lemme see what [the] coordinates were... #1, #2, #3: no affect
06:13:07	Charlie	is it "well-developed"? #1: interest / neutral
06:13:18	Alice	Should be an interesting experiment. #1, #2: anticipation / low / positive #3: interest / neutral
06:13:19	Dana	yes #1, #3: agreement / neutral #2: no affect
06:13:20	Dana	big!! #1: excitement / agreement / high / positive #2, #3: excitement / low / positive

Table 4.2: Example Application of Affect Codes by Multiple Coders

In many cases, multiple substantive codes, those codes which capture the nature and meaning of a message, may apply, such as "annoyance" and "frustration" applying to these three messages, sent by the same person: "Did I see a bunch of = vs == in there??? / WHAT / WHO DID THAT". The theoretic basis of the Plutchik taxonomy includes relationships between codes that are more or less intense variants of one another (e.g., apprehension/fear/terror). Additionally, multiple substantive codes can be used simultaneously, such as "anger / confusion / low / negative" expressed in a

conversation about error-prone software. Example messages where this expressiveness is especially useful are included in Table 4.2. Of the messages coded, 1,599 were coded with multiple substantive codes simultaneously by at least one coder (129 were coded with more than two substantive codes by at least one coder).

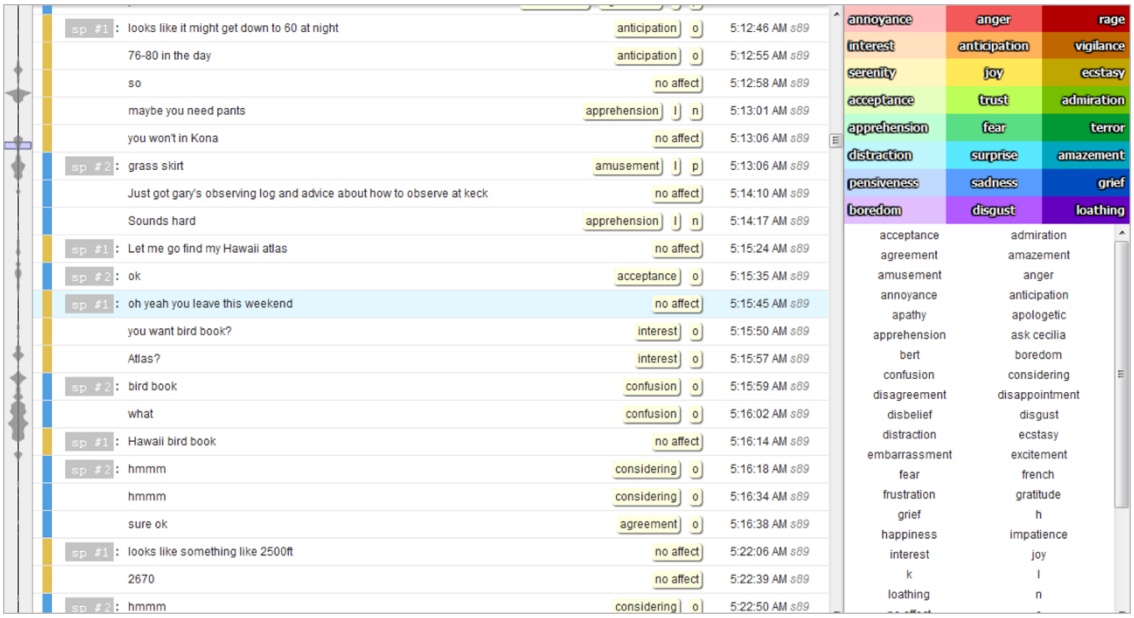

Figure 4.2: A screenshot of the Text Prizm coding tool.

This process took several months, and leveraged a tool for coding chat logs that was developed within our team (shown in Figure 4.2). The tool was developed over the course of a year, simultaneously with the creation of the taxonomy, to make the coding of chat logs faster and easier, and coded data more accessible for analysis (via storage in a central relational database and a carefully designed user interface).

4.5.1 Inter-Rater Reliability

Although the grounded methodology itself does not always call for the calculation of inter-rater reliability, verifying that human annotators can reliably apply codes validates the use of a grounded taxonomy for further analytic steps. However, the construction of this taxonomy does not

necessarily produce one that is non-exclusive. Applying multiple codes at once, while necessary for capturing nuanced dimensions of affect expression, for example, violates one typical assumption of reliability metrics: the exclusivity of codes. Cohen's kappa (1960) and other widely used reliability metrics that calculate the reliability based on *observed agreement* to *chance agreement* tend to assume exclusive application of codes. The main problem with such an application is that when coders can apply multiple codes per item, the standard estimate of the probability of chance agreement becomes erroneous (underestimating the true probability). We analyzed our coded data using a modified version of the kappa statistic, which overcomes the problem of non-exclusive code application through a Monte Carlo simulation.

We first extended the *observed agreement* term to work for non-exclusive codes. We defined agreement about a particular code on a single chat message in the following way: if more than half of the people who coded the message said that the code was present, then they agree. If all of them said that the code was absent, then they also agree. Any other combination is disagreement. For comparison, traditional kappa calculations, which deal with only two coders, also consider the coders to be in agreement when they chose the same rating. We used this definition of agreement because our coders had many non-exclusive codes available, and because *not* using a code on a specific message does not strongly imply that the coder disagrees with that code, only that it was less appropriate than other codes available (e.g., *rage*, *annoyance,* and *fear* may co-occur).

Estimating the probability of coders agreeing by chance is more complex. Since chat messages may have variable numbers of coders, and coders may choose to apply variable numbers of codes, it is difficult to compute the probability of chance agreement directly. We developed an estimate of the probability of chance agreement based on a Monte Carlo method. We first calculate the probability of choosing each code for each individual coder, and the probability of applying

specific numbers of codes for each individual coder. This gives us a profile of each coder's general behavior, independent of which chat message is being coded.

Next, we randomly simulate ratings for a very large number of messages. For each message we are simulating, we decide which coders are going to rate it, based on the proportion of messages rated by those coders in the dataset. Then, for each of those coders, we randomly choose a number of codes to apply, sampling from the distribution we already calculated for that coder. Each of these codes is randomly selected from the coder's prior distribution of code choices. Counting the number of these simulated messages where agreement occurred allows us to estimate the probability of random agreement. This approximates the typical measure of chance agreement in the two-rater exclusive-code case, but generalizes to our more heterogeneous data. The Monte Carlo simulation continues until all probability estimates are stable to within 0.0001, generally requiring about 2 million messages to be simulated.

Code	Obs. % Agreement	Prob. Chance Agreement	Kappa
interest	0.925	0.609	0.808
amusement	0.933	0.827	0.611
considering	0.931	0.864	0.490
agreement	0.954	0.909	0.491
confusion	0.906	0.755	0.615
annoyance	0.929	0.693	0.770

Table 4.3: Modified-kappa reliability scores[3]

To finally calculate this modified kappa, we divide the difference between the rates of observed and chance agreement by the difference between one and the rate of chance agreement (Cohen, 1960). Some example reliability measures over the data are shown above in Table 4.3.

[3] Cohen suggested the Kappa result be interpreted as follows: values ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement.

4.6 DISCUSSION

The method that was applied during the first phase of research to this specific problem area and data set is based on embracing the qualitative process, and embracing the flexibility and extensibility of grounded theory. As a result of the work presented in this chapter, we were able to address our first research question in a way that effectively and purposefully accounted for the specifics of expressions of affect found in text. Not only does this taxonomy represent a contribution of this dissertation, but it was also an important step in the process of the larger research agenda aimed at addressing questions about distributed affect. The validation or evaluation of this method poses several key limitations that we hope to be able to address in future work. We also frame the work that we have completed thus far in the context of a larger research agenda, with the possibility of extending our method to account for other data sets and phenomena not specific to affect in terms of this adapted approach to be used for the generation of taxonomies or other labeling tools.

Given the size of the data set that we are coding (485,045 messages), it is reasonable to assume that there could very well be unique instances of affective expression that we have not yet encountered during the grounded theory coding process itself, or the subsequent coding of our data with the resulting taxonomy. Although we have tried to anticipate and account for this—not only through rigorous sampling of the data, but also through the integration of the Plutchik taxonomy with our own in order to make it more robust and flexible—we acknowledge that there may be affect in the data that is not specifically accounted for in our taxonomy. Therefore, we do not claim that our taxonomy is exhaustive, but only that it has thus far successfully accounted for the affective content we have encountered.

In both formulation and application, the coding scheme is not comprised of mutually exclusive codes. While it is often the case when creating or using a coding scheme to have only one specific code that is applicable to any given piece of data, we found this restriction too limiting in effectively capturing the variety and subtlety of the affective content that we sought to identify in our data. The flexibility of combining concepts afforded by non-mutually exclusive coding, such as in open coding, is in tension with analytically-motivated exclusive coding along each dimension, typical to axial coding. The decision to favor the flexibility of non-mutually exclusive codes influences the interpretation of coded data. For instance, for a given line of chat, if code A is applied, but not code B, code B might still have been justifiable, but subjectively less than A. If one coder applies A and B, and another only A, it is a different sort of disagreement than if one of the coders only applied code C. There are also consequences for the measurement of inter-rater reliability. Standard formulations of reliability metrics are not strictly applicable in this case; a modified kappa methodology appropriate here was detailed in section 4.5.1.

Despite the difficulties introduced by foregoing exclusivity in coding, this decision grants the taxonomy more expressive power. There are instances when a single line might share two or more codes (such as anger, frustration, and annoyance all occurring simultaneously). Because these affective states often co-occur, we find it valuable from an analytical standpoint to retain access to this granularity of coding. We deliberately chose to avoid flattening the instances of codes occurring in our data by collapsing several co-occurring codes into a single unified code. It was more practical to allow the co-incidence of codes, such as anger and frustration, or surprise and frustration, rather than increasing the taxonomy, potentially combinatorially, in response to the complexities of affect expression in chat.

Finally, we constructed this taxonomy to answer specific questions about the role of affective expression in the dynamics of a particular distributed collaborative team (SNfactory). Thus far, we have not attempted to apply it to another corpus of chat logs or other forms of text-based communication. We plan to address these limitations through our future research which will explore the usefulness of this taxonomy for other chat data sets.

4.7 CONCLUSION

The method described here resulted in the construction of a robust taxonomy of affect that is firmly grounded in the data set and builds on a large body of related work on emotion and affect. Unlike more traditional grounded theory approaches, our method focuses on adapting aspects of the method that maintain closeness to emergent themes in the data to construct an analytic lens both sufficient for our data and flexible enough to be used in other types of investigation. As Charmaz notes, even finished grounded theories are somewhat open-ended and the constructions of concepts are able to shape both the process and the final product (2006). It is expected that this would be reflected in any continued refinement of this taxonomy as it was continued to be applied to data sets.

Our ongoing research on the role that affect plays in distributed group collaborations motivated the development of a taxonomy that accounts for the distinctive expression of affect that takes place in text-based online communication. We drew upon existing bodies of research on both emotion and computer-mediated communication to inform our approach, and ultimately used a novel adaptation of the grounded theory method to construct an appropriate taxonomy. We wanted to account for the nuanced and specific ways that affect is communicated and expressed in a text-based medium, and existing taxonomies of emotion were found to not be a good fit for this goal. This adapted

grounded theory approach was our solution to the problem of attempting to translate a very large body of work on affect and emotion into a more appropriate and useful analytic lens that accurately reflected the phenomena of affect found in our data. The resulting taxonomy has been used to code a significant portion of the corpus of the SNfactory chat logs. I hope that other researchers in this area will find both the method and the taxonomy we have presented to be of use in their own studies.

Chapter 5. A FRAMEWORK OF DISTRIBUTED AFFECT

Affect underlies and informs all human interaction, and is central to group functioning. Acknowledgment and understanding of its role in driving group creativity (Aragon, 2011) and productive working (Amabile & Kramer, 2011), particularly under pressure, is often lacking or denied (Urch Druskat, 2006) especially in technological and scientific areas (Newstetter et al., 2011). This chapter presents a framework for a deeper understanding of affect's impact and operation, focusing on distributed groups that are communicating predominantly through text chat.

