Emotions in the Social Aspects of Human-Computer Interaction

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Modern humans interact with a variety of electronic devices to accomplish tasks, entertain themselves and to communicate with others. Traditionally this interaction has been conceived of as being the interaction between a user and a tool (McCarthy and Wright 2005). There is no emotional value in that interaction, it is not social. The interaction is merely functional. The problem with that approach is that humans do express emotions toward computers, smart phones and other computational devices. Some of the concepts involved in the computer science sub-field of human-computer interaction describe these interactions as social and refer to computers as social actors (Nass 1994; Andre 2013). If computers are to be treated social actors, then emotions must be considered in evaluation of the interactions in which they take part. Despite the anthropomorphist properties that some in the computer science discipline apply to computers, computers, including artificial intelligences, do not experience feelings. Therefore, the concept of emotions in human-computer interaction must be considered through different frameworks and from the perspective of the human actors involved. Humans develop social relationships with their technology (Nass 1994). Like any relationship involving humans, the quality of the relationship is impacted by the emotional exchanges involved. Emotion is an important component of human-computer interaction because of the amount of time that humans spend with their devices and because the capability to interact successfully with other humans depends upon strong social and emotional skills.

In this paper, I argue that computers can be actors in an emotional exchange, but that computer actors act primarily as proxies for their programmer’s emotional capability and as sites of reflected emotional assessment for their users. I will describe relevant components of affect control theory as they apply to this paper, then I will review the existing literature concerning emotions in human-computer interaction from both the technical and social disciplines. The literature will be separated into categories of user emotion, which primarily explains how users develop emotional relationships with technology, and emotion recognition, which explains how technical systems recognize and process human emotion. Finally, I will discuss the implications of the literature on the future of emotions in human-computer interaction.

For the purposes of this paper the term “computer” shall be used to mean any electronic computational device, which has a user interface. This definition includes personal computers, tablets, smart phones and public service kiosks. Artificial intelligence interfaces are also included in this definition; however, in the future it may be necessary to consider artificial intelligence as a separate category of social actor due to advancements in the capability of neural networks to emulate human cognition. Nass and Moon (2000) point out that in the future the ubiquity of computer technology will result in the need for computers to be more narrowly classified by their characteristics for the category to be useful in theory development.

The terms “human actor” and “user” are interchangeable, with the former indicating a human that engages in social activity and the later indicating a human that is engaged in interaction with a computer, in a social or a functional way.

“Developer” and “programmer” are related terms that refer to humans who create software or design computer hardware systems. The role of the developer is to design the system and oversee the governing principles of the system. Developers, usually in the form of a collective of humans, decide how a system should look and the general way that interaction with the system should occur. Programmers typically are responsible for writing code and making specific decisions about how the directives of the developers are to be given form in the system.

EMOTION

Emotion is a much-debated concept across sociology. There are many approaches to emotion inside the discipline, including evolutionary, symbolic interactionist, exchange and power and status (Turner 2009). Most sociological theories of emotion are directed at human-to-human experiences of emotion. For example, Peggy Thoits (1989) states that emotion must include “changes in physiological or bodily sensations.” This excludes social actors that do not have physical embodiment or situations where emotion must be projected upon a subject. As Jonathan Turner (2009) observed, “emotions operate at many different levels of reality.” While evolutionary or biological approaches do not currently apply to most aspects of emotion in human-computer interaction, the symbolic interactionist approach does. Humans are the origin of social emotional concepts and therefore are responsible for applying emotions to human-computer interaction situations. Biological and evolutionary theories can be used to explain how humans formed the emotional concepts that are applied in these situations, but to invoke emotion into an interaction with a machine requires a level of anthropomorphism. This anthropomorphism occurs through the creation of symbols and interpreting computer interaction as a social ritual. The user enacts the ritual through acts or speech that invokes the computer as a social actor that is receiving emotion. The developer enacts the ritual through designing the system based on how they want the system to be perceived by the user.

