You Said What? Assessing the Impact of Collaboration Technologies and Message Characteristics using Physiological Measures

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Abstract

Collaboration technologies often are effective but sometimes they can distort messages, especially in emotional communication. We propose and test a theoretical model to explain how different technologies and message characteristics influence the emotional responses of recipients and how recipients evaluate the emotional content of the messages. Two collaboration technologies—email and voicemail—were examined because they differ in richness and naturalness. As some individuals are more capable in interpreting and understanding emotion, we also examined the role of emotional intelligence. The results show that a message sent via email was likely to trigger a different immediate psychophysiological emotional response and be evaluated differently by the recipient than the same message sent using voicemail, depending on the content of the message, its tone, and the emotional intelligence of the recipient.

1. Introduction

Collaboration technologies (CTs), such as email and voicemail, have become ubiquitous because they provide increased efficiencies, are low cost, and enable virtual teams and communication with individuals who are not collocated or work at different times. Despite these benefits, the usage of CTs has some limitations; it is difficult to communicate emotion accurately using leaner, less natural CTs such as email [12, 29]. Byron [3] has theorized that email may cause the emotional content of messages to be distorted so that positive email messages are interpreted by recipients as more neutral and neutral messages as more negative than the same messages communicated face-to-face. We choose to study email and voicemail because both technologies are ubiquitous in business and personal communication, are asynchronous, and can be utilized in a controlled laboratory experiment, but differ on the important theoretical dimensions of richness [8], social presence [34], and naturalness [14, 18]. Considering their widespread use, these CTs are under-researched and the implications of their use may be poorly understood [3, 13, 33].

We examined both the message recipient's perceptions of the message as well as his/her immediate physiological response (measured using skin conductance and facial electromyography (EMG)) [5]. We found that a message received via email triggered a different immediate physiological response and a different understanding of its emotional content than the same message received via voicemail. We believe that this study provides guidance to CT users and designers in understanding how CTs and message characteristics influence communication.

2. Prior Theory and Research

2.1 Emotion in Communication

The role of emotion in the adoption and use of information technologies has gained increased attention in IS [23]. Research has shown that lean, text-based CTs can convey emotion [12] and that differences in emotional communication influences communication partners [13]. In this study, emotion is characterized along the dimensions of valence (positive or negative) and arousal (low or high) as is common in psychology and media studies [2, 27].

Some message recipients may be better able to understand and manage emotion when communicating [11]. These individuals who possess higher levels of emotional intelligence (EI) may not be influenced by CTs in the same way as others and they may also be better able to perceive and understand differences in the messages.

When humans communicate, we use a variety of cues including facial expressions, vocal tone, gestures, pauses, written text, images, and others [8]. From face-to-face communication to email, different CTs support the conveyance of different cues [9]. In this study, we are interested in how two aspects of messages—the valence of message content and its tone—influence the recipient and his/her evaluation of the message. Message content valence refers the positivity or negativity of the meaning contained in a message. A message containing news about a poor

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exam grade is negative in content valence and a message of praise is positive in content valence.

Content is only one part of the emotional nature of a message. Senders are able to use a variety of cues to imbue a message with a particular tone [13] which may also be evaluated as positive or negative in valence. For example, a voicemail message sent with an angry vocal tone is negative in tone valence and an email with smiley face emoticons is positive in tone valence.

Examining where and how messages are distorted will help researchers and practitioners adjust technology-usage behavior and design better CTs to overcome these problems. We developed a theoretical model that integrates two important theoretical perspectives—1) cue filtering and social information processing [28, 30] and 2) Byron's [3] neutrality and negativity effects—to explain emotional responses and evaluations that occur when messages are received [3] (see Figure 1).