Although the mechanisms of distributed cognition (Hutchins, 1995; Stahl, 2011; Stahl, 2006) have been extensively studied in distributed teams, less work has been done on the operation of affect beyond the individual. To address this gap, we examine how affect is dynamically distributed when people collaborate, specifically through text-based media, drawing on an extensive data set of chat logs derived over four years from the Nearby Supernova Factory (SNfactory), an international collaboration between French and American scientists (Aldering, 2002). We build upon two sets of related research on affect in groups using text-based communication: Aragon and Williams' work (Aragon, 2011) where the term distributed affect is used without detail; and works by Scott et al. (Scott, 2012) and Brooks et al. (Brooks, 2013) identifying and codifying a taxonomy of affect in chat logs. These demonstrations that affective processes are visible in groups' text-based communication in decision-making establish the need to describe in more detail how affect operates within the processes of distributed groups. Our research builds upon previous work on cognition, postulating that Hutchins' (Hutchins, 1995; Stahl, 2011; Stahl, 2006) and Arrow et al.'s (Arrow, 2000) respective approaches to group cognitive dynamics apply equally to affect, and that

an affective ecosystem of dynamics between group members and their environment can be observed in our chat data set.

Put plainly, the question underlying this research is: "What is distributed affect, and how does it work?" In this chapter, I describe the process whereby I identified five distinct features of distributed affect that provide the mechanism for understanding its operation within a group context as observed in the data: *transference, resonance, pervasiveness, persistence,* and *representation*. I describe the five features and provide examples of each based on key affective events in the data set, building upon previous work in affect and emotion, distributed cognition and dynamical systems to explicate each of the features of distributed affect.

5.1 Acknowledgments

Substantial portions of the work presented in this chapter were carried out collaboratively, with significant contributions from Daniel Perry, Alison Williams, and Cecilia R. Aragon. Parts of this chapter were previously published as "Beyond the Individual: The Dynamic Features of Distributed Affect" in the 2016 ACM International Conference on Supporting Group Work (Scott et al., 2016). This work has been revised and expanded by the author for inclusion in this dissertation.

5.2 Related Work

In this section, I review related work that has begun to push the boundary for where the line is drawn around affect and cognition, additional development of their often-intertwined relationship to one another, and some of the first moves towards describing the operation of affect as being distributed (definition 3 in section 1.2) as evidenced by indicators from the text.

5.2.1 Shared Affect

Moore and Isen's (Moore, 1990) work on positive and negative affect and Watson et al.'s PANAS (Positive And Negative Affect Schedule) (Watson, 1988) propose that people are affected by or affect others, and that the affect is shared. Paralleling this, Hatfield, et al. (Hatfield, 1993; Hatfield, 1994) examine 'emotional contagion': how affect and emotion are transmitted between people. They describe a *multiply determined* family of psychophysiological, behavioral, and social phenomena that is also *multilevel* where "the precipitating stimuli arise from one individual, act upon (i.e., are perceived and interpreted by) one or more other individuals, and yield corresponding or complementary emotions […] in these individuals" (Hatfield, 1993; Hatfield, 1994).

These concepts of emotional contagion have further been applied within computer-mediated communications by Hancock et al. (Hancock, 2008), finding relationships between affect and the production of words, terms, and message rates. However, they did not account for more dynamical relationships over time, which we have found to be a crucial component of our findings. Additionally, both Barsade and George (Barsade, 2002; George, 1990) acknowledge that "group emotions" do exist and have an effect on group dynamics but also that the process by which these effects occur is not well understood, a question our research directly addresses. The laboratory studies carried out by Barsade showed strong evidence of emotional contagion in groups, but he specifically calls for future research to focus on a longitudinal study in an ongoing working team, which is precisely what we set out to do.

Gottman et al.'s (Gottman, 2014) methodologies for analyzing affect in recorded exchanges by married couples, while not directly applied for the purposes of this research, have been applied to organizational domains by Jung and Leifer (Jung, 2011) to understand interaction dynamics and

the performance of engineering design teams. Such instances of a complex reading of affect and emotion inform the framework of distributed affect and its dynamical quality as evidenced across the SNfactory data set.

5.2.2 Distinguishing Between Cognition and Affect

Cognition and affect are distinct in principle. Cognitions can be evaluated for veracity, since comparisons between cognitions can be made. For example, one can be asked to compare the height of the Seattle Space Needle to the Empire State Building, and these estimates can be evaluated for accuracy. However, an expression of how the two buildings affect you, as in "I think the Space Needle is more attractive than the Empire State Building," cannot be evaluated for accuracy, since some people might have opposite sentiments about these two buildings. Furthermore, the contents of cognitions are always representational: directed at or about something; affective states do not necessarily represent or refer to anything outside of themselves and some affective states do not refer to anything at all, such as free-floating euphoria (Zajonc, 2000). As noted earlier, cognition and affect are often interrelated in studies of collaboration, and so this distinction plays the role of differentiating what is being accounted for in terms of group functioning when placing distributed affect alongside distributed cognition.

5.2.3 Cognition and Affect in The Wild

The distributed cognition framework (Hutchins, 1995), "extends the reach of what is considered *cognitive* beyond the individual to encompass interactions between people and with resources and materials in the environment" (Hollan, 2000) and where "interaction [is] a source of novel structure" (Hutchins, 2000). Cognitive processes thus extend beyond the individual to other members of a social group, involving coordination between people and their environmental

context, and are capable of being distributed temporally so the outcomes of earlier events impact later events (Hollan, 2000). Recent work in the study of cognition acknowledges the importance of distributed cognition, contrasting the 'extended' with the 'brainbound' mind (Clark, 2011), and proposing a "potent, slow, pattern-based learning [enabling us] to learn to deal with highly complex situations in a remarkably nuanced and efficient manner" (Clark, 2011).

Aragon and Williams (Aragon, 2011) note that Hutchins does not explicitly call out possible affective states driving the collaborative problem-solving demonstrated by the distributed navigation system, despite the high levels of stress involved in the operation that might have been thought, inevitably, to have played a part. Furthermore, Clark's discussions of the extended mind (Clark, 2011; Clark, 1997) focus on cognition but not affect. However, the growing body of literature on affect and emotion previously referenced demonstrates the importance of affective states in group interaction, laying some of the groundwork for this research.

5.2.4 Expressions of Affect in Text

Chat is a central computer-based collaborative tool, used by teams for general communication, and extensively for problem-solving when there are events to be dealt with (i.e., things going wrong, or things going right). Incidents that occur during the course of work and are encountered by these teams catalyze affect, positive as well as negative, which is expressed in the chat through content (what is said) and expression (how it is said) (Aragon, 2011). In face-to-face communication, affect is frequently communicated through unconscious, spontaneous, non-verbal expressions such as body language, speech rhythm, and intonation. In contrast, text-based communication, with fewer expressly non-verbal channels available, requires more explicit, deliberate expression of affect, although some evidence exists of spontaneous non-verbal cues still playing a role in the

interpretation of affect in text-based communication. For example, Gill et al. (Gill, 2008) found that the length of a message had an impact on how well participants agreed on any particular affect being expressed in a blog post, particularly where the affect expressed had low agreement among interpreters.

While the communication of affect in text has been previously tied to spontaneous non-verbal cues such as message length, the results of research on text-based chat communication suggest that this factor may play a less significant role than previously thought. Hancock et al. (Hancock, 2008) reported that spontaneous non-verbal cues (such as message frequency) were not responsible for the spread of emotions between text-based chat partners. Rather, in an earlier study, Hancock, Landrigan and Silver (Hancock et al., 2007) found that the use of intentional verbal and nonverbal cues such as disagreement and punctuation were accurate predictors for how a chat partner could correctly discern their partner's affective state. Similarly, Guillory et al. (Guillory, 2011) found that people intentionally use verbal and nonverbal cues to communicate affect in text-based chat, and Walther and D'Addario's (Walther, 2001) study of the intentional use of emoticons found that a smiley face amplified a positive message while a negative message became more strongly interpreted as negative with a frown face. These studies suggest that the expression of affect in text-based communication may be a more cognitive, deliberate, and explicit act than in face-to-face communication, and as such, represents a rich account of the intentional expression of affective states of the participants where evidence of distributed affect can be empirically observed.

5.3 The Method in the Mess

As work was being completed on the taxonomy development described in the previous chapter, several of my collaborators and I developed a growing interest in exploring the relationship

between the expressions of affect we were seeing in the text, and how those related to salient events that the SNfactory scientists encountered during the course of their work. It was our initial hypothesis that there was a meaningful and important connection between these events and the specific substantive affect that was being communicated as the group worked through them, but exactly what this connection might be, we were unsure. During our early stages of investigation, we sought out related research that was aimed at describing relationships between affect and group collaboration, and were directed towards the previously described research by Aragon and Williams. In that work they name distributed affect and provide evidence for its existence in text-based communication and contribution to group creativity, the exact nature of distributed affect as a comprehensive theory remained—as they suggested— "to be described" (2011). And there we arrive at the specific call to action that motivates my second research question aimed at identifying and defining these features of distributed affect.

While the underpinning and guiding method used in the service of addressing this question is constructivist grounded theory, the active means through which the features and their definitions were arrived at can best be described as bricolage. The concept of bricolage, referring here to a construction from diverse means, has been explored by other social science scholars as an approach to challenging traditional perceptions of the research process as linear, structured, and planned at all stages (Kincheloe, 2001; Lambotte & Meunier, 2013). It is additionally seen as validating more informal research approaches by "denot[ing] methodological practices explicitly based on notions of eclecticism, emergent design, flexibility and plurality" (Rogers, 2012). I see this acknowledgment of the "mess" that can often typify qualitative research as being particularly well suited to capturing the activities that my collaborators and I undertook as we interacted with the data at various stages in the research process (including reflections on work already

completed), and also in the meaning we constructed as a result. In the following sections, I describe these activities, provide examples of their enactment and outcomes, and their connection to the emergence of the five features of distributed affect presented in this chapter. In some instances, I will refer specifically to activities undertaken by myself, undertaken separately by others, or carried out collaboratively.

5.3.1 Guiding Methodological Concepts

We arrived at the framework of distributed affect and a description of some of its features in the textual chat logs through mixed methods (Sandelowski, 2008), using multiple sources of data, and situating them within contextual related research used as analytic lenses (Furniss, 2011). At the core of our approach is constructivist grounded theory, whose structure, while requiring a rigorous 'fit' with the data (Pidgeon, 1996), permits initial concepts and findings ('exploratory conceptual and theoretical development') (Furniss, 2011) to emerge early in the process. These concepts mature iteratively through a comparative method (Glaser, 1978) over the course of the study. Grounded theory allows the use of data of 'whatever type' (Glaser, 1992) from multiple sources (Charmaz, 2000).

During this phase of the research we analyzed various data types into categories as they were collected and tested findings as they emerged. These multiple sources of data included the chat logs themselves, as we immersed ourselves deeply in the copious amounts of text, researched and constructed a taxonomy of affect within the logs and scrutinized early work on distributed affect; our continual reflections and discussions, captured in notes, memos, and digests; and the pertinent literature and our reading of it in this emerging context, again noted and memo-ed. Constructivist

GT (Charmaz, 2000) encourages wide reading at all stages of the research, which is reflected in the discussion of the features in a later section.

5.3.2 Coding the Data for Affect

The SNfactory chat logs described in Chapter 3 were coded for affect using the taxonomy of 42 distinct codes as outlined in Chapter 4. This taxonomy included substantive codes that were not mutually exclusive, as well as valence and intensity labels. Using this technique, nearly 67,000 (approximately 14%) lines of the corpus were manually coded using each chat message as a discrete element, and it is these coded logs that form the central focus of our analysis.

We recognize the necessarily interpretive nature of this type of qualitative coding. In this research we remained mindful of Glaser's (1992) principle of distance in conceptualizing the data while at the same time "embrac[ing] and discuss[ing] the idiosyncrasies of unique ethnographic encounters" (Rode, 2011) as reflective researchers. Our goal in applying these codes was to capture the affective expressions that could be empirically observed in the text, rather than any attempt to infer the internal state of the speaker. To assess reliability of the coding, Cohen's kappa was calculated over all messages coded by two or more people (Scott, 2012), achieving an overall kappa value of 0.647, with per-code kappas ranging from about 0.4 to 0.8.