This paper will primarily utilize the affect control definition of emotion as described by Robinson et al (2006), but will also rely on the functional descriptions of emotion work by Arlie Hochschild (1979; 1983). Emotion, as it relates to affect control theory, is the label and cultural meaning attached to feelings that occur in relation to an interaction (Robinson, Smith-Lovin, and Wisecup 2006). Affect control theory also describes associated phenomena such as affect, sentiment and mood, which will be described in detail later. Emotion management is performed through feeling rules in each culture. These rules work to maintain meanings at a cultural level, often through institutions (Hochschild 1983). Emotion work is the occupational extension of cultural meaning making, requiring the worker to manage their own feelings or the feelings of others in an effort to preserve cultural meanings and the existing social structures (Hochschild 1979).

AFFECT CONTROL THEORY

This paper will utilize affect control theory as a theoretical perspective to address the functioning of emotions between human and computer actors. Affect control theory was designed to explain behavior in social situations (Robinson, Smith-Lovin, and Wisecup 2006). Affect control theory is rooted in symbolic interaction. Mead's symbolic interaction concept involves meaning making in social situations based on the interaction between the concepts of the *I* and the *me*. The *I* possesses situational agency and impulses to action. The *me* element is responsible for symbol interpretation and for projecting potential reactions and assessments of others. Affect control theory differs from Mead's symbolic interaction in the type of meaning that is expected to have control of a situation. Symbolic interaction was heavily influenced by cognitive meaning making from social symbols. Affect control theory is focused on the affective meaning of symbols. From the affect control theory perspective emotions are cultural labels that are assigned to feelings that are experienced after or anticipation of an event or interaction (Robinson, Smith-Lovin, and Wisecup 2006).

Affect control theory utilizes a measurement scale as a mechanism for empirically testing symbolic concepts. The measurement scale represents labels (such as emotions), roles (such as identities, occupations and classes) and other symbols on the dimensions of evaluation, potency and activity (EPA). The ratings are established for different lexical items by surveying multiple people from a population about their judgements on those attributes about each lexical item (Heise 2002). EPA measurements can be used to predict outcomes to interactional situations using mathematical models. EPA values are relatively consistent across a culture and mostly stable over time (Hoey, Schröder, and Alhothali 2016). In practice and in theory the EPA scale is one of the most useful components of affect control theory and could be used as a concept to govern the operation of an artificial intelligence (Hoey, Schröder, and Alhothali 2016).

Affect control theory is particular applicable to human-computer interaction over other theories utilizing the symbolic interaction metatheory because it allows all actors to be considered based on their label. Identity theory (previously identity control theory) shares many of the same mechanisms but does not allow for varied assessment of the execution of a role in the same way, due to reliance upon an internal identity validation compared to generalizable affective sentiments (Hoey, Schröder, and Alhothali 2016). The use of general affective sentiments allows for applying specific attention to the way in which affect is involved in all social interaction, which predicts emotional outcomes, and is more easily applied to situations of social agents that have a limited understanding of context.

COMPUTERS AS SOCIAL ACTORS

Clifford Nass (1994) argues that computers are social actors and as such are able to engage in the same types of social exchanges as human actors. Nass studied the interaction between humans and computers using an experimental setting in a computer lab. Nass found that the interaction was fundamentally social regardless of the of the computer having a face, personality or other attributes of a “rich human expression” (Nass 1994). Nass (1994) also claims that the use of first-person pronouns is not necessary for a social reaction, nor does the human actor perceive the interaction with the computer as a medium for interaction with the programmer.

Alan Turing (1950) proposed that in simple exchanges a computer could easily replace a human in what he referred to as “the imitation game”. Turing stated that the objective in machine interaction should not be for the machine to imitate human behavior, but rather to provide answers (behaviors) that would “naturally be given by man” (Turing 1950). In Hochschild’s (1979) terms, a computer does not have to experience emotions, but rather it must surface act in a way that is consistent with display rules. Warwick (2005) supports Turing’s assessment that the ability to actually reproduce a genuine human experience is less important than a computer’s ability to effectively pass as human. Turing’s (1950) imitation game was originally designed as a way to answer the question “Can machines think?”, but the question could easily be replaced with “Can machines feel?” and have the same outcome. For over 60 years the question of “can machines think?” has resided in the purview of cognitive philosophers and there has so far not been a decisive answer or even an agreed upon criteria for what would be required to identify machine-thought (Warwick 2005).

