Regulating Feelings During Interpersonal Conflicts by Changing Voice Self-perception

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ABSTRACT
Emotions play a major role in how interpersonal conflicts unfold. Although several strategies and technological approaches have been proposed for emotion regulation, they often require conscious attention and effort. This often limits their efficacy in practice. In this paper, we propose a different approach inspired by self-perception theory: noticing that people are often reacting to the perception of their own behavior, we artificially change their perceptions to influence their emotions. We conducted two studies to evaluate the potential of this approach by automatically and subtly altering how people perceive their own voice. In one study, participants that received voice feedback with a calmer tone during relationship conflicts felt less anxious. In the other study, participants who listened to their own voices with a lower pitch during contentious debates felt more powerful. We discuss the implications of our findings and the opportunities for designing automatic and less perceptible emotion regulation systems.

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous; See http://acm.org/about/class/1998/ for the full list of ACM classifiers. This section is required.

Author Keywords
emotion; conflict; feeling; voice; anxiety; power; emotion regulation; self-perception; heart rate; interpersonal conflict

INTRODUCTION
Interpersonal conflict permeates our lives [17]. Whenever we try to solve a problem at work, discuss politics with friends, settle negotiations, or discuss a crisis situation with our romantic partner, conflicts may arise. Whether these conflicts turn out to be helpful or harmful depends largely on conflict management [17], which is the "process of limiting the negative aspects of conflict while increasing its positive aspects" [2].

Recent studies found that emotion regulation plays a crucial role in conflict management. By emotion regulation we refer to the processes by which "individuals influence which emotions they have, when they have them, and how they experience and express them" [27]. Research by Curseu, Boros, and Oerlemans [15] showed that teams which are less effective in regulating emotions are more likely to move from helpful task conflicts to harmful relationship conflicts. Further, Yang and Mossholder [71] found that emotional intelligence, which in part refers to the ability to regulate emotions, determines the transformation of helpful into harmful conflict. Finally, research on conflict in marriages showed that the ability to regulate emotions during conflict is crucial in maintaining high relationship satisfaction [23].

To manage conflict effectively, it is important to down-regulate negative emotions. Studies across professional and personal contexts have shown that the more negative emotions are experienced and expressed during conflicts, the more harmful are the consequences [37] [24]. When expressed to others, negative emotions have a tendency to escalate the conflict and initiate a spiral of increasing negativity [3]. Therefore, finding ways to reduce negative emotions during conflict is important towards the development of new conflict management approaches.

One way in which our emotional experience can be affected is based on the way we perceive our own expressive behavior. According to self-perception theory [6] "individuals come to 'know' their own attitudes, emotions, and other internal states partially by inferring them from observations of their own overt behavior and/or circumstances in which this behavior occurs". Indeed, studies indicate that when individuals produce sound patterns associated with emotions such as joy, sadness and anger, they tend to have congruent emotional experiences [31][5]. For instance, when producing sounds of laughter, people tend to feel happier than when producing other emotional sounds [31].

CHI 2018 April 21–26, 2018, Montreal, QC, Canada

ACM ISBN 978-1-4503-5620-6/18/04.
DOI: https://doi.org/10.1145/3173574.3174205

Inspired by these studies, and drawing from self-perception theory, theories of conflict management and emotion regulation, we propose a novel way of regulating emotions during interpersonal conflicts: the regulation of how a person perceives their own voice. By using software that manipulates how a person perceives their own voice through headphones, we conducted two studies in which participants engaged in interpersonal conflicts while their voice was subtly manipulated to elicit a specific emotional tone. The results of the studies show that it is possible to regulate how individuals feel during interpersonal conflicts without requiring their conscious attention and effort.

The paper is organized as follows. First, we show a review of the literature on conflict management, nonverbal signals, self-perception and emotion regulation. We then present two studies in which participants engaged in interpersonal conflicts while their voice was subtly manipulated and played back via headphones in real-time. The paper concludes with a discussion of the findings and implications for theory and design of technologies for emotion regulation.

Our work makes the following contributions:

- First, we present an overview of studies and theories from conflict management, nonverbal signals, self-perception, and emotion regulation, and show how previous work can be leveraged to design interventions for regulating emotions during interpersonal conflicts;
- Second, we present a subtle and effortless approach for regulating emotions during interpersonal conflicts, which consists in