Our previous work coding the data (see section 4.5.1 for a discussion of coding statistics and inter-rater reliability), both in the first phase of this research and continuing through the second, and the writing of digests and field notes described in section 5.3.4 formed a substantial part of the exploratory conceptual and theoretical development (Charmaz, 2006; Furniss, 2011) of distributed affect and the emergence of its features.

5.3.3 Sampling the Corpus

The telescope and its specialized software are the integral shared instruments of the SNfactory and a main focus of their communication. Problems that arise, especially equipment and software failures, can adversely impact crucial data gathering opportunities. Immediate solutions to these problems as they arise are a high priority for the group and these events lead to frequent instances of problem-solving communication in the chat logs. For example, the scientists explicitly focus on debugging the telescope in 59 chat logs, and they collaborated to solve more complex errors in 23 chat logs. The SNfactory's computer infrastructure is also a potential target for hackers. A possible unauthorized access to the SNfactory instruments and collected data required the scientists to assess the problem and repair any possible damage speedily.

For our examination of the emergent properties of distributed affect we adopted a purposive sampling approach, in which we identified events recorded in the logs that held a high possibility of affect, owing to their out-of-the-ordinary nature. Weiss and Cropanzano's Affective Events Theory (AET) highlights the role of workplace events as proximal causes for affective reactions (Weiss, 1996), promoting affective cycles among group members. We therefore focused on three kinds of events that produced both negative and positive affective states: discovery of a security threat, shared system bugs, and shared tool failure, selected through an iterative process that identified recurring problem solving events in the dataset involving the interaction of several SNfactory members. We combined keyword and affect code searches over the chat logs to select data to analyze more closely. This method was repeated with different keywords to generate a list of logs containing potential events to analyze further. These three event types reveal the highly-layered and complex role that distributed affect plays in the dynamics of the group as they use collaborative problem solving to resolve these critical issues.

5.3.4 Digests and Early Analysis

As previously described in section 4.3.1, memos were produced during the open coding step of grounded theory. These were typically a result of examination of text data such as field notes or transcripts of interviews. These memos were meant to record concepts, categories, and especially researchers' ideas about what is being constructed and captured through a reading of the data. It was also at this stage that comparisons were made among what was recorded in the memos, similarities were being noted, and core aspects of the theoretical concepts were emerging. Charmaz describes memos as an opportunity to become "actively engaged" in the data (2006), grounding the emerging analysis during a phase where there are limited expected restrictions on what is of interest to the researcher producing the memos.

For the purpose of capturing relevant information from the full conversational accounts recorded in the chat logs, I developed a method of writing "digests," which drew from and expanded on these traditional memoing techniques. I chose the name based on the following definition: *to organize into a systematic arrangement, usually by summarizing or classifying.* I formulated the concept of a digest as an abstraction of the relevant information contained in a given log, with each consecutive portion of the digest representing a further abstraction of the data in the original log. I also developed a set of instructions for compiling a digest, and shared this with my collaborators. Treating the chat log as a high-fidelity record of what transpired during any given shift of observation, I "replayed" the events and wrote "field notes" in the form of episodic time stamped summaries taken directly from the logs. I also included semi-analytic asides as we read through the logs in the form of reader comments (RC) that provided the opportunity to note insights that were not purely factual. Based on these field notes, we produced memos of several paragraphs that included causal claims about what was captured in the summary and attempted to build

relationships. In contrast to the field notes, this write-up took an analytical perspective to reason about the phenomena of affect and events. These digests proved to be valuable resources for early surfacing of patterns, insights, and concepts that would contribute greatly to the formulation of the features.

In the below excerpt from one of the digests, we can see emerging ideas about how a particular aspect of interaction (in this case, speculation) can take on both positive and negative affective tones. This could be seen as an early indicator that both positive and negative affect can play a role in how the group addresses a problem:

> There seem to be two parallel threads of interaction during this event. The first involves the investigation, which is marked by apprehension, confusion, and speculation. The second involves amusement, speculation, and jest. Speculation is the common thread, and it is interesting that it can take on both positive and negative (i.e., fearful) affect. After the topic of conversation shifted away from the hacker, the amusement/joking persisted while the apprehension faded.

More importantly in this example, the final line provides strong early evidence of observations surrounding the persistence of affect at the group level over given periods of time, as well as a note that while one of the affective states persisted (amusement), the apprehension that had previously been interspersed with this positive affect faded away. This could be interpreted as a sign of resonating affect whereby the increase in positive affect from the joking between members of the group created a damping effect on the negative affect that was expressed in response to the initial investigation of the problem of the potential hacker.

At times, the analytic reflections presented in the digests would focus more specifically on actions, expressions, and characteristics of the participants; theorizing about or commenting on

interpersonal dynamics; or noting a personality trait that they perceived. These reflections were often very fruitful in highlighting the affective components that were present in exchanges between members of the group, as well as building some initial identification of patterns of interaction and corresponding affective expressions. Within even a short excerpt from the digests, there can be several indicators of the concepts and observations informing the emerging features. In the following excerpt, we see some clear examples of this when Roger, Ross, and Morris are trying to address a bug in a script that they believe is partially responsible for the telescope being stuck, both problems being frequent occurrences for the scientists:

> The main event in this log was the early trouble with the stuck telescope. Roger became very frustrated with the hanging SNIFS_on script, while Ross was fairly detached about it. It seems to me that Roger is annoyed because he is somewhat responsible for the scripts not functioning. As he is in a position of authority on the matter, he is socially permitted to be angry about it.
>
> Ross, on the other hand, takes a step back for most of his shift and lets Roger and Morris debug things. He seems eager to help, but Roger and Morris do not address his queries for helpful tasks to do. Eventually he leaves to go to bed.

This first part of the memo introduces the problem and the participants, and there is some discussion of affect (frustration, anger) as well as some narration of the sequence of events, ending with Ross exiting the chat. The memo then continues:

> Morris was also involved in debugging the telescope problems, but did not express frustration the way Roger did. Rather he seemed to maintain a lighthearted attitude about the matter. Perhaps this was a reaction to Roger's somewhat extreme verbalizations of frustration, or just his personality. While Morris also seems able to assist with fixing the problem (unlike Ross) he is still not responding in a way that vilifies the system the way Roger is.

> After the issue is resolved, both Ray and Marcel engage in joking and lighthearted chitchat. Ray in particular seems to like to make jokes. The remainder of the log is fairly uneventful, but the positive mood after fixing the telescope problem seems to linger.

There are several interesting things to note here, especially as they relate to the features introduced in the following section. First, it is noted that there was a contrast in the way that Morris and Roger express affect during debugging, with Morris maintaining and expressing a more positive, lighthearted attitude, which is noted as perhaps being a reaction to Roger's extreme negativity. This highlights additional evidence for the possibility of affect of one valence type (in this case positive affect expressed by Morris) being a means of damping the spread of affect of another valence type (in this case the negative affect expressed by Roger), noted numerous times in the logs and memos as a probable component of one feature of distributed affect that would later be identified as resonance.

The second important thing noted in this excerpt, is the comment that Roger "vilifies" the system (here referring to the software and related tools) as perceived through the "extreme verbalizations of frustration." This was interpreted by me to be a particularly compelling and formative example that affect can be intimately tied to an artifact or tool, and that a tool can "store" affect based on past interactions, or even possibly serve to represent or stand in for the overall feelings that a participant expresses. Finally in this excerpt, we have the acknowledgment that as the issue is resolved, there is a release of positive affect and that this positive mood "lingers", an example of how affective states can persist after they are precipitated by an interaction between the scientists as they work. And so even in this fairly short excerpt, we have three notable pieces of evidence contributing to the broader theorization here about how distributed affect might operate—and there

are many more examples of such clues contained in the excerpts, memos, and summaries present in the digests we compiled.

These digests were shared between my collaborators, and a close reading of them along with frequent discussions helped us gain additional insight into the themes that were merging across different logs, as well as some of the analytic insights that my collaborators were generating concerning interactions and affective patterns observed directly in the logs. The original instructions for creating a digest I drafted and shared with my collaborators, as well as an example digest, can be found in Appendix A.

5.4 The Five Features of Distributed Affect

In this section I expand upon the mechanism whereby affect moves from being, in Aragon and Williams' (Aragon, 2011) terms, an observation of affective states of individuals in a distributed group, to a dynamical property of that group's interaction with each other and with their context. During the first and second phases of the research presented in this dissertation, five features emerged to describe its operation in the data: *transference, resonance, pervasiveness, persistence,* and *representation*. I define and describe these features, provide examples for each one as observed in the data, as well as discuss their relationship to existing theories below. While the features themselves are a direct result of an examination of the data, this discussion of related literature is referenced to better situate our contribution within the context of other relevant work in this area and is representative of the sources we consulted as we were engaged in the grounded approach (Charmaz, 2000) we detailed above, and in Chapter 3. This set of five features, while representing a thorough accounting of the full breadth of emergent concepts and patterns found in the data, may not be exhaustive as there could still be additional features yet to be identified.

5.4.1 Transference

Transference: the passing and sharing of affect between members of the group.

In our overall observations of what occurs in the data, transference of affect was identified as one of the key mechanisms by which the other features are catalyzed and precipitated. Transference emerged as a proposed feature early on in our analysis. During initial interactions with the data and in discussion with my collaborators, we noted instances where the introduction of a specific affective expression into the conversation was often met with a similar expression in terms of substance, valence, or both. I posit that, as will be seen in the discussion of later features, this sharing or passing of affect seems to be a basic component of how distributed affect can be described to operate.

The transference of affective states is evidenced in work on emotional contagion (Barsade, 2002; Guillory, 2011), and we see additional evidence of this passing of affect in our own data. We expanded upon that previous work, which focused on dyadic pairs, to examine how affect can be transferred to multiple participants at the same time through their simultaneous engagement in the chat. As will be seen later (when we talk about pervasiveness), it is also possible to consider the outcome of this spreading of affect at the level of the entire group.

In the following excerpt show in Table 5.1 we see four of the SNfactory scientists going about using their script-based software to identify and perform analysis on observation targets, and encountering a snag when things aren't going as planned with one of the targets. There is a series of messages mostly coded with interest, some confusion, and a few positively coded messages as well.

Time	Name	Message	Affect Codes
11:58:22 am	Daniel	So are we on 20050205_002, or 2005M, or 2005ag?	interest, confusion
11:58:28 am	Roger	The first	no affect
11:58:33 am	Daniel	Oh, the new one?	confusion
11:58:37 am	Roger	yep	agreement
11:58:40 am	Daniel	Is it turning out to be interesting?	interest
11:58:47 am	Nancy	it's in the TCS, right?	Interest, confusion
11:58:48 am	Roger	We will see in minute hopefully	apprehension, hope
11:58:53 am	Daniel	Okay.	no affect
11:59:22 am	Roger	ok wanna see ima?	interest, relief
11:59:28 am		ima first or just go to spec?	interest
11:59:34 am		I wonder if there is even target there first	confusion
12:00:21 pm		hmmm	considering
12:00:39 pm		?.fits	Confusion, frustration
12:00:44 pm		:(	sadness, frustration
12:00:50 pm	Nancy	:(	sadness
12:00:59 pm	Gina	:-(	sadness
12:01:01 pm	Roger	how about red	interest, apprehension
12:01:18 pm		:(	sadness

Table 5.1: Chat log excerpt showing evidence of *transference*

Towards the end of the excerpt, we see Roger, who has been speaking for several messages in a row, uses a "sad face" emoticon at the end of a string of messages. This is immediately responded to in kind by Nancy who had been engaged in the conversation with Roger and Daniel, but had not previously been displaying any expressions of sadness (or negative affect in general). While this can be seen as evidence of transference of sadness taking place between the two, it is the fact that Gina then also sends a similar emoticon (although slightly different with a "nose") that lends even stronger evidence that transference is taking place. First, this presents multiple speakers showing evidence simultaneously that the sadness had been transferred to them, but perhaps most interestingly is the fact that up to that point, Gina had not been participating in the conversation actively, but even her passive observation is then broken by an expression of sadness, which I suggest is evidence of transference from Roger, or Nancy, or both.