Nass and Turing discuss similar concepts with regard to the capability of a computer to interact in a social exchange, but they provide important insights into different components of social interaction. Nass provides evidence that in human-computer interaction it is possible for computers to be recipients of social responses. Turing on the other hand provides a framework which allows for computers to be reciprocal partners in social exchanges. Neither Nass nor Turing address the function of emotions in human-computer interaction, but due to the essential nature of emotion to social interaction the impact to the interaction can be inferred. Turing’s suggestion that the machine should supply a response that would be given by a human would require at least a minimum token of emotional performance. Similarly, in Nass' experiments some form of affective reaction, even if not a named emotion, would be present in the social exchange.

ROLE OF COMPUTERS IN SOCIAL INTERACTION

Current literature in sociology of emotion does not describe or explain the occurrence of humans expressing emotions toward computers and most existing literature assumes that only humans can be involved in emotional exchanges. To introduce human-computer interaction to the emotion literature requires establishing what role computers perform in social interactions. There are many options for the roles that can be performed by computers. This is due to the variety of ways that computers can be inserted into social situations and because of the structure of existing theoretical approaches to emotion.

The clearest role that a computer can take in a social interaction is that of a mediator. Mediation is a relatively passive role as it only involves being the medium through which other actors communicate. In terms of emotion, the mediator is often a barrier to emotional communication and may force the actors involved to change modes of emotional expression to ensure effective communication (Garcia et al. 2009). An example of this would be using a smart phone for text messaging. The device mediates communication and forces a change of mode over a face-to-face or voice conversation, but is almost invisible to the actors involved. A somewhat unexpected consequence of this change of mode is that the new mode encourages emotion to be converted from human analog emotion signals to digital emotion signals that can be classified by an electronic system. In the example of text messaging, emoticons are used as symbols to indicate emotions. This mediation encourages human actors to communicate emotions using a graphical lexicon (Malin 2014). Combined with the context of the conversation the emoticons take on meanings that could be utilized by a device to interpret the emotional state of the actors.

Another passive social role is that of the anthropomorphic symbol. In this role the computer does not act, but is acted upon linguistically by human actors. In this role the human actor may talk to a computer (that is not configured for voice input) or otherwise engage with it as if it were a human regardless of its capability to interpret or respond to said gestures. The human actor does not expect a response and consciously acknowledges that the computer is not able to interpret the gestures, but yet acts anyway. Perhaps this is a convenience linguistically to allow the human actor to produce emotional expressions of feelings about the situation (Gong 2008). Beyond the simple anthropomorphic symbol role is a role in which the user develops a deep emotional investment in the anthropomorphic representation of the computer actor. In this particular role the human actor may show loyalty to a specific device over another in ways that cannot be explained by an argument of consistency (Sundar 2004).

The most advanced role currently possible is that of the emotionally interactive exchange partner in which the human actor and the computer actor both perform emotional states in reaction to each other (Nahl 2007). In this role if a human actor expresses sadness, then the computer actor should respond with sympathy. These roles are not exhaustive of all of the possibilities, but are major categories in which most types of emotional interactions with computer actors should be able to be classified.

USER EMOTION

Users become dependent on their devices as tools, resources and companions (Sundar 2004). Computer science scholars most commonly use the term “human-computer interaction” to describe exchanges between human actors and computers. Sundar (2004) considers whether the concept of “human-computer relationships” would be a more effective concept as it leaves open the possibility of emotional interaction rather than a purely functional interaction. Emotional engagement with technology began with the application of anthropomorphic properties from users toward their devices (Gong 2008). That engagement has been enhanced and continued by software developers who choose to engage the emotions of the user as a method of improving the computing experience (Lottridge 2009). Human computer users experience emotions toward computers that they would not toward other types of tools (Nass and Moon 2000). The difference between emotions toward computers and other tools is not well understood. One possible difference is the overall complexity of a computer compared to other tools, including the perception of their use of language and ability to interact with a user through shared meanings. In terms of affect control theory computers are seen as more active and more potent. In a sense, computers are assigned an agential role compared to the passivity of other objects that require being acted upon (Gong 2008).