2.2 Cues and Cue-Filtering Theories

CTs differ in their ability to transmit cues to convey meaning (e.g., vocal tone, gestures, words, etc.) [8]. Many theories have used the ability to transmit cues to explain why a given CT is more or less effective or why users choose to use it [8, 10]. The idea that some CTs have limited ability to convey meaning because they are unable to transmit some cues is the basis for the cues-filtered-out model [28]. This limiting—or filtering—of the number and variety of cues that the CT is capable of transmitting restricts the effectiveness of communication. Early empirical studies suggested that cues conveying social information and emotion were most likely to be filtered out in text-based CTs [32].

An alternative explanation of cue transmission differences in CTs is offered by social information processing (SIP) theory [30]. This "cues-filtered-in" theory argues that although CTs differ in the cues they transmit, over time these differences in relational communication become minimal because senders learn to compensate for the limitations of the technology [30]. Senders using leaner CTs will simply make more effort to transmit task and social information using other mechanisms such as emoticons, text formatting, and/or chronemics (temporal signaling such as pauses in conversations) to convey social and affective information [29, 32].

While some studies suggest that emotion is filtered out in lean, less natural CTs, others show that it is possible to convey emotion using them [12]. What is not clear is how the different CTs and the cues transmitted affect the receiver's response to the message and its interpretation.

2.3 Neutrality and Negativity Effects

Byron [3] argues that the inability of email and other lean CTs to convey vocal cues may cause messages to be distorted at the time of receipt. She proposed a theoretical model of emotional communication (in)accuracy in email. In the model, differences in the characteristics of the sender and recipient lead to a neutrality effect (i.e., positive messages are inaccurately assessed as more neutral than intended by the sender) and a negativity effect (i.e., neutral messages are inaccurately assessed as more negative than intended by the sender).

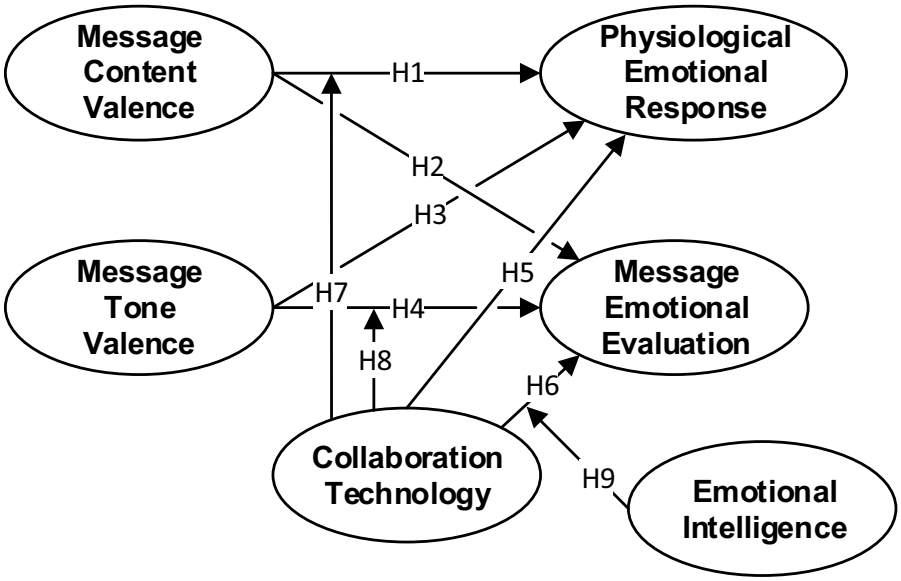

Figure 1. Research Model

Although Byron argues that the model may hold for other CTs, her theorizing is focused on a single CT—email—and does not account for differences in CTs. In this study, the influence of two CTs email and voicemail—were examined to understand how message distortions vary in CTs that transmit different cues. While a test of Byron's model is not the primary goal of this study, portions of the model can be tested to determine their theoretical usefulness.

2.4 Effects of Message Content

Before we can theorize about the distorting effects of CT, we must consider how the content of a message (the words themselves) and its tone affects the recipient. We are interested in both the immediate physiological emotional response and how the recipient perceives the message.