Lastly, we saw examples in the data of transference of affect not only between human members of the group, but also transference of affective states to technical and conceptual artifacts which are related to the group's work and social lives, as will be evidenced in section 5.4.5 below, and again in Chapter 6. For instance, as affect is expressed during a conversation, affect may be specifically targeted at a piece of software, some other tool, or aspects of the type of work taking place (i.e. the cyclical and often frustrating process of debugging software). In this sense, these expressions of affect are targeted at non-human components that are part of the context in which the SNfactory scientists work. I posit that such targeted expressions of affect towards artifacts also constitute an example of transference.

5.4.2 Resonance

Resonance: the amplification and damping of affective states via positive and negative feedback loops.

This feature describes how affective states can build in positive or negative feedback loops between members of the group. Note that when talking about "positive" in the context of a feedback loop, it does not refer to valence, but rather the reinforcing effect of this feedback. This might be seen in the data by a series of supportive, positively coded messages sent by one subset of participants that are acting to damp the production of negative affect as the whole group works to, for instance, solve a difficult problem.

This concept draws on Aragon and Williams' (2011) "creative resonance" in which ideas are amplified or damped according to affective and social aspects of group interactions within a system. I extend this understanding to include the production of new and additional affective states

(e.g., how the damping or amplifying of one affective state, such as confusion, can precipitate that of another affective state, such as surprise or apprehension).

As an example of this amplification via positive feedback loop, the following excerpt shows Patrick and Roger working through a problem with a software script that starts with interest and surprise, and then quickly escalates. Note how there is a building of negative, similarly coded affect:

Time	Name	Message	Affect Codes
5:21:21 PM	Roger	make it print	no affect
5:21:53 PM		is it event getting to that line?	interest
5:22:58 PM		ok	confusion
5:23:06 PM		!!!!!!!!!!	surprise, confusion
5:23:27 PM		It is checking for 0 and not set????!!?!?	surprise, confusion, frustration, anger
5:24:23 PM	Roger	where is call to pick_fchart	interest, confusion
5:24:50 PM	Patrick:	????	confusion, surprise, frustation
5:25:42 PM		it doesn't anymore no ? match _fchart does ..no ?	confusion, considering
5:25:52 PM	Roger	I have no idea now	annoyance, confusion
5:26:19 PM	Patrick	why all this stuff about x then ...	interest, confusion
5:26:27 PM	Roger	Look I don't know	annoyance, confusion, impatience
5:26:32 PM		gary chopped all this logic out	annoyance, apologetic
5:26:35 PM		and then put it back in	annoyance, apologetic
5:26:48 PM		and told me I had some checks that stopped others from running because some things weren't set	annoyance, apologetic
5:26:59 PM	Patrick	…hum …	considering
5:27:02 PM		so I don't understand the logic anymore, gary completely rewrote it	confusion

Table 5.2: Chat log excerpt showing evidence of *resonance*.

In this passage that there is a reinforcing of the negative affect present in both the codes as well as the content of the messages—especially the use of punctuation—that shows a kind of building up of negativity. This is clearly evidenced by the message sent at 5:23:27 where Roger exclaims "It is

checking for 0 and not set????!!?!?", which is coded with four separate labels all indicating an inflection point of resonating negative affect.

It is also worth noting an additional example of transference that is occurring between the two speakers, with a very specific example coming in the form of the use of multiple question marks by Patrick immediately following a similar use of repeated punctuation by Roger in the preceding messages, both of which are similarly coded in terms of affect as well.

Resonance was seen to occur quite frequently in the chat, and was associated with the production of both positive and negative expressions of affect. In addition to the bursts of positivity meant to damp negativity, there are instances that might best be described as feeding back into themselves as a way of maintaining or accelerating the same affective state, such as several members of the chat telling jokes and being playful in a continued but increasingly positive manner. Lastly, it is important to note that at times, the features seemed to have an ordering or occur in overlapping ways. For instance, transference precipitating resonance, with the amplitude of that resonance potentially influencing how likely an affect is to spread through the group and to then endure over time, as will be discussed in the description of the later features.

5.4.3 Pervasiveness

Pervasiveness: the spread of one or more affective states throughout the group currently engaged in the chat.

In contrast to earlier examples centered around the expression of affect, the feature of pervasiveness captures the importance of viewing affect at the group level, characterized as an affective state. For instance, when the group is simultaneously expressing anger, frustration, and annoyance, it could be said they are in a pervasive, negative affective state.

Pervasiveness is evidenced in the data through commonalities shared by the messages. This might be through the content of the messages themselves being comparable, or through the codes that have been applied to them being similar, or even through all the messages being of the same valence. In each case, there is some shared commonality between the affect being expressed by all of the participants.

Previous research in emotional contagion offers evidence of affect shared and spread among individual members of a group (Barsade, 2002). Pervasiveness, in the framework of distributed affect, is concerned with how this can influence the dynamics of the group as a whole, extending the boundary of what is taken into consideration beyond the individual. As the affective state is distributed across all members, the unit of analysis must necessarily expand to account for this. It can be ambiguous if an affective state can be considered pervasive in a given context, as there may be times when some subset of the active group is not expressing similarly substantive or valenced affect as the other members. One way to interpret pervasiveness and resolve this ambiguity is through a simple "majority rules" approach. We found this to be effective for our flexible analysis of the feature's operation.

Time-stamped summaries of the line-by-line reading of logs can quickly highlight or note instances of pervasiveness occurring within the larger context of events that can span much longer sessions and hundreds of lines of chat logs. These excerpts make it easy to illustrate how this feature was observed in the data. At the time the following example occurs, there were seven people in the chat—with five of them actively participating in this exchange—and there were shared concerns over meteorological conditions of cloud cover and humidity, two things that can prevent telescope observation:

> At 3:04 am Mark and Phil discuss how cloudy the weather is. At 3:41 am Mark and Roger are both seem apprehensive about the humidity and clouds. At 3:45 am Bert [the chatroom bot] says to open the dome of the telescope towards the east, so Daniel does so despite the bad weather. Then Phil gets frustrated because he is having issues coding and using something called "getfits." Roger, Phil and Greg try to figure out what's going on. At 4:05, Derek and Mark discuss what to do about the high humidity. Daniel and Mark both seem apprehensive. Then Daniel points out that the humidity was high yesterday and the dome closed itself and was able to open later so everyone becomes calmer.

In this section of the chat, everyone participating was expressing apprehension, concern, and frustration over the current state of affairs. Towards the end of the summary, it is noted that Daniel points out an earlier example of a similar situation working out with a favorable result, and then "everyone becomes calmer", an indication that a pervasive state of calmness spread throughout the group. Another example of this is shown in the following excerpt where there were five members of the group interacting, and when Patrick joins the chat, it is noted that all members of the group start positive expressions of affect:

> At 11:42:18, they start to have trouble with the ultra-focus. It is resolved within three minutes and Daniel decides to award himself with a snack and Gina is supportive of this action. Next Patrick comes into the chat room at 12:13:29 and seems to have a positive effect on everybody's emotions. Patrick says things like "hello my dear Gina" and "hello my dear robot." The following text has many amusement and supportive codes. Discussion becomes more friendly and personal, with members talking about chocolate and travel. For the next hour there is little talk about work or research. Members are mostly discussing personal stuff, such telling stories about family (12:48:16).

Not only is there an example of transference when Patrick joins the chat and injects positive expressions into the chat, it can also be seen in this example that after the positive affect becomes

pervasive, the overall tone and topic of conversation turns towards a more socio-emotional and personal nature, with little discussion of work over the course of the next hour. This demonstrates how a pervasive affective state can persist for an extended period of time—a feature described in the next section.

5.4.4 Persistence

Persistence: a lasting, non-interruptive temporal duration of affective states in the group.

The feature of persistence captures the observation that there would sometimes be comparably longer stretches of messages contained in a given log where similar expressions of affect (substance or valence) would occur. These instances of persistence were often precipitated by the onset or resolution of some important occurrence or event. In both instances, the same affective state might be seen to persist for a period of time disproportionate to the rest of the log.

While persistence as a term has been used in the psychology literature in reference to an emotional state felt or demonstrated over time (Plutchik, 1990), the unit of analysis has largely been that of the individual, not that of a more complex group system. Similarly, in text-based analysis of chat data, researchers have used persistence to refer to the likelihood that users might switch between emotional states as determined by a mean score of individual users (Garas, 2012).

An illustration of persistence in the data comes from an exchange between Nancy and Gina. They are in the midst of a technical discussion related to entering commands in one of the observation tools, as seen in this digest excerpt:

> 02:24:49: Nancy says that the "red spectrum looks badly extracted." Gina comes back from taking a break and apologizes. They continue to troubleshoot the problem for ~20 minutes. Gina thanks Nancy for her help and she responds "de nada."

When Gina thanks Nancy for her help in understanding how to properly execute a specific command, Nancy responds by saying “de nada ;)”. This language response catalyzes a long series of messages exchanged between the two relating to cultural discourse concerning language, music, and travel. This exchange lasts about 30 minutes with approximately 45 messages being sent during this time. These messages represent an example of persistence as the majority of them were coded as substantively similar and with positive valence as seen from the brief excerpt in Table 5.3 below:

Time	Name	Message	Affect Codes
2:57:29 pm	Gina	thanx	gratitude
2:57:38 pm	Nancy	de nada ;)	supportive
2:57:58 pm		(sorry I learned spanish and not italian at school)	apologetic
2:58:30 pm	Gina	esto es bueno	supportive
2:58:56 pm	Nancy	:)	happiness
2:58:58 pm		si!	excitement
3:00:00 pm	BERT	1 hrs 0 min to 12deg twilight (at 16:00 UTC)	no affect
3:00:03 pm	BERT	(sunrise at 16:39 UTC)	no affect
3:00:05 pm	Nancy	the problem for us french people is that when we learn both spanish and italian we mix all up....	distraction
3:00:28 pm	Gina	yes	agreement

Table 5.3: Chat log excerpt showing evidence of *persistence*.

Persistence of distributed affect stands in contrast to the relatively short-lived and interruptive experiences often associated with an individual emotion (Fox, 2008). The duration of what is considered to be *persistent* can vary depending on context, and relies on interpretation in the analysis. Within our data, there is the means to identify evidence of persistence directly in the applied affect codes by noting, for example, stretches of recurring codes of either similar substance or valence. In other words, the same types of affect being expressed consistently over a given period of time. Additionally, it is important to be mindful of the time intervals between the sent messages in addition to the period over which the messages occur when considering persistence in

order to distinguish between duration and volume of messages. Context clues such as this are very informative when analyzing the logs and interpreting which features are present.

Aragon and Williams (Aragon, 2011) noted the importance of temporal context in understanding creative resonance in one dynamic group. These persisting affective states were very frequently seen to occur during such times as when everyone was frustrated or angry over the inability to resolve a technical issue that prevented observations for an extended period, or for instance during times of high socio-emotional conversations that were full of joking and playfulness. An example of the latter instance was briefly discussed at the end of section 5.4.3 above when an extended period of pervasive lightheartedness followed the resolution of a particularly stressful problem.

5.4.5 Representation

Representation: Affect stored in a representational form within shared tools, events, memories, cultural artifacts, and historical artifacts.

This feature is informed by concepts of the propagation of representational media in Hutchins' theory of distributed cognition (Hutchins, 1995), and is positioned as a means of capturing the specific effective interactions and references that often occur between the SNfactory members and the myriad artifacts and tools they interact with as a part of their ongoing work. Examples show how affect is propagated not only by the group members themselves, but also as stored representations and references in artifacts (e.g., the telescope or software) based on past experiences of the group and manifesting through shared references.