Sundar (2004) explored the concept of computer loyalty among computer lab users as a function of the sociality attached to human-computer interactions. Sundar observed that the existing literature in computer science well documents short-term socialness, but neglected to observe any long-term relationships or absence thereof. Sundar’s study was conducted in two phases. The first phase was a simple analysis of computer usage patterns, matching logged in user names to computer addresses to look for patterns in computer selection to confirm the base hypothesis that loyalty, either “consistency loyalty” or “hardcore loyalty”, existed. It was found that in general users tended to always use the same computer if it were available and for some users if their preferred computer was unavailable they would have shorter computing sessions than the average for their preferred computer. In the study there were 871 computers available for 42,845 users, on average each user logged in to 4.6 computers. The second phase of the study involved administering an exit questionnaire to a random sampling of lab users after they had completed their computing session. The survey asked questions related to traits of anthropomorphism and traits of consistency in an attempt to determine motivations for selecting to use the same computer with each lab visit. The study found that only one third of the computer users had a strong preference for consistency, but that two thirds demonstrated agreement with anthropomorphic concepts toward computers (Sundar 2004). The studies described do not speak toward a specific emotional interaction between users and computers, but do describe preferences and sentiments that the computer users studied hold. Due to the study being conducted in shared computer labs instead of on privately owned devices it is more reflective of the type of associations that are held in human relationships. Confirmation of loyalty through anthropomorphism implies a positive affective relationship, although the study was too limited in its depth to draw specific conclusions as to what those affective responses may be or if there are aspects of the computer interaction experience that influences the choice of a the same computer for each session.

Nass and Moon (2000) found contrary information regarding anthropomorphism in their research compared to Sundar's (2004) findings. Each research team used a different method of inquiring about a user's interpretation of anthropomorphism. Nass and Moon (2000) asked questions that were obvious probes into anthropomorphic properties such as "should computers be treated the same as humans when completing a task?" Sundar (2004) on the other hand asked users to provide a level of agreement with less-direct statements such as "I would be less impatient if a slow-loading computer apologized for the amount of time it was taking" and "I would be glad if a computer praised my job." Nass and Moon's direct questioning asks the user to consider a conceptual idea with regard to the treatment of computers which requires the users to address the computer in terms of a particular identity, in this case the general label "computer" which is attached to a cultural definition. If the users have a cultural definition of "computer" that says computers are inanimate and of a lesser class than humans, then the non-anthropomorphic response would be expected because it maintains the cultural meaning of the label. Sundar on the other asks users to evaluate statements based on specific interactions with a computer. The statements inquire about personal preference in those situations rather than raise a challenge to a cultural label. Sundar's statements ask about the same cultural label as Nass and Moon, but provides situational context that modifies the label. Nass and Moon (2000) discuss users' treatment of computers as social actors as "mindless behavior." Users who do not consciously engage with the idea that they are interacting with a computer are likely to interact with the computer in a social way or in ways consistent with social rules (Nass and Moon 2000). Despite the previously mentioned finding of conscious acceptance of computers as anthropomorphic agents, demonstrated behavior in experimental settings shows that users do interact with computers as social actors utilizing emotional responses and other human social rules. Users express politeness toward computers, even when the computer is not programmed to give particularly social responses to interaction (Nass, Moon, and Carney 1999). In studies where computers provided seemingly intimate disclosure, such as about their capabilities and the lack of utilization of those resources by users, users receiving the information would often respond with emotion words and reciprocal disclosure (Nass and Moon 2000). In addition to enacting social rules toward computers, users also expect that computers meet basic social rules. In usability studies conducted with Microsoft's Clippy, an anthropomorphic paperclip personal assistant attached to versions of Microsoft Word before 2007, users were asked to describe their interactions with him. Clippy was a minimalist artificial intelligence that was designed with only a basic personality and was activated by specific user actions such as typing “Dear” at the beginning of a document. Clippy would offer advice and critique while the user was working on a task, but was not advanced enough to learn about user preferences or even ask the user their name. Many users reported interpreting Clippy as rude or mean. Some users expressed outward hatred after interactions with Clippy (Nass 2010). Users’ technical expectations were not met due to the lack of sophistication of Clippy, but more importantly, the users’ social expectations were not met.