When humans perceive a stimulus such as a message or an object, they have an automatic subconscious emotional response [27]. This reaction has both a valence (i.e., positive or negative) and a level of arousal (from low to high) [6]. Our focus is on the valence of a message; we measured but did not manipulate arousal during our experiment.

Individuals presented with positive or neutral stimuli tend to be curious and inquisitive about the stimuli [4] and exhibit positive emotion in a natural approach behavior, which stems from the instinctual need to search for food and potential mates [20]. When individuals receive cues indicating a threat, they exhibit avoidance or "flight" behavior, where the body prepares to physically leave so that the individual is removed from danger [4]. Negative emotion is part of this avoidance response [20]. Emotional reactions can occur even when no real threat is present [1]. We argue that when people receive messages that contain positive content, they experience positive physiological emotional responses, and when presented with negative message content, experience negative physiological emotional responses.

H1: The valence of message content will have a direct effect on the valence of emotional response.

When people read or hear a message, they cognitively process the message and consciously or subconsciously evaluate its emotional content. The content conveys information and the intended meaning of the message. We expect that when recipients evaluate a message, they will interpret the valence of message content accurately (as its author intended) such that negative content will lead to negative evaluations and positive content will lead to positive evaluations.

H2: The valence of message content will have a direct effect on the valence of emotional evaluation.

Messages often contain cues that are not explicit in the words themselves, but are added to provide additional meaning. Variations in vocal pitch and volume, pauses, text formatting, and other non-content cues (which we call the tone of the message) can be used to clarify the valence of the message when its content may be equivocal. Tone is particularly important for the communication of humor, sarcasm, or emotion, where the message content may be ambiguous [8, 29]. Research is mixed on whether lean, less natural CTs are less suitable for communication requiring additional cues to transmit meaning, even though these CTs can communicate humor, sarcasm, and emotion through the use of symbolism (e.g., emoticons) or temporal signaling [29]. We argue that tone cues will be correctly interpreted. A message with a positive or negative tone will evoke a matching physiological emotional response.

H3: The valence of message tone will have a direct effect on the valence of emotional response.

We argue that the tone of a message will be correctly interpreted. A negative or positive tone will lead to an evaluation that corresponds to that tone.

H4: The valence of message tone will have a direct effect on the valence of emotional evaluation.

2.5 Effects of Collaboration Technology

Media Naturalness Theory (MNT) proposes that CTs are more "natural" when they are closest to face-to-face communication and emphasize vocal communication, facial expressions, and synchronicity [14, 16]. To be considered natural, a CT must be used while co-located or provide the perception of co-location, provide synchronicity in interaction, and enable the conveyance and interpretation of facial expressions, body language, and speech [14, 16]. Email lacks auditory vocal cues so it is considered an unnatural CT by MNT [14, 16].

Leaner, less natural CTs like email may cause cognitive frustration when used because of differences from face-to-face communication [14]. The limitations of email make message composition slower (e.g., typing text is slower than speaking on average), which can cause annoyance at the communication delay between messages [15]. Less natural CTs are less exciting and social, which may cause users to prefer and enjoy more natural CTs [14, 16]. Since humans more naturally process the emotional cues in vocal communication, a CT like voicemail that conveys vocal cues will elicit a more positive affective response independent of the tone or content of the message [16]. All of these influences

should cause recipients of email messages to experience stronger negative physiological emotional responses to email messages compared to voicemail messages.

H5a: People will experience a more negative emotional response when receiving email messages than when receiving voicemail.

More natural CTs should also elicit greater emotional arousal in recipients, because they convey a greater number and variety of cues, leading to stronger perceptions of social presence with communication partners [16]. This is especially true when the human voice is communicated, because message recipients will process the communication as more social, exciting, and arousing [16, 34]. Recipients presented with messages using a CT where some cues are filtered out (e.g., email lacks vocal tone) will experience less emotional arousal than when receiving a greater number and variety of cues. When receivers perceive and process a wide variety of contextual and content cues, they will have stronger physiological emotional responses.

H5b: People will experience less emotional arousal when receiving email messages than when receiving voicemail messages.