For example, the phrase "stuck again" uttered by one of the researchers points to the telescope as a shared artifact, but also invokes a history of stored negative affect that the group can immediately

latch onto and understand, share, and echo. Here are some example utterances related to the telescope being stuck, taken from our sampling of the logs:

Time	Message
8/23/07 2:53	tele stuck quite unhappily
5/23/07 3:18	telescope stuck
10/21/06 5:21	stuck
5/18/07 5:56	TELESCOPE STUCK ?????
6/1/07 4:27	totally stuck
7/29/07 2:44	tele is stuck
4/16/08 10:56	this is the worse version of getting stuck.
10/26/06 5:08	wow it is totally stuck
8/2/07 5:43	telescope stuck
4/1/08 5:50	stuck ?

Time	Message
5/14/06 14:22	damned telescope stuck
6/3/06 12:19	scope is stuck?
12/8/06 3:52	uh oh, telescope stuck?
4/17/07 5:12	stuck again!
6/2/07 3:07	telescope just got stuck
7/7/07 10:22	dome always stuck at early time of tonight
2/23/06 8:28	Is the telescope still getting stuck?
6/10/06 5:24	telescope stuck again
12/10/06 3:33	probably telescope stuck
4/6/08 5:47	owwwwwwwww dome stuck

Table 5.4: Chat log excerpts containing examples of *representation*.

This type of phrase holds context-independent pre-existing negative affect among the group members who know the difficulty of having the telescope in this state. It was not uncommon for a reference to the telescope being stuck precipitate a chain of negative affect, or to be a very negative affect-laden expression itself, serving as a representation of the affect that has been transferred to this shared artifact over time.

Evidence of this feature was shown in section 5.3.4 when discussing how Roger was noted to "vilify" the software system. This would suggest that there is not only negative affect "stored" in the reference to the tool, but that it can be invoked and used as a type of shared pointer to past, negatively charged interactions with the system. While the framework is formulated to capture this interplay, this feature in particular calls for additional research to provide a more thorough account of how artifacts are employed in this context, and the unique properties that distinguish them from the human actors in the system. Several specific examples of this feature at work are shown in Chapter 6 in the context of interactions with these artifacts, tools, and shared references to them.

5.5 CONCLUSION

In this chapter, I elaborated five features of distributed affect that form the foundation of the framework my research presents. By discussing the bricolage exemplified by the collection of grounded research activities my collaborators and I engaged in throughout this phase of research, I provided an overview of the "messiness" of the process that led to the emergence and identification of the features and the flexible, highly interpretive approach that it promoted—an aspect of the research process that was invaluable to use as we attempted to bring together our diverse set of data, methods, and perspectives. I also gave clear insight into how each feature is exemplified in the data through both specific, direct excerpts from the logs or other primary data sources, as well as descriptions of some of the initially observed higher-level interactions between the features. The defining of these features and a description of how they can be seen to operate in the data serve to directly address RQ2 and provide the mechanism by which distributed affect can be seen to operate in the text-based medium. The accompanying examples also serve to contextualize the features, and to provide some early insight into their interactions and higher level outcomes that will be presented in the following chapter.

Chapter 6. DISTRIBUTED AFFECT IN CONTEXT

Once we identified and defined the five features of distributed affect that were empirically observable in our data, we turned our attention to the third phase of this research to address RQ3 and gain a better understanding of how the features interact with one another and how these interactions contribute to the dynamics of the SNfactory group as they go about their work. We were particularly interested in instances of creative problem solving, as the previous research we had surveyed suggested that these would help to provide clear insight into the role that distributed affect was playing during such times.

We utilized the previously introduced computer-mediated discourse analysis (CMDA) method (Herring, 2004) as our primary means of qualitative analysis to study affective responses to unforeseen events occurring in our data set, mapping affective interactions over the four years of the collaboration. CMDA is a linguistics-based content analysis method specifically formulated for computer-mediated communication (CMC), and its different levels of language as a means of surfacing aspects of the text that are most relevant to the concept under study that can be used to examine expressions of affect as we have operationalized them. The features are then examined in context to demonstrate their usefulness in accounting for the dynamic affective interaction of the group as they go about their work. Through this analysis, we position our framework as an effective tool for posing and answering future research questions about the operation and importance of affect in distributed teams and the unique ways that the communication of affect occurs in text.

6.1 ACKNOWLEDGMENTS

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6.2 CMDA: LEVELS OF LANGUAGE

Of key importance to this analysis of the features in context, is that CMDA is specifically formulated to apply to the examination of five levels of language in CMC. These levels were particularly relevant in scrutinizing the chat logs for evidence of each of the emergent features of distributed affect. Each of these levels is described below (ranging from smallest to largest unit of analysis) (Herring, 2004) including a brief discussion of how they specifically correspond to our dataset. These levels of language played an integral role in how we went about operationalizing the features of distributed affect in Section 6.3.

1. Structure: Structural phenomena include the use of special typography or orthography, novel word formations, and sentence structure. This level can be found in our own dataset in the use of emoticons, intentionally deformed spellings and punctuation, and in the use of all caps.

2. Meaning: This level includes the meaning of words and utterances. Our data allow for us to make judgments about technical terms, foreign language use, and utterances that

are specific to the technical work being carried out which go beyond usages found in normal conversation.

3. Interaction: The interactional level includes turn-taking, topic development, and other means of negotiating interactive exchanges. Turn taking is clearly demonstrated in the ordering of the messages in the log, and topic development is of importance to us in identifying shifts in the tone of a conversation as well as the focus of participants in addressing their work.

4. Social Behavior: The social level includes linguistic expressions of play, conflict, power, and group membership over multiple exchanges. Given the large number of ever-shifting participants in any given log, there are a variety of social dynamics that we examine in our data. It is also at this level that we would expect to have the most salient discussion of the affect codes which have been applied to a message.

5. Participation Patterns: These patterns are measured by frequency and length of messages posted and responses received in threads or other extended discourse samples. Our logs include information about the speaker and the time a message was sent (timestamp). This allowed us to measure the frequency of participation for each participant in a given log and leverage this information as an additional indicator of other levels.

We operationalized each of the features into well-defined concepts that can be directly observed in the logs in accordance with the five levels of language. Using a phenomenon-based sampling technique (Herring, 2004) a qualitative analysis was carried out informed by relevant discourse phenomena as outlined in the CMDA approach, the previously applied substantive affect codes

from the taxonomy, as well as the specific distributed affect features identified in the logs. The details of how these features were operationalized can be found in the following section.

6.3 CONTEXTUALIZING THE FEATURES

We now build upon our presentation of the features to address RQ3, fleshing out the framework of distributed affect to address relevant factors, how and why they are related, and in which contexts the features apply. In order to empirically identify these features and highlight their interactions in the data, we utilized the previously discussed levels of language highlighted by the CMDA method (structure, meaning, interaction, social behavior, and participation patterns) as a means of operationalizing the features of distributed affect defined and described in the previous section. The levels of language served as a guide for surfacing and structuring the key elements that would best account for the unique ways that the features manifest themselves in this unique text-based medium (Herring, 2004). The specifics of this step in the CMDA process are highlighted here to provide additional context for how these features were then analyzed within the event-driven examples from our data.

Transference is operationalized when:

a) A speaker absorbs and reflects back a newly introduced expression of affect. For instance, transference can be observed as a change in the initial affective expression of a participant (e.g., substance, valence, intensity) as a result of exposure to the affective expression of another participant.

b) An artifact (which may be digital, cultural, or ideational) is imbued with an affective state by a member of the group.

Resonance is operationalized through:

a) Fluctuating intensity (increasing or decreasing) of the lexis including words, punctuation, capitalization, lengthening of vowel sounds, and emoticons; for example: "frustration…frustration!!!... FRUSTRAAATION!?!?".

b) Repetition of affective content and expressions occurring between participants over a given window of time, often resulting in amplification or damping of the other participants' affective expressions.

Pervasiveness is operationalized when:

a) A majority of the participating members of the group are expressing the same affect within a given window of time.

b) A new participant is exposed to the affective state of the group and also begins to express similar affect.

Persistence is operationalized through:

a) The sustained, repeated and pervasive expression of similar affect (e.g., substance, valence, intensity) by one or more members of the group over a given window of time.

Representation is operationalized when:

a) An ideational representation is invoked to express or produce an affective response in the group (e.g., saying, "here we go again" when the telescope is stuck).

6.4 EVENTS AND DYNAMICS

In this section, we look at the five features in the context of the previously identified affect-laden event types based on AET as described in Section 5.3.3.: discovery of a security threat ("Hacked?"), shared system bugs ("No vacation from bugs!"), and shared tool failure ("Stuck again"). Each of these acute events calls forward distributed cognition in how the team members respond intellectually to the situation; here we examine how the group's *affect* is distributed. Through the examination of distributed affect's operationalized features, we demonstrate how they map to real-world interactions between members of the group in the chat logs (for the sake of privacy, pseudonyms have been used below). At times the features display an ordering, as transference and resonance can often occur as processes that precede and influence the pervasiveness and persistence of affect as expressed in the group. These features can also occur in overlapping ways with feedback loops, with one or more features building on another as dynamical systems. In this section we examine how these features emerge and are interacting in the system, and are also contributing to some goal of the group, in three individual event types. Examining the behavior of the affect features and mapping their patterns over periods of time longer than a single event is part of future work on the corpus.

6.4.1 "Hacked?"

In this example of a highly affective event, we observe the features of transference, persistence, pervasiveness, and resonance at play. Table 6.1 provides an excerpt from the chat log under discussion in this section.

The SNfactory scientists implicitly rely on their software and systems to aid them in their highly technical work, and any possible compromise of their integrity or reliability is seen as a potentially

major threat to overcome and prevent. Because the SNfactory system is a high-profile operation, it is a prime target for compromise. The scientists had obvious concerns over this eventuality, and therefore we purposely sampled this type of event, observing a varied series of affective responses in the group as they worked towards a solution.

In the chat log prior to the evidence of the hacker arising, the affective state of the four members of the group currently participating in the chat is *pervasive*: everyone is focused on their work, making simple inquiries about ongoing tasks, and many of the preceding messages (~50) are coded as "no affect". We note that the majority of participants are expressing the same types of affect, specifically "agreement" or "no affect," and that when a new member (Will) joins, he also begins to express similar affect; thus the pervasive mood in the group spreads to the new member. We have observed this pervasiveness of affect in the chat logs, and it also serves to set the stage for the oncoming event.

Phil first notices something may be awry when he notes "very funny history in account ccd" (3:58:28 am), meaning that he has found some unusual activity in one of the logs he is checking which indicates that there was a potentially unauthorized access to an adult website by an outside party that should not have occurred. This information triggers a flurry of questions and information-seeking activity as the group members work to understand the situation.

Time	Name	Message	Affect Codes
03:58:28AM	Phil:	very funny history in account ccd	amusement
03:59:03AM	Simon:	I find it empty	confusion
03:59:15AM	Phil:	which shell do you use?	interest
03:59:16AM	Will:	me too	agreement
03:59:20AM		csh	no affect
03:59:23AM	Phil:	ahhh	surprise
03:59:39AM		bash history had some curls to a porn site	surprise
04:00:00AM	Will:	bad!	disgust, surprise, anger

04:00:08AM	Simon:	hacked?	interest, considering
04:00:13AM	Roger:	whaaaaaaaaaaa	surprise, confusion
04:00:17AM	Phil:	I hope not	apprehension
04:00:22AM	Will:	how old?	interest
04:00:29AM	Phil:	impossible to tell	no affect
04:00:35AM	Simon:	what site ;p	amusement
04:00:37AM	Phil:	it was before I logged in	no affect
04:00:45AM	Simon:	they all say that Phil	amusement
04:00:46AM	Phil:	hahahahaha	amusement

Table 6.1: Chat log excerpt containing possible evidence of a hack.

The other three scientists meet this news with surprise and confusion, and we see a display of this affect when Roger replies with, "whaaaaaaaaa" (4:00:13 am). The *transference* of this negative affect then occurs between all of the other participants in the chat except for one. Although a *pervasive* and *persistent* state of negative affect sets in for the others, Simon actually tries to combat this by damping the building of negative affect (*resonance*) by injecting humor into the situation. He inquires, "what site ;p" (4:00:35 am) with the emoticon representing a winking face with the tongue sticking out indicating a light-hearted joke that he is curious which site was accessed. Although this joke is met initially with laughter (e.g., "hahahahaha") from one of the other scientists, the damping effect of this humor is short lived as the discussion quickly returns to a long series of technical and logistical back-and-forth attempting to get to the bottom of the issue.