Gong (2008) conducted a study to determine to what level a computer having anthropomorphic properties influences a user’s willingness to interact socially with it. As discussed previously, Nass (1994) found that anthropomorphic properties are not a necessity for computers to be considered social actors or to elicit a social response from users. Gong’s study extends on Nass’ work to determine if anthropomorphism can be used to enhance the social interaction between users and computers. Gong begins with two assumptions that are to be tested. The first assumption is that if a computer represents itself as being more human-like, then users will respond more socially to it. The second assumption is that users being more social with computers will increase the effectiveness of human-computer interaction. To test the assumptions users were presented with a series of interactive scenarios where they were presented with five different faces representing the computer asking questions or providing instructions. The faces varied in the degree to which they resembled a human face. The faces were shown in a random order and associated with different sets of dialog for each user to minimize the impact of order based or content based bias in the experiment. The experiment confirmed that users talked out loud more frequently when interacting with faces that were the most anatomically complete. The study also found that users were more likely to agree with the judgements made by the computer when it was represented by the highly anthropomorphic faces. All of the anthropomorphic faces, regardless of complexity, received more social interaction from users than a text-only interface, with the exception of the face with the lowest anthropomorphic quality, which was described by some users during debriefing as "intimidating". Users were also found to interact more effectively with the computer if it had a more anthropomorphic face as users were more likely to take advantage of functions to get more information from the computer. The author states that this is a somewhat limited analysis for answering the second assumption about improved efficiency because of increased social interaction. During a post-study survey it was found that users identified with the more anthropomorphic faces and described them in terms of warmth, friendliness and sociability. Faces that users described as seeming warm, friendly or sociable received a higher rate of social interaction (Gong 2008). Gong's findings indicate that characteristics of warmth and friendliness are important to encouraging social interaction with computers. This could be an indication that the symbolic interpretation of those characteristics is more important to the situation than a genuine cognition driving the traits that triggered those perceptions.

Users do not approach computers with an identity of being only a user. Often human actors interact with computers as tools to effectively enact other identities, such as an occupational identity. It is therefore the emotions, expectations and meanings carried in that identity that interacts with the computer, not a computer-specific identity (Nass and Moon 2000). If a user has a personal appraisal of being a good writer, but their word processing application begins to highlight phrases to indicate they are not grammatically correct or have spelling mistakes the user may begin to experience deflections between their personal assessment and the way they perceive the computer is assessing them. The highlighting may be due to limitations in the word processor's capability to interpret language constructs, excessively strict parameters for language or by the writer making an error. The cause of the assessment from the word processor is not entirely relevant to the impact that it has on the user's perception of the situation. The strength of the deflection is based in the meaning that the user, through socialization, has assigned to the word processor. If the word processor were viewed as an exchange partner with low status, then deflection would be minimal. If the word processor were viewed as an expression or gatekeeper of cultural norms for writing, then the deflection would be somewhat greater. In either case, due to the programmatic nature of such assessments the user is encouraged to conform to the expectations of the program. This is a different interaction than getting feedback on writing from a peer or even someone with an elevated status (an advisor perhaps) as evaluations from other human partners tend to be fleeting over time and are easily incorporated or discarded (Heise 2002). A computer's feedback is usually persistent and must be actively dismissed or suppressed (Nass and Moon 2000).