The lack of cue variety in email communication may cause frustrations that influence the evaluation of messages. Email recipients may experience a negativity effect where they perceive emails to be less positive and more negative, because fewer cues are available to transmit emotion and there is no immediate feedback [3, 31].

Email may also be perceived as more business-oriented than voicemail and this connotation may make its use feel more utilitarian and boring and less hedonic and positive to users. The task-oriented nature of email and its limited ability to convey cues will cause message recipients to evaluate email as more negative than voicemail.

H6a: People will evaluate email messages as more negative than voicemail messages.

Messages received using lean, less natural CTs are less likely to demand the automatic attention of recipients [14, 16, 18]. The lack of cues makes email messages less exciting and arousing. Under MNT, the human voice signifies social communication and should cause recipients of voicemail messages to evaluate them as more arousing than email [16].

Another factor contributing to higher arousal in voicemail is the pace at which the message is processed. Although it is possible to replay a voicemail message, recipients usually try to process and understand voicemail messages on the first attempt because the nature of the CT requires listeners to start again if the message is not understood the first time. The processing of voicemail messages takes place at the same speed the sender composed the message, whereas the decoding and interpretation of email messages may be done at the pace set by the recipient. These CT differences will cause voicemail messages to be evaluated as more arousing than email messages.

H6b: People will evaluate email messages as less arousing than voicemail messages.

Email recipients rely primarily upon text formatting and emoticons for the interpretation of message tone. This limitation of email will cause message recipients to rely more on the content of the message for understanding its positivity or negativity. Individuals will unconsciously place more weight upon interpretations of email content because tone in email is limited by cue filtering. Recipients should also be less distracted from the content of the message because there are fewer cues on which to concentrate. The physiological emotional response felt by someone processing an email message will be more influenced by the content valence of the message than with voicemail.

H7: The relationship between message content valence and the valence of emotional response will be stronger for email than for voicemail.

When people hear a human voice, they immediately—often unconsciously—interpret its tone, which is made up of pitch, volume, pace, and other auditory characteristics. In many situations, receivers can interpret the positivity or negativity of vocal tone before transmission of the message is complete. In text-based communication, individual interpretation of message tone relies on cues whose meaning may depend heavily on context. For example, the use of emoticons is one of the most common methods for conveying meaning using textual cues, but even writing a smiley face in text can take many different forms (e.g., :) , :-), =), and others), which may not be interpreted uniformly by all recipients, especially across cultures [29]. Text formatting may also be difficult to interpret because the meaning of these cues may not be standardized and may be idiosyncratic to an individual.

Because of the potential difficulty of conveying tone in email, recipients will rely more on tone in vocal communication. Thus, CT will moderate the impact of tone on the valence of emotional response.

H8: The relationship between message tone and the valence of emotional response will be weaker for email than for voicemail.

2.6 Effects of Emotional Intelligence

Emotional Intelligence (EI) can be conceptualized as a trait comprising an individual's propensity to consistently perceive, assess, control, and respond to his or her own emotions and the emotions of others

[11, 25, 26]. EI influences a number of organizational and personal outcomes [7, 11, 19, 21, 24], but has not been examined extensively in IS research. Those who possess a high degree of EI should recognize how the use of the CT influences his or her interpretation of the message at the time of receipt. These recipients will consciously or subconsciously compensate for the effect of the CT on the cognitive evaluation of received messages. We have hypothesized that the use of email will cause recipients to evaluate messages as less arousing and more negative than voicemail. Individuals who are highly emotionally aware (i.e., high in EI) will not be affected by the technology and will focus on the content and tone of the messages. EI will weaken the relationship between the CT used and the recipient's evaluation of the message's valence and arousal.

H9a: The relationship between CT and message valence evaluation will be weaker for individuals high in EI.

H9b: The relationship between CT and message arousal evaluation will be weaker for individuals high in EI.