We then enter a long stretch of dialogue that is coded with persistently negative valence affect codes (apprehension, confusion, annoyance), and these affective states are *pervasive* across the entire group attempting to solve the problem. Simon intermittently continues to try and damp this negative affect by making further humorous comments and lighthearted jokes that are often accompanied by an appropriate emoticon. Eventually it is indicated by Phil that "it may not be an intruder, just someone with a misguided cut-and paste" (4:23:53 am). This comment is followed up with several more jokes from Simon, and these seem to achieve their desired damping effect and

finally break the *persistent* and *pervasive* negative mood of the group. We then see a shift towards all of the members of the group sending messages that were coded with "amusement" and other positive valence affect codes, signaling a transition to a new state of positive *pervasiveness* which alleviates all of the tension from the preceding half an hour of chat, along with the sense of a resolution to their problem. At this point, Simon suggests that they return to finishing their current telescope scan before conditions for viewing are no longer suitable. The rest of the group agrees that the potential hacker situation will need to be returned to later if it is deemed to be an actual threat, and thanks to Simon's continued damping of the negative affect resonating throughout the group, they are able to return to progress on their primary goal, thus resolving their immediate problem.

This example shows several of the features operating at once, feeding into one another (transference and resonance leading to a pervasive and persistent affective state) or serving to mitigate the effects of one or more features (Simon's humor working to defuse the situation and bring levity back to the group). At no point is any one person specifically setting the overall affective tone for the group, but rather the combined affective contributions and responses of all of the members trigger the group's global dynamic and problem solving. Through this dynamic the affective properties of the entire group assume a level of importance that moves beyond individual interactions highlighting the significance of the distributed nature of the mechanisms we see at the heart of the framework we develop.

6.4.2 "No vacation from bugs!"

This instance from the chat logs exhibits the features of resonance and its damping, and representation at play across the group as they work to solve a problem with a software bug. Table 6.2 provides an excerpt from the chat log under discussion in this section.

Fixing software bugs absorbs SNfactory scientists' time and energy as they impact the group's ability to collect data and effectively monitor the telescope. In this particular event, Roger, one of the core contributors of software code in the group, gets increasingly frustrated and upset as he realizes that no one contacted him the previous evening regarding a system bug. When he is first introduced to the chat he asks playfully, "any buggies?" to which one of the participants replies, "big one" to which Roger replies two seconds later with "shit". Here we see how a bug in the software acts as a *representational* object, having developed negative affective attributes based on previous shared group experiences in finding and fixing them.

There is no need to explain why a bug might be bad for their workflow, as the implications of a "big one" are pre-existing in the group. Roger's negative affect increases and starts to resonate as he goes from confusion about the bug throughout the next hour of the event to increased annoyance and frustration at having not been contacted earlier as he gains more information about it. We see the resonance of this negative affect exemplified by the use of elongated speech patterns such as "Baaaaaaaaaaaaad" (5:07:36), and within one single minute period the use of four frowning faces to indicate his state of displeasure. Roger's negative affect starts to resonate in other participants: Paul, for example, immediately after this strong resonance in Roger, expresses the same type of frowning face, and then in other participants who use these same elongated

speech patterns as they work on their continued efforts at debugging "Grrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr" (6:01:14 pm).

Time	Name	Message	Affect Codes
4:14:16 PM	Roger:	any buggies?	interest
4:14:20 PM	Rita:	big one	apprehension, frustration
4:14:22 PM	Roger:	shit	apprehension, frustration, anger
4:18:42 PM	Rita:	this append twice on standard ...with more than 1 finding chart (first guess)	no affect
4:21:30 PM	Roger:	I am utterly confused	confusion, annoyance
-		-	-
5:06:56 PM	Roger:	Someone not looking at image reconstructions?	interest, annoyance
5:07:23 PM	Patrick	yes Rita ...saw them ...but didn't react ...	apprehension,
5:07:36 PM	Roger:	Baaaaaaaaaaaaaaad Rita	annoyance, anger
5:07:56 PM		Now life is much harder for online guys ... :(	annoyance, frustration, apprehension
5:08:02 PM		We have to try to debug in vacuum	annoyance, frustration
5:08:14 PM		:(:(:(	sadness, frustration
5:08:27 PM	Paul:	:(	sadness, frustration
5:10:28 PM	Roger:	this is so annoying	frustration, annoyance

Table 6.2: Chat log excerpt of participants debugging software.

Once Roger finds the source of the bug ("SHIT there it is") the negative affect is damped, and this damping is reinforced by Patrick, a French scientist, who initiates the shift to positive affect saying "relax … we got a standard today" to which Roger agrees "Yes, relazed (sic) now, because i know the bug!" (6:12:02 pm). Positive affect can now be seen resonating in the system as the members see the solution to their problem. We see the expressions of affect change with the expression of positive smiley emoticons among several group members showing persistence of this new affect state.

6.4.3 "Stuck again."

Here we observe the features of representation, transference and pervasiveness in the chat logs, as seen in the excerpt from Table 6.3 below.

The most common of the type of events we sampled from our dataset is the telescope getting stuck. When this happens the scientists are no longer able to do their work, and face losing important and valuable opportunities for observation; so there is significant pressure to get the telescope working again. Because the scientists operating the telescope are doing so remotely and therefore do not have direct physical access to the telescope, if they are unable to resolve the problem themselves they have to contact another party physically located near the telescope to resolve the problem.

Time	Name	Message	Affect
2:53:30 AM	Roger:	tele unstick failed	no affect
2:53:36 AM		trying again	no affect
2:54:21 AM		looks like gonna fail again	anticipation
2:55:14 AM	Will:	I guess try sending it the other way?	supportive
2:55:39 AM	Roger:	gonna see if I can zslew back -- it tried the "one way then the other"	no affect
2:55:45 AM		but that failed	no affect
2:57:52 AM	Will:	what was the other instrument when you started?	interest
2:58:05 AM		maybe they changed instruments and didn't get the balance right	interest, supportive
2:58:56 AM	Roger:	didn't notice	no affect
2:59:10 AM		but I called summit and Ed was there when it was time for flats	no affect
2:59:15 AM		I see if he is still there...	no affect
2:59:33 AM		calling	no affect
2:59:43 PM	Will:	stuck again	annoyance
3:00:04 PM	Roger:	yes	agreement

Table 6.3: Chat log excerpt of the telescope being stuck.

This particular telescope stuck event begins when Roger notes, "hmmm…telescope is sticky" (2:43:29 am). This news is met with responses that are coded with annoyance, frustration, confusion, and even anger (all negative valence and high intensity) by the three primary

participants in the chat at the time, and by a fourth member who joins later in the log as well. In this case, we see the negative affect not only being transferred between the group, but also being transferred to the telescope itself as a shared artifact which is becoming the focus of this negative affect. As well as transference, we see further evidence of the previously noted frequent occurrence of the telescope being invoked as a representation of negative affect specifically when it is stuck. Throughout this portion of the chat log, there are numerous examples of a reference made to the stuck telescope being followed by utterances coded for negative affect. For instance, after an initial attempt to use the available software-based resources to try and unstick the telescope, Will says, "stuck again" (2:59:43 am) and Roger, Will, and Morris all respond with messages that are coded as negative affect which is directed at the telescope.

Of particular interest in this example are also simultaneous occurrences of messages that were coded as positive, supportive affective expressions that immediately follow these small initial build-ups of negative affect. These bursts of supportive, positively coded messages are, we suggest, acting as negative feedback loops which serve to damp the resonance of the negative affect that pervades the group whenever the telescope being stuck is mentioned and as they work to solve this problem. This dynamic group process is, we posit, a way to maintain affective equilibrium during this highly stressful time, and thus prevent the situation from sliding into an unchecked stream of negativity and counter-productivity. This dynamical loop occurs repeatedly throughout this log as members join or leave the chat.

6.5 Conclusion

We have presented three narratives, from the many in the logs, that show the dynamic interplay of the five features of distributed affect evidenced in the corpus. These examples were identified

based on the sampling techniques noted above, but are by no means exhaustive. Given the size of the corpus, and the guidelines of the CMDA process, we sampled by phenomenon once we had identified a suitable candidate log. This allowed us to show the features at work in several different contexts that are highly relevant to the group, as well as providing specific instances of how the features interact with one another.

The analysis of the above examples shows how group members and representational artifacts act as agents providing affect feedback loops that can support problem solving across the entire group. These feedback processes mirror similar feedback loops researched by Arrow et al. (2000) in a complex systems approach to understanding small group organizations. In the "hacked" example above, Simon's playful quips are eventually able to damp the pervasive negative affect that grows during the discovery of the hack, and push the group back towards a state of equilibrium to continue telescope scans. In the "bug" example, negative affect resonates at a growing frequency as group members work quickly to find the source of a bug, yet the tension is released quickly when the bug is fixed and the problem is solved. In this case, the software bug itself is acting as the representational agent that instigates and damps the pervasiveness of the affective state. Similarly, in the example of the telescope being stuck, the negative affect is damped by negative feedback loops as group members share supportive messages.

As can be seen from these illustrative examples, the global affective state of the group as it is described through the interactions of the five features frequently plays a critical role in maintaining and progressing the problem solving displayed by the group. Russ (1993) has suggested that moderate amounts of negative affect can facilitate this process, whereas negative affect levels that are too high may stifle creativity, resulting in a curvilinear relationship. Observed patterns in the logs further suggest that while the transference and resonance of affect may exist in bursty cycles

based on the impact of outside contextual dynamics (e.g., the discovery of a bug or telescope failure), feedback loops of affect states including humor and support occur in more regular and persistent intervals to help the group more quickly return to a state of equilibrium when problem solving.

These examples also show how affective state is stored and propagated not only in the group members themselves, but also as stored representations and references in artifacts (e.g., the stuck telescope) based on past experiences of the group. There is strong evidence to suggest that not only must the unit of analysis shift beyond the individual when considering affect in this type of distributed, collaborative setting, but also that multiple features, interacting with one another in a dynamic system, must be accounted for. While our framework is clearly formulated to capture this dynamic interplay, additional research is needed to provide a more thorough account of how artifacts are employed in this context, and the unique properties that distinguish them from the human actors in the system.

For this initial inquiry we chose to focus on salient events that act as catalysts for the communication of affect; our goal was to better describe these features of distributed affect and their interactions through an examination of relevant examples from the corpus of chat logs. There is undoubtedly still work to be done to continue to develop and fully describe the specific properties and interplay of the features in order to clarify their operation and identification as unique but interrelated aspects of the same overall framework, and to better situate them within the larger context of potential states of the group. As referenced earlier, it would be useful to examine the role that affect plays during "down" times as well. There may be equally important normative and meaningful instances of distributed affect, for example the important element of trust-building, which are taking place on a less dramatic level during times not accounted for through our method

of sampling. Additionally, our research accounts for only a single chat data set. We intend to extend our study to other text data sets to further test the emerging theory of distributed affect and to examine additional examples from other settings to corroborate our formulation. While we posit that our current framework is well suited to collaborative chat, due to the unique properties of this form of communication, there may be additional features of distributed affect yet to be identified. We intend therefore to expand our analysis to look for such mechanisms that may account for the distribution of affect in other forms of communication beyond text.

While we have focused on selected event types in this qualitative analysis described in Section 5.1, the five features also provide a means to examine longitudinal group patterns in future work and could be applied in a more quantitative manner to also examine patterns occurring over longer time scales than a single event. Additionally, we also propose a more discrete examination of creative outcomes as related to the five features of DA. While previous work has argued for a more complex understanding of affect and creativity that moves beyond simply binning positive and negative affect (De Dreu et al., 2008) we would like to further address how the cyclical states of affect as captured by the features relate to specific areas of creativity such as the fluency, originality, and flexibility of ideas over time.