Much of the current literature regarding emotion in human-computer interaction is focused on the perceptions of the computer as a social actor. The literature accepts the idea that computers are social actors and that users have and express emotions toward interactions with computers. In the twenty years since Clifford Nass (1994) originally proposed the idea that computers are actors in social settings there have been several lines of inquiry opened to explore a variety of theoretical mechanisms that could possibly explain this phenomena. Simplistic anthropomorphic theories expect emotions to exist because of subtle human-like qualities (like language) that computers exhibit (Sundar 2004). More robust theories invoke computers as holders of social meaning with which users identify (Hoey, Schröder, and Alhothali 2016).

EMOTION RECOGNITION

An element of human-computer interaction that makes an analysis of emotion with regard to computers particularly useful is the development of emotional recognition capabilities in computer interfaces. If a computer can recognize when a user is becoming frustrated, agitated or angry, then it can react accordingly to provide assistance or otherwise engage the user to return to a mundane state. Much of emotion recognition is rooted in physiological metrics of emotion such as tone of voice, relative pressure used in a physical interaction, facial cues or changes in metabolic properties such as blood pressure (Cowie et al. 2001; Andre 2013). Despite the use of physiological cues used in recognition, physiology is only minimally important in the analysis of emotion work in human-computer interaction because the cues have no meaning to a computer outside of their raw data value. The physiological data must be evaluated against standards for expected emotional states and then assigned an appropriate label before action can be taken (McCarthy and Wright 2005).

Transmissions to a computer by a user in an interaction event carry two primary types of content. The most obvious type of content is the explicit message, which may contain information about a specific topic, whereas the second type is implicit information about the user. In this implicit information, sometimes referred to as interactional metadata, is contained cues for user emotion (Cowie et al. 2001). Speech recognition has been perfected to the degree that it is possible to transcribe human speech with great accuracy, but if only the content is interpreted the meaning is lost (Dinsmore and Moehle 1990). Humans depend on both components of the transmission to create emotional understanding of an interaction. If computers are to evaluate a user’s emotional state to react to it, then the same type of mechanisms will need to exist in an emotion recognition system. As with human interpreters of emotion, computers can be inhibited from reading emotion due to interference from display rules, deception and affective ambiguity (Cowie et al. 2001).

Cowie, et al. (2001) do not reference affect control theory directly, but rather take pieces of various psychological and cognitive models of emotion to develop the root of a computational emotion recognition system. The concept for emotion used does not propose to interpret emotion from interaction, but rather only external cues to that suggest emotion. The categories for emotion are also carefully tailored to reflect a difference between expressions, attitudes, emotions, moods and traits (Cowie et al. 2001). Whereas affect control theory interpretations use the relationship between the affective state and the individual identity to separate these categories, Cowie, et al (2001) use time as a proxy to those categories. Various methods have been proposed as ways to get emotional cues from the user. The most obvious are the use of vocal tones and facial expressions. Other mechanisms such as heart rate, skin reaction, body temperature and pupil response are more invasive to measure and in many cases are inaccurate without careful calibration or context data. Many emotions have physiological signals that are very similar and in some subjects are undetectably different. For example, a subject may have a similar increase in heart rate for mind anger or intense passion. Without context information, such as the content of vocal communication or information about the stimulus it is not possible to make the determination as to what emotion the user is experiencing (Cowie et al. 2001). Despite not invoking affect control theory directly, Cowie, et al. encounter problems in their research of backing literature and in development of a theoretical mechanism for emotion processing that align with the objectives of activity control theory. Physiology can suggest changes in the emotional state of a user, but it cannot be used as a determiner of emotion alone. Likewise, linguistic information alone does not provide complete information to label an emotion. The situational context and the personal context (identity) of the user must be considered to approximate what emotion the user is experiencing. All aspects of the experience can contribute to the definition of the situation, through which the user has an emotional response. It is only by interpreting the cultural value of each element and determining how they interact that emotional labels can be reliably generated computationally (Hoey, Schröder, and Alhothali 2016).