3. Method

The experiment used a repeated measures crossover design in which each participant received all treatments to maximize power and control. Three pilot tests assessed different aspects of the manipulations, measures, and experimental protocol.

3.1 Participants

72 undergraduate students participated in this study. They were recruited from two undergraduate courses at a large public university and all participants were heavy users of both CTs examined.

3.2 Task

Each participant received nine email messages and nine voicemail messages. Participants randomly were presented with each message one at a time and they evaluated the emotional arousal and valence of the message. Participants were also given several different distractor questions during evaluation such as "how many words were in the previous message" to reduce hypothesis guessing and encourage participants to fully interpret each message. The messages that participants received and evaluated were adapted from different sources. We used emails and voicemails that had been composed by other students during the pilot testing of two separate studies as the basis for most the stimuli. The remaining messages were fabricated and voicemails were recorded by actors. This process created realistic messages representative of the types of messages received by the participant population.

3.3 Independent Variables

For each message, participants received either an email or a voicemail message. Email messages were displayed on the screen and appeared as a simulated Gmail interface for viewing a new message. This interface was selected because undergraduate students at the university use the Gmail system for their email. Participants listened to voicemail messages as if they were retrieving them from a voicemail system.

The content valence was varied in each message. Participants were presented with messages that were positive, neutral, or negative. The identical content word-for-word was presented in text in the email treatment and vocally in the voicemail treatment.

The messages contained positive, neutral, or negative tone valence. Email tone valence was manipulated using formatting (e.g., capitalization) and emoticons. Voicemail tone valence was manipulated using vocal tone. All of the experimental manipulations were validated during pilot testing.

EI was measured using the short form of the trait emotional intelligence questionnaire (TEIQue-SF) [25]. The scale has been widely used and was found to be reliable in this study (Cronbach alpha = .831).

3.4 Dependent Variables

Physiological emotional responses (valence and arousal) were assessed using NeuroIS measures. Valence was operationalized by recording Corrugator supercilii muscle response and physiological arousal by recording skin conductance. Consistent with other NeuroIS studies, the physiological measures were cleaned prior to data analysis, averaged over the time each message was read or listened to, and compared with a baseline to produce change scores. We followed recording and cleaning procedures described in [6, 27], but space constraints preclude a full description of the process.

Recipient evaluations of messages were measured using adapted versions of scales developed to measure emotional valence and arousal [2, 22].

3.5 Procedures

After obtaining consent, the researcher set up the electrodes prior to the beginning of the experimental session. Participants first answered demographic questions and then were presented with the email and voicemail messages. Participants randomly received messages one at a time and were asked to evaluate the valence, arousal, and distracter questions about each message. Then they completed the TEIQue-SF, were debriefed, and dismissed.

4. Results

The data were analyzed using repeated measures general linear modeling (GLM) in SPSS. We used the Greenhouse-Geisser correction to adjust the degrees of freedom to compensate for unequal variance in the data that violate sphericity assumptions of GLM.

The hypothesis testing is discussed first; however, we found significant interaction effects and the direct effects may not be interpretable in light of these interactions. Table 1 summarizes the results.

4.1 Effects of Message Content

H1, which argued that the valence of message content would directly affect the valence of the physiological emotional response, was supported. A significant 4-way interaction between CT, content, tone, and EI on emotional valence was obtained, which limits interpretability of the hypothesis of a main effect of content valence on the valence of physiological emotional response. This 4-way interaction affects H1 and several of the subsequent hypotheses and is discussed in Section 4.3.

H2, which argued that the message content valence would directly affect the recipient's evaluation of the message's valence, was not supported. However, content valence participates in an interaction with tone valence, and EI on the valence of message evaluations.

H3, which argued that tone should directly affect the valence of the physiological emotional response, was supported. A significant content valence by tone interaction on arousal was also obtained. Messages with neutral content and positive tone were the least arousing.

H4, which argued that the tone valence would directly affect the recipient's evaluations of the valence of the messages, was not supported, but there was a significant tone by content by EI interaction.