Chapter 7. CONCLUSION

Affect will continue to be a challenging, but highly rewarding and productive area of study for researchers wishing to gain a better understanding of the crucial role it plays in how humans interact with, and through, our technology. My work encourages researchers and designers to account for and preserve the intrinsically human element of affect through an acknowledgment of the implications it has for shaping the design and use of communication tools—while being mindful of how we adapt or conform our expression of affect to fit those tools. Alongside our evolving understanding of the cognitive, creative, and collaborative elements central to computer-supported cooperative work, it is important to provide researchers with new perspectives and analytic tools for seeking out and analyzing affect in a variety of contexts and data types. In the following sections, I present the contributions this work has made, summarize some of the current challenges, and discuss possible future opportunities for distributed affect.

7.1 Findings and Contributions

In addressing my research questions, this dissertation conceived a framework that uniquely positions affect as being distributed between people, their environments, and their tools as part of a dynamic system. Through an exploration of the research questions posed, three phases of research were carried out using qualitative, grounded methods aimed at describing a novel understanding of affect in the text-based medium. Below, I discuss and reflect on the findings and contributions that have resulted from this work.

7.1.1 The Five Features

The primary contribution of the research I have presented is the introduction of the distributed affect framework consisting of five features: *transference, resonance, pervasiveness, persistence, and representation*. These features present a vocabulary of concepts that are used to frame affect as a distributed phenomenon, offer a unique means of structuring both the identification and analysis of affect in text-based communication, and also provide a novel theoretical lens through which new questions about affect can be formulated. This framework can help to inform and guide inquiries into affect and its distributed nature as it relates to the computer-supported cooperative work and communication systems context that is the focus of this dissertation, but also has clear implications for conceptualizing affect more generally. I also presented an event-driven application of this framework to the examination of a collaborative group communicating via text, that exemplifies its usefulness and appropriateness as an analytic tool for the study of affect in such a context. This application of the framework provided insight into the important role the features and their interactions play in relation to the dynamics of the group, and their contribution to the creative problem solving they displayed.

7.1.2 The Taxonomy

Much of the work carried out to arrive at the five features was supported by the creation of the taxonomy of affect presented in Chapter 4. The work that led to the creation of the taxonomy, as well as the coding that it afforded, both played valuable roles in immersing the researchers in the data, gaining a better understanding of what it represented in terms of affect that informed early concepts about the features. The adapted grounded theory approach that I described, and that was supported in work done by Furniss et al. (2011), may prove useful for others in need of a means to craft a highly-contextualized taxonomy of their own. More importantly, however, I present the

taxonomy itself as a successful translation of a large existing body of work on the study of emotion and on text based communication into a useful analytic lens that can be used by others to directly label affect in their own data.

7.1.3 Theoretical Perspectives

In reflecting on the primary motivating aspects of this work that draw from research on affect, cognition, and text, I have also put forward ideas that may be useful in further opening up discussions concerning how we think about the nature of these core human faculties, both from a theoretical standpoint, and also from their relationship to the technological solutions we design. For example, it was not that long ago that we had specific and widely accepted ideas about the nature of cognition, and were largely quite satisfied with characterizations that delineated the boundary of where cognition took place to be squarely inside the brain (Clark, 2011). And now, we acknowledge that cognition is much better characterized as a dynamic, interactive, temporally and culturally situated phenomenon that extends well beyond the original boundary.

Shifting the unit of analysis to include the physical environment, tools and artifacts, other individuals, and even culture, reveals how these systems may have cognitive properties that cannot be accounted for by solely studying the individual—demonstrating the theoretical potency of this distributed framing. Paralleling this, recent research on emotional contagion, shared affect, and the role of affect in group creativity (e.g. Hancock, 2008; Brennan, 2004; Amabile et al., 2005; Aragon & Williams, 2011) shows an emerging trend towards challenging the historical framing of affect and emotion as a singular, interruptive, internal, and in many ways self-contained phenomenon. With affect, as with cognition, there exist properties that cannot be accounted for until we extend the unit of analysis beyond the individual.

7.1.4 Methodological Reflections

Calling back to earlier discussions of the sociotechnical gap in Chapter 2, recall that the "gap" under discussion was meant to point out a divide between the rich, flexible, and highly contextualized settings of human activity and the technical systems that we design to support them (Ackerman, 2000). I have reflected on the use of grounded theory in this dissertation, and given its highly flexible and extensible nature, its application to my research questions was useful and effective. Additionally, grounded theory has been shown in numerous studies to be well suited to building conceptual frameworks or theories about contextualized, real-world settings that are rich in affective and cognitive interactions. As Charmaz points out, "the potential strength of grounded theory lies in its analytic power to theorize how meanings, actions, and social structures are constructed and enacted" (2004). Much of how GT is framed as a research method is centered around situatedness, participation, observation, actions, interviews, etc. These are a fundamentally "lived in" set of data types that stand in contrast to those "records of discourse" that are commonly utilized by CMDA. The power of CMDA is that it provides a rigorous framework for analyzing discourse in text-based online interactions (which Ackerman points to as an approximation of the social requirements of a technical solution) to study a broad range of language-oriented phenomena. However, Herring makes the important observation that it is some ways limited in that, "we can only directly analyze discourse behavior, and must infer larger social and cognitive formations indirectly" (2004). In fact, CMDA is particularly useful for comparing discourse features with independently established technical, social or psychological phenomena (Herring, 2004), such as those that might be uncovered during the course of a GT study.

In looking forward to potential future work, I argue that these two methods complement one another in further and richer analysis of distributed affect in a research setting by, for instance, first GT to study some situated activity that also has an online component (social requirements), and then using CMDA to understand the relationship of these observed discourse features (via a technical system) to this independently established social phenomenon. This two-pronged approach produces a thoughtful acknowledgment of the "gap" that lies between the two, and especially how the features of distributed affect manifest, operate, and perhaps overlap in each context.

7.2 LIMITATIONS

The five features I have presented are a meaningful step in establishing components and mechanisms of a distributed view of the phenomenon of affect that is clearly grounded in the empirical examination of text-based evidence. In this section, I briefly summarize some key aspects of the current work that are still open to further exploration.

The SNfactory chat log corpus is a longitudinal and interaction-rich data set full of highly collaborative and creative instances of problem solving—and as such was well-positioned to support the research questions I posed. As has been shown throughout the course of this dissertation, the logs have been at the core of the investigative, interpretive, and explanatory aspects of this research. It helped to drive the emergence and characterization of the five features, as well as provided an opportunity for examining the features interacting in the context of the event-driven analysis presented in Chapter 6. However, there is undoubtedly the opportunity and need for the framework to be applied to other, comparable data sets of text-based interaction as a means of evaluating its transferability to other contexts and sources of data. While there has been

much to learn from the application of the distributed affect framework to the SNfactory chat logs, a better understanding of how well it accounts for affective interactions in other, similar data sets would provide additional support for the current formulation of the framework and its features.

Following from that, and as previously noted in Chapter 5, the five features, while representing a thorough accounting of the emergent concepts and patterns found in the SNfactory data, cannot be said to be exhaustive. The previously discussed application of the framework to another data set may be able to highlight affective interactions that were not present in the data utilized for this research—or that were not surfaced due to limitations in the methods used to sample and analyze subsets of the text. The five features have been demonstrated to be an effective tool for the analysis of affect in text, and extension of the framework through the identification of additional features may well increase that effectiveness.

This dissertation has also presented discussions and reflections on the methods that have been employed, and in continuing with that open reflection, I also acknowledge that the methods utilized for the answering of my research questions necessarily constrained how the framework was arrived at and evaluated. The use of these methods, in conjunction with the interpretive analysis they enable, play a part in shaping what questions can be asked and the outcomes of research.

7.3 Future Opportunities

The framework of distributed affect is a means for examining affect as a dynamic and ongoing distributed phenomenon, existing—as distributed cognition does—beyond the unit of any one individual person. The five features represent a first step in outlining the components and mechanisms of a distributed view of the phenomenon of affect, and are grounded in the examination of text-based evidence. Furthermore, the distributed affect framework, as a theoretical

lens, can provide scaffolding and guidance for researchers theorizing about and examining the role of affect in their own research.

Text necessarily excludes many other channels of human communication that are particularly important in relation to affect. Focusing on text reduced the number of variables to be accounted for, and made clear the expressions of affect through a focus on the utterances, their substance, valence, and intensity. But this text-based approach is not without opportunities for extension. A promising opportunity for future work as it relates to the framework itself is to move beyond text-based communication, to examine affect in richer, multi-modal, face-to-face contexts; to be able to say something about the functioning of affect, more generally speaking, as a distributed phenomenon. While this is clearly beyond the scope of the work I have presented, it warrants acknowledgment particularly in the context of the relationship between affect and cognition. The exploration of cognition in highly contextualized, dynamic, and collaborative environments—rich with the full spectrum of human communication and coordination—has proven to be very fruitful for understanding and describing its distributed nature (e.g., Hutchins, 1995, 2006, 2010; Clark, 2011), and how that distribution impacts our interactions structured around the use of technology (e.g., Hollan et al., 2000, Hutchins, 1996; Stahl, 2006, 2011). The framework of distributed affect may be applied to an analysis of real-world interactions, to see what level of transferability the proposed features identified thus far from the medium of text have to the medium of face-to-face communication.

Along this same line, and referring back to the possibility of combining GT and CMDA to the continued study of distributed affect in section 7.1.4, I point to the setting of education as one such possible highly contextualized domain of human interaction. Given that many learning environments encompass both the physical and the virtual, it could provide a rich landscape to

apply or expand the framework. This might, for instance, take the form of contrasting an application of the framework to the analysis of affect through collaborative interaction in both environments; the physical classroom offering data rich in highly multi-modal, face-to face verbal interaction, with the online class setting offering a corpus of text-based communication via discussion boards. Such a study, may be able to provide valuable insight into the commonalities and uniqueness of the role of affect, and could lead to a refinement of the framework that would further increase its usefulness as a research tool.

7.4 Final Conclusion

The kind of computer-supported cooperative work I have examined in this dissertation is increasingly taking place between distributed groups who must rely on tools, such as online chat, that do not allow for the rich, multimodal forms of communication which accompany face-to-face interactions. As noted, affect has been studied in research on computer-based collaborative systems, but the focus is primarily and historically focused on the cognitive properties of the group (Halverson, 2002; Stahl, 2006). My analysis demonstrates the importance of considering affect from a dynamic systems approach that operates at the level of the group rather than solely as a property of the individual, the crucial role that distributed affect plays in how these groups carry out their work, and how that affect is conveyed and propagated in the text-based medium. In much the same way that shifting and reframing cognition beyond the brain-bound model when accounting for cognitive accomplishments broadens the landscape of possibilities when looking for solutions to the "problem" of understanding high-level, complex human interactions, here I present another step along the way towards doing the same for affect.

This framework of distributed affect can serve as a theoretical lens to provide scaffolding and guidance for researchers wishing to examine the role of affect in their own similar data. At the core of this contribution are the five features and how I have defined and operationalized them within the specific textual phenomena that are of primary importance when analyzing the expression of affect in this context. I have provided a means for related research to move beyond the analysis of affect as being a phenomenon that is necessarily tied to the individual, and have put forward a framework that can highlight affective properties and dynamics at the group level. Ultimately, this framework provides a tool that I hope will be helpful to researchers in articulating questions about affect in their own investigations in a more robust, dynamic, and human-centered way than might otherwise be possible.

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APPENDIX A – DIGEST WRITING INSTRUCTIONS

Introduction

After a thorough discussion with Katie and then following up with the rest of the group at Friday's meeting, we have agreed on a process for writing what I am going to start calling a "Digest" for each of the logs that we analyze. The reasoning and process for digests is outlined below, along with examples and relevant links. Please let me know if you have any questions.

What is a digest?

For us, a **digest** is an abstraction of the relevant information contained in a given log, with each consecutive portion of the digest representing a further abstraction of the data in the original log. I have chosen the term 'digest' based on the following definition: *to organize into a systematic arrangement, usually by summarizing or classifying*

Treating the chat log as a high-fidelity recording of what transpired during any given shift, we "replay" the events and view that recording as we do a line-by-line reading of the log. From our viewing of this recording, we write 'field notes' in the form of an episodic **summary** with time-stamps taken directly from the logs. Also include Reader Comments (RC) which are semi-analytic asides that provide the opportunity to note insights that are not purely factual. For instance, in the summary would not say "Ray was angry" Instead, make factual statements about the language and content that Ray sent in his messages, the rate at which he sent messages, any affect codes associated with the messages, etc. However, you should add an RC which notes that Ray seemed very agitated and a brief explanation as to why you think this is.