Elisabeth Andre (2013) observes that the trend in human-computer interaction is away from task-oriented interaction to more social dialog-like interactions. This change is due to the assumption that interfaces that treat users as social actors are more likely to be accepted and fit into the user's environment more easily. Adapting machines to interpreting users as social actors is a challenging task as every piece of data in a situation must be calculated and interpreted, whereas humans perform those functions intuitively and can easily discard data that is not relevant. One difficulty that Andre (2013) finds is that most of the data that allows for empathic computing is being transmitted by the user unconsciously. Intentional user input is directed at computer in a way that the computer is specifically designed to accept, or has a mechanism to correct the user if the type of input is not as expected. In the case of the unconscious user signals the relevance of a cue has to be determined and it has to be determined in near real-time to be useful. While it is expected that users will generally find the computer's attention to emotional cues useful, if they are accurate, obvious adaptations to unconscious cues are distracting to the user (Andre 2013). This point is particularly important, as the typical interaction between users and computers is one of input and output, where the user expects a direct result from the interaction based on their intentional input. This is a case where having an accurate EPA profile for various computer interactions would be useful to extending Andre's point. Actions taken by the computer on behalf of the user due to unconscious input would violate a cultural norm where computers are expected to have a low level of situational power (low activity). An adaptation taken by a system labeled as an artificial intelligence, which is a specialized computing system, may not cause the same type of disruption because the label associated has a different meaning and a different expectation of activity.

“The cognitive operations of users are directed and regulated by their feelings and intentions” (Nahl 2007). As users integrate technology more heavily into their life, it becomes essential for continued human growth to incorporate emotions and other affective components into human-computer interactions. In human-computer interaction, this belief is referred to as the “affective revolution”, indicating an acceptance of the idea that affect and emotion work are a part of computer science. Human-computer interaction is most often informed by cognitive science, which has resulted in a cognitive-biological focus in designing mechanisms to recognize human emotion. This has resulted in an approach that is heavily weighted toward understanding the procedures that users go through when interacting with a computer and using primarily behavioral cues, such as cursor movement, eye movement or repetition of behavior to interpret a user’s feelings. This approach restricts assessment to the immediate situation within the user interface and does not account for external factors, which may have an impact on an underlying mood that may influence the user’s expressed actions (Nahl 2007).

Hoey, Schroder and Alhothali (2016) propose an affect control process model for intelligent affective interaction. They do not specify a specific method for recognizing emotions like the previously noted authors. Instead they propose to use and extend affect control theory for the purpose of creating a statistical model which can be used by intelligent agents to accurately interpret human emotion based on object and situational labels. Hoey, Schroder and Alhothali (2016) paired affect control theory with a Markov decision process to create an agential simulation that they refer to as "BayesAct", in reference to both the affect control theory and Bayesian logic processes that provide major influence to the agent's logic. The use of the Markov approach allows for the agent to make decisions based on a combination of *known* information, such as the task situation, and uncertain information, such as meaning the user attaches to linguistic labels (Hoey, Schröder, and Alhothali 2016).

EMOTION WORK OF PROGRAMMERS

Software system developers and programmers have the burden of selecting how to engage the emotions of the users. The programmer must enact as part of their own role the role of the computer. Users may have a conception of who wrote the software or designed the hardware they interact with, but there is no direct social relationship between the user and the programmer. The computer actor must proxy the interaction, but more importantly the developers and programmers must project a concept of an identity upon the systems they create. This identity is how users learn to interact with the system and the types of emotions that users create with the system (Lottridge 2009).

The two major categories of the human-computer interaction discipline of relevance to emotional interaction are user interface design and user experience design. User interface design decisions influence how the user interacts with a system. This can contribute to the emotional environment as it determines the mechanisms accepted for input, which can determine how expressive a user is encouraged to be. Nass (1994) found that humans will talk to and socially engage with a text-based interface, but the addition of capabilities for the computer to accept other modes of input and react to them encourages more of the multi-modal interaction (Wachowicz et al. 2016). User experience design decisions are directly concerned with feelings that users have when using an interface (Sourina, Li, and Pan 2012). In considering user experience concerns in software development the developer must consider how the interface will be interpreted by the user. For the maintenance of the identity of developer it is necessary to consider the role of the user.