4.2 Effects of Collaboration Technology

We argued that the simple act of receiving messages in different CTs would elicit differences in emotional responses. However, we found no main effects of CT on the valence or arousal of emotional response. H5a and H5b were not supported. As we noted above, there was a 4-way interaction which we discuss in Section 4.3.

H6 argued that differences in CTs lead to differences in message evaluation: emails should be evaluated as more negative and less arousing than voicemails. Email was not evaluated as more negative. Contrary to predictions, email was evaluated as more arousing than voicemail. H6a and H6b were not supported and the relationship for H6b between CT and the evaluation of message arousal was significant in the opposite direction.

H7 argued for an interaction between the technology and content valence on emotional responses. The data showed support for H7 that voicemail triggered both a stronger negative emotional response when receiving positive content and a stronger negative response when receiving negative content. However, a four-way interaction among CT, content valence, tone valence, and EI superseded this interaction.

P-Values Using Greenhouse-Geisser Adjustment				
Source	**Corrugator Activation**	**Skin Conductance**	**Evaluation of Message Valence**	**Evaluation of Message Arousal**
EI	0.178	0.576	0.349	0.112
CT	0.197	0.301	0.312	0.050*
CT * EI	0.341	0.359	0.004**	0.020*
Content	0.027*	0.834	0.532	0.084
Content * EI	0.035*	0.870	0.006**	0.366
Tone	0.027*	0.619	0.556	0.005**
Tone * EI	0.036*	0.669	0.024*	0.001**
CT * Content	0.019*	0.454	0.386	0.152
CT * Content * EI	0.021*	0.548	0.233	0.216
CT * Tone	0.006**	0.868	0.628	0.652
CT * Tone * EI	0.010**	0.883	0.149	0.864
Content * Tone	0.002**	0.050*	0.241	0.510
Content * Tone * EI	0.005**	0.061	0.043*	0.420
CT * Content * Tone	0.003**	0.648	0.535	0.170
CT * Content * Tone * EI	0.007**	0.650	0.054	0.282

* $p < .05$; ** $p < .01$

Table 1. Summary of Results

H8 argued that CTs would change the relationship between tone and physiological response. The data showed a significant interaction effect where positive emails triggered the most positive physiological responses and positive voicemails triggered the most negative. Email weakened the relationship between tone and corrugator response for negative tone, supporting this hypothesis.

4.3 Effects of Emotional Intelligence

H9 argued that individuals who are high in EI should be able to lessen the impact of the CT on their evaluations of message valence and arousal. There was a significant interaction on evaluations of arousal and on evaluations of valence. The interactions were in the expected direction so that people who are high in EI evaluated voicemail messages as less arousing. People who were high in EI evaluated email messages as more positive and voicemail as mildly more negative. H9a and H9b were supported.

As we noted earlier, there was a 4-way interaction in the valence of physiological emotional response. When receiving email, individuals high in EI listened more to tone than to content, but when voicemails were received, those who were high in EI picked up on any negative information (content or tone). The interaction was driven by two conditions: when the email message contained positive message content and negative tone and where the voicemail message contained negative content and neutral tone. The parameter estimates indicated that these combinations were the only significant ones for the interaction.

Figure 2 shows the 3-way interaction holding EI constant. The results show that voicemail generally elicits greater corrugator activation, meaning a more negative physiological response. This is particularly true in the negative content – neutral tone condition where voicemail recipients experience the highest negative emotional response. This response is decreased by those high in EI. EI also increased corrugator activation when participants received emails with positive content and negative tone.

5. Discussion

The results showed that the same message received via email versus voicemail triggered a different immediate physiological emotional response and led to different perceptions of message content. The emotional response and perceptions of the message were also influenced by the message content and tone, as well as the EI of the recipient, but not in ways suggested by prior research.