Based on these field notes, you should produce a **memo** of several paragraphs that include causal claims about what is captured in the summary and attempts to build relationships. In contrast to the field notes, this writeup takes an analytical perspective to reason about the phenomena of affect and events.

A holistic reading and discussion of these memos produces the theory/findings that will be written up in the final paper.

Why are we creating digests?

The basic premise here is that the better job we can do of abstracting the relevant content of a log for our qualitative analysis, while still having a very systematic and thorough means of tracing our path back to the original log, the better off we will be! This will make our lives much easier in the long run by putting in a little extra effort now. If, for instance, we come up with a very interesting hypothesis from reading several of the memos, we can then compare and contrast specific instances from the summaries, and then even go back to the original logs quite easily to look for additional data. At each level of abstraction, a different type of analysis is afforded, each with its own unique level of granularity and focus. Not only that, but we will also be building up a wealth of higher-order data in the form of these digests that can aid in future analysis of this extremely large and rich data set made up of all of the raw chat logs.

What comprises a typical digest?

The digest will consist of a pointer to the log, a summary of the log (with time-stamps and reader comments), and a memo about the log. The digest might also include a visual summary of the log (if we can find an appropriate visualization), as well as any corresponding hypotheses that were derived by the reader from the writing of the digest.

The progression goes like this - note that those items in parentheses constitute a digest: (Log ----> Summary ----> Memo) ----> Theory/Paper**Where can I find an example of a digest?**

I have uploaded both an example digest as well as a digest template to the dropbox. You can find them by navigating to: ETC Dev ---> Events + Affect ----> Qualitative Digests ----> Template.

PLEASE use this template for all of your digests!

Where do I find a log to create a digest for?

We have an Events Spreadsheet that contains logs suggested for events coding. Please add your name beside the log that you are going to/have create(d) a digest for in Column E.

Again, I also recommend that if you are going to code, you might as well use one of these legs and fill in the appropriate information for the log you are coding. Note: This

spreadsheet needs to be updated, but it will suit our purposes for now.

Here is a link to the spreadsheet: -LINK REDACTED-

What tool should I use to view the log when drafting a digest?

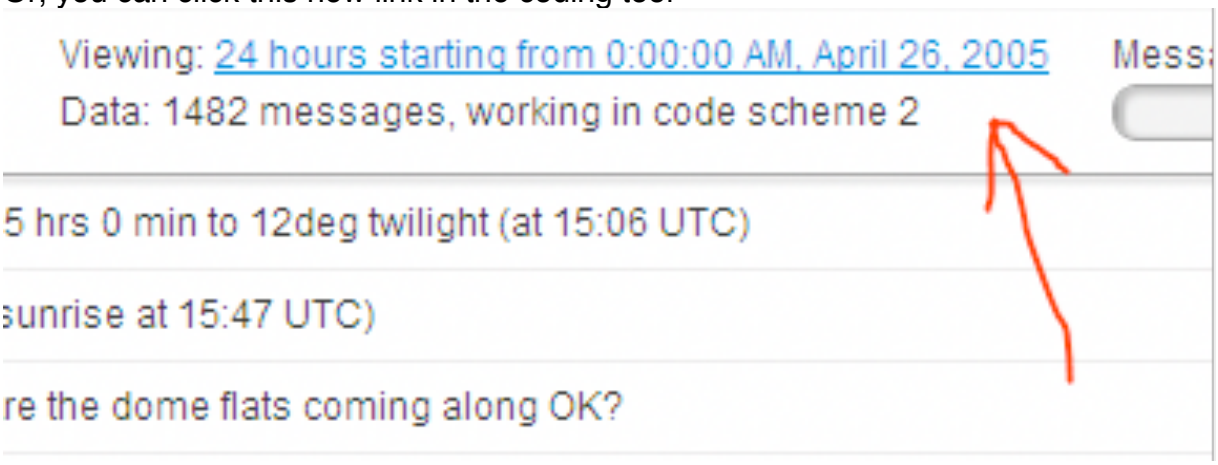
Thanks to Michael, we have a spiffy new tool for this! From Michael:

I have finished putting a new message viewer for Text Prizm online. It shows all of the codes anyone has applied, and loads messages as needed for speed (or all at once, via a button). You can also click on codes to highlight them. Let me know if you have any issues/questions!

The messages viewer can view messages by session (log) id or date like this:

-LINK REDACTED-

Or, you can click this new link in the coding tool



What should I do after I have completed a digest?

Please upload your completed digests to the dropbox folder by navigating to: ETC Dev ---> Events + Affect ----> Qualitative Digests ----> Finished Digests. Please also ensure that you have updated the Events Spreadsheet.

APPENDIX B – EXAMPLE DIGEST

Digest Written By: Reader 1
Date: DD/MM/YYYY

Link to Log: -LINK REDACTED-

Total message Count: 862

Relevant Event Types (if applicable): Software bugs

Summary

06:52:23 AM:
Roger begins this log by clarifying that "the mod to the fcharts should have no effect on acquire or match_fchart." Greg thanks Roger for the clarification. Roger responds by elaborating about his "check" added in register_fchart isn't really checking what he wanted it to check. Greg responds by articulating a problem that he himself is having: "(For some reason I don't hear iChatter voices anymore)." Roger immediately responds by letting Greg know that "it is Rossy to know if the HDU is malformed" and then proceeds to help Greg troubleshoot his problem for the next few minutes but then Roger stops helping when his solution does not work (6:54:21).

RC: It is interesting that Greg offers up a problem he is having to Roger after Roger starts to clarify some issues that he may be having. It's like this creates a natural transition/space for problem solving.

06:54:53 AM:
Simon comes into the chat to let everyone know he is signing off. This prompts Greg to reply that he replied to Simon's feedback. Greg and Roger then discuss charts and they both agree that the charts "will be fine." They then discuss the way the moon is impacting their work and then Roger states that his cell phone doesn't work in "Forestville." Then they immediately transition into a discussion about Roger's local area—the nice weather, geographical properties (river), and drives that one could take if visiting. Greg seems to become interested in what Roger is saying about his area (coded interest by two coders) and then Roger says that his area is more scenic than Oakland.

07:03:12 AM:
Daniel pops into the chat and says that he is going to go shooting after his meeting. Greg advises Daniel to not end up in jail. Roger becomes interested in Daniel's location, which he thinks is Uganda. Greg states "some people don't like to be shot" and then says that "Bender can be shot without harm in his very next statement.

07:10:58 AM:
Roger tells the group that Simon has been trained to scan and that he/she has scanned ~15 and states that Brian has completed 94000 scans. Roger states that he's only done 7800 in comparison. Greg says that Roger/they'd better get Brian a prize.

07:12:46 AM
Daniel jumps into the conversation to answer a question that Roger asked earlier about his location. Then Daniel proceeds to discuss his travel plans, stating that he's in Nairobi now but that he'll be in Montreal in a few weeks. Greg chimes in to tell Daniel that Roger is in Forestville. Daniel states that he's never been there and Roger describes it as "Waimea only not as humid." Daniel says that it sounds like a nice place. Roger responds that it is a quiet place—"Heard an owl earlier." Roger signs off and offers his phone number to the chat log.

07:56:34 AM
Ross joins the chat and immediately states "this doesn't look good." Daniel responds that "He's saying that because I'm here, isn't he?" Ross clarifies that the aic crashed in the middle of the day shift. Greg jumps into the conversation and offers to "play with Director." Daniel states that it's a good thing it didn't crash while anything important was happening with a ':)' Ross asks Greg if he's trying to debug the problem and if he knows what's going on with the problem. Greg comes up with what he refers to as a temporary solution ("for now") and shows Ross how to fix the problem. Ross becomes concerned that he won't be able to prepare for his work: "the question is whether it'll have enough time to complete the calibration before we're on for tonight." Greg seems to offer assurance to Ross, but Ross responds "all right, well we can hope." Greg signs off.

04:05:15 PM
Rita states something that was coded as being apprehensive by two coders: "so we end in error due to the 2 min spent on the arc …" Rita then articulates that it's a "logic of the tcs" and "the fact that we check twice if the slew is right …." and "you cannot clearly do the second check." This information occurs over 5 uninterrupted messages in a row from 4:05:44-04:06:25 or in 41 seconds. The average rate of messages for these 5 uninterrupted messages from Rita is one message every 8.2 seconds. Rita then asks if Roger will be working on that day. Brian states that Roger will not be working that day.

04:12:36 PM (Bug event continues until the end of the log at 5:32:02 PM)
Rita states "this is stupid" and Brian considers his statement "hmm." This response was coded as considering by two coders. Brian responds to another comment shortly after

again with “hmmm.” Again, this is coded as considering by two coders. Then Roger joins the chat and asks if there are “any buggies” to which Rita responds “big one.” Roger immediately responds “shit” then Rita responds “or small one.” Roger responds “mine?” to which Rita responds “big one then.” Rita then reveals that he’s not really Rita—he’s actually Patrick. The next three lines get coded with amusement by two coders. The “Rita” tells Roger where to look to find out more about the bug. At first, Roger does not see the bug and gathers more information from Patrick.

04:47:25
Patrick and Roger continue to troubleshoot the bug and Patrick is coded by two coders as being frustrated: “the number claim by acquire is stupid.” Two coders code Roger’s response as agreement: “Yes it is supid.” As they troubleshoot Roger continues to express his confusion: “This is confusing.”

04:51:42
In the midst of Roger and Patrick trouble shooting a bug, Brian comes into the discussion to ask for help: “who knows how to copy over the subs so that we can scan?” Ross jumps in to offer help: “I can do that.” Patrick states that he is talking to his mother and that she’s not happy, so he’ll have to go soon.

05:02:41
Roger appears to discover a problem with the code he is looking at “Did I see a bunch of = vs == in there???” His next two lines are in all caps: “WHAT” and then “WHO DID THAT” to which Patrick responds “I did.” Patrick tells Roger that the code is correct.

05:05:49
Roger expresses that he was not called so there is no way to test if the == vs = is the source of the bug. At 05:06:49 he repeat that if someone had called him “we could have debugged.” He then immediately states “WHY?” in the chat in 1 second after the last. Patrick then tells Roger that Rita saw the image reconstructions but did not react. Roger responds “Baaaaaaaaaaaaaaad Rita” (05:07:36).

05:10:28
Roger becomes annoyed “this is so annoying” (coded by two coders as annoyed). Patrick’s immediate response was coded by two coders as apprehension: “But it sound I’m wrong.”

05:27:22
Roger again repeats that “since NOBODY called me we can’t do full test.”

Memo

This log begins with some banter between members and demonstrates some of the techniques that distributed members use to maintain social cohesion. For example, one

common theme through the first half of this log is the chat participants discussing or telling each other about their geographical location. The second half of the log consists of Roger and Patrick trying to debug a problem. Three times Roger insists that the bug is difficult to solve because nobody called him when the bug first occurred. Patrick and Roger determine that Rita was in the best position to discover the bug, but failed to do so. What we see during the debugging process is a good deal of expressed (coded) confusion and annoyance (coded). These expressions of text seem to be followed by coded expressions of agreement, apprehension, and considering. It is very possible that we can see this (along with other more 'supportive' codes) throughout the data set, depending on the type of event in which the confusion/frustration/annoyance affect takes place.

Visualization

(FORTHCOMING – TBD)

Hypothesis

H1: Discussion about the geographic locations in which the scientists currently reside is extremely important for the social cohesion of the group.

H2: When a scientist gets frustrated, confused, or annoyed in response to some problem event as expressed in the chat room, the other participants in the chat room become more considerate, apprehensive, and agreeable, as evidenced by their responses to the frustrated person being coded as such.

Additional Notes

Perhaps we should be picking out the events from the log (in this log the bug event occurs from 04:12:36 PM and continues until the end of the log at 5:32:02 PM. It would be much easier for people to write more digests this way, and possibly also go through and code these events for affect.

VITA

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