One area where there is some flexibility in the boundary between the user and the programmer is feedback. The feedback ranges from brief surveys inside applications that interrogate the user about their experience to recordings of user interaction with the application (Lottridge 2009). Unlike traditional human-human interactions where feedback is provided directly in the interaction scenario, the computer mediates the feedback process and often the feedback and the reaction are separated by large amounts of time. In the intervening time, it is possible that the set of users may have changed or that the users have adapted to whatever problem was causing a disturbance in their experience. Despite the emotion work that developers must do to ensure that their interfaces have the intended emotional and functional effect upon users they are seldom witness to the outcomes beyond limited feedback they may receive during user-engaged testing or in intentional acts of feedback by the users (Lottridge 2009).

IMPORTANCE OF EMOTION IN HUMAN-COMPUTER INTERACTION

As computers become ubiquitous in modern societies, it is important that emotions are a component of their design. The capability to recognize and respond to emotions has become a reliable component of human culture. As much interaction becomes mediated and in some cases time previously spent with humans, such as in an office environment, is now spent in the companionship of devices, computers must fill the social void. Humans vary their responses to each other based on the perceptions of emotional states and may alter conversational topics based on those perceptions. In human interaction this contributes to productivity and wellness. If computers vary the prioritization of information displayed or assist a user with selecting music to be played based on emotional information the same effect can be achieved in human-computer interactions (Cowie et al. 2001).

Not all computing tasks are pleasant. The ability to adapt can improve the user's mood and increase the effectiveness of the interaction. Intense interactions, especially for novices, can be stressing and cause negative situational evaluations (Nahl 2007). An unpleasant and intense experience that is noted in several studies is the case of a tutoring system (Hoey, Schröder, and Alhothali 2016; Andre 2013; Nass 2010). Tutoring systems attempt to assist students with learning material, but the process can be affected negatively by the user's emotional response. If the user is bored, frustrated or experiencing stress, then the tutoring system cannot effectively complete its task. Adapting to negative emotions or taking advantage of positive emotions can improve the benefit to the student. If a student is feeling frustrated, then presenting simpler material or providing hints may correct the unwanted emotion. If a student is feeling satisfied with their performance, then providing material that is somewhat more challenging could reinforce that feeling and allow the student to engage concepts that are more difficult.

Emotional self-awareness may be valuable to the overall well-being of humans. The addition of functionality that will allow computers to monitor the emotional state of their users and make them aware of the type of emotional signals they are producing could be used to reduce stress or simply improve mood (Cowie et al. 2001). The addition of biological cues may make computers more aware of their users' emotional states than is possible for human social actors (Nahl 2007). The effect of incorporating the biological component would be a reduction in the ability of users to hide their emotions with display rules or other forms of emotion work designed to maintain social norms while sacrificing personal emotional expression.

CONCLUSION

In human-computer interaction, the humans are the meaning-makers. Developers and users both bring meaning to computational situations. Users treat computers as social actors with regard to expressions of politeness and expressing loyalty. Emotions are expressed consistent with the user's unconscious expectations of the interaction situation. Little progress has been made in establishing an exact social cause that encourages humans to treat non-anthropomorphic computers as social actors. Computers can be programmed to make crude interpretations of human emotion using linguistic context, biometric data, vocal tone and other unconscious signals that users produce. In most uses of this technology the emotion of the user has to be given a label to allow for it to be used in any type of programmatic action to alter its interaction with the user. Many of these technologies are still limited because they are either not capable of processing data in real-time or are overly dependent upon making large-scale changes that would disrupt the user. Human-computer interactions are becoming more social through the ubiquity of computing devices. Some computer scientists, such as Hoey, Schroder and Alhothali are making use of sociological theories to improve emotional interpretation and emotion production in computer responses. Computers are not autonomous emotional agents and rely on users and developers to engage them in social emotion.

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