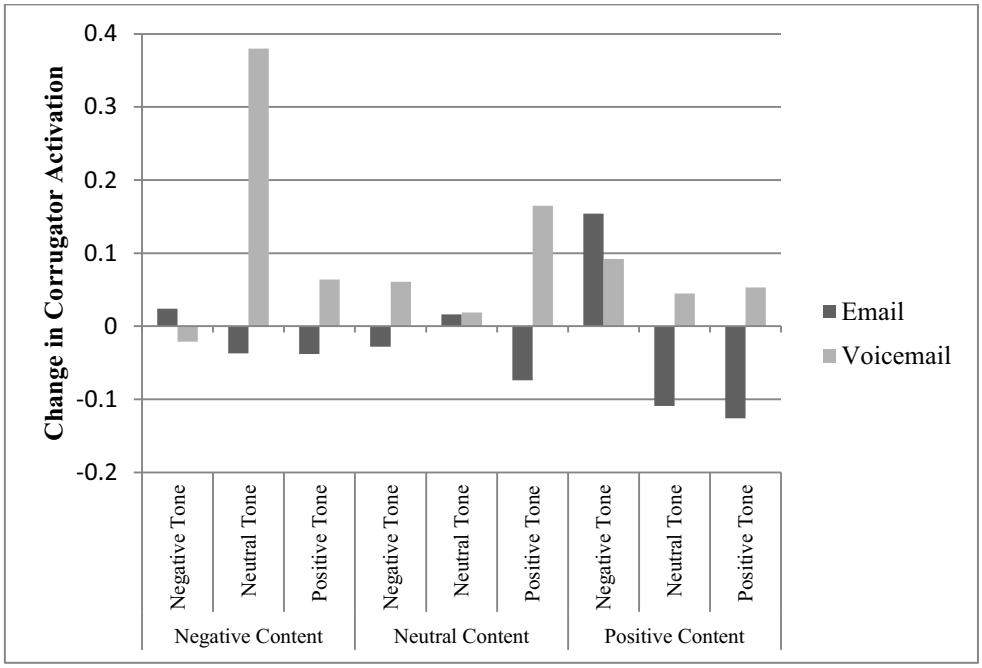

Figure 2. Impact of CT, Content Valence, and Tone Valence on Corrugator
Note: Positive changes indicate a negative emotional response

There was a four-way interaction between CT, message content, message tone, and EI for valence of physiological emotional response. We performed additional analysis and found that only two of the cells had a significantly different parameter estimates: individuals high in EI viewing email messages with positive content and negative tone, and individuals high in EI listening to voicemails with negative content and neutral tone. The combination of positive content and negative tone is likely quite uncommon and may only occur rarely in business and personal communication. Those who were higher in EI were more likely to recognize that positive content with a negative tone is an unusual combination. They saw the emoticons and message formatting that represented the message valence, but realized that they did not make sense in light of the content of the message. High EI participants saw the contradictory valence of content and tone and experienced stronger negative physiological emotional response, indicated by increased corrugator activation.

The second condition EI affected was when participants received voicemails with negative content and neutral tone. This may be the most common case when recipients receive negative news from others. In mass communications, newscasters tend to deliver negative news in a neutral tone. Message recipients in this condition recognized the negative content and those who were high in EI had even stronger negative emotional responses.

Since EI only affects these two combinations, we will discuss the three-way interaction for all of the conditions where EI was non-significant. The most positive emotional response occurred when participants received email messages that were positive in tone and positive in content, closely followed by email messages with neutral content and positive tone. The most negative emotional responses to email occurred when an individual received email messages containing positive content and negative tone. The interesting aspect of this result is that when participants received email messages, it was the tone of the message (manipulated using text formatting and emoticons) that drove the emotional response, *not the content of the message*. This suggests that emoticons, which were the primary means of communicating tone in email, are very powerful. More research is needed into how the different methods of varying tone in email (e.g., emoticons, fonts, capitalization, colors, etc.) individually work to convey message tone.

Differences in CT also influenced the way in which recipients evaluated messages in terms of arousal and valence. There was a direct effect of CT on the evaluation of a message's arousal, but this was superseded by the interaction between CT and EI on both the evaluated arousal and valence of the message. As expected, individuals who were high in EI were able to suppress the influence of the CT on their evaluations of messages, but not on their physiological responses. This result shows the importance of EI in the evaluation of messages sent using different CTs, but also the usefulness of NeuroIS measures to better understand what is really happening emotionally when these different technologies are utilized. Examining the role of EI in interacting with the technology is important to understanding changes in emotional communication. More research is needed to understand in greater detail how EI influences the use of these and other technologies.

This study contributes to theory in several ways. First, it developed and tested a theoretical model of how CT differences, characteristics of messages, and EI impacts the immediate emotional responses of recipients and how they evaluate messages.

Second, we examined some aspects of Byron's [3] negativity and neutrality effects to evaluate the cues-filtered-in vs. cues-filtered-out models. We found no support for a neutrality effect and no support for a negativity effect. Email messages were *not* evaluated as less positive or more negative than the voicemail messages. Byron's theorizing centered around the differences between email communication and face-to-face communication. It is possible that voicemail and email are too similar for a full evaluation of Byron's propositions; however, the two technologies differ in terms of richness, naturalness, and other important dimensions. This study was not designed as an empirical test of Byron's model and we did not assess many of the constructs contained in the model. More research is needed to better evaluate Byron's model as well as to understand how emotional intent is distorted during communication. This study also found support for the cues-filtered-in model as participants were able to communicate emotion even through lean, unnatural, and text-based email.

Third, we investigated one of the propositions of MNT [14, 16]. MNT posits that more natural CTs will be more arousing, but we did *not* find support for this tenet. We did not examine face-to-face communication and it is possible that email and voicemail are too similar in their level of naturalness and that users of both CTs made adaptations to communicate emotion [15-17]. Alternatively, lean, less natural CTs may elicit different emotional responses than existing theory predicts.

It is surprising that none of the independent variables had a significant main effect on physiological arousal as measured by skin

conductance. We did find a significant un-hypothesized message content by tone interaction on arousal. While we did not posit this relationship a priori, the content and tone of the message could certainly influence arousal. Jointly, these individual message characteristics make up the overall emotional content of the message, which may act together to influence the physiological emotional responses of recipients.

Consistent with the hypotheses predicting main effects of content and tone on physiological response, we found that positive content and positive tone had the lowest corrugator response. Future research should examine physiological emotional response in more detail to understand how it is influenced by the CT and the messages. Email communication may not suffer from some of the drawbacks suggested in the literature. For example, email is certainly capable of communicating emotion, and email messages may cause emotional responses in recipients that are more closely aligned with the intent of the message senders. When conflicting emotional information is received, those high in EI are capable of looking past the tone to the content of the messages.

The results of this work provide guidance for users and designers of CTs. Users need to carefully consider their choice of CT when sending messages. Sending messages with emotional content and tone using different CTs may cause different emotional responses in message recipients than expected. Recipients of communication messages need to understand these distortions and compensate accordingly. Researchers and CT designers should use these results to examine technological solutions to reduce distortions. Users should also understand the role of content and tone in their messages. Emoticons should be used cautiously because they have a very strong effect on the receiver's immediate emotional response to the message; choose carefully. The use of NeuroIS measures proved useful in investigating breakdowns in communication at the time of message receipt. Psychophysiology is a useful tool for understanding cognition during technology usage, and researchers will need to consider using these measures in their studies to examine and control for the subtle influences of the technology on individual cognition and behavior.

It is clear that CTs and message characteristics may cause different physiological reactions than senders intend by subtly affecting communicators. Additional research is needed to investigate different forms of CTs such as video conferencing, telephone, social networking websites, blogs and micro-blogging services, and others. These technologies differ in synchronicity, anonymity, naturalness, and along other important theoretical dimensions.

This study shows that we may know much less about the use of email and voicemail than we think we do, and that some of the communication theories of the past may not apply. Researchers cannot ignore how the technology subtly impacts its users and the tasks they are performing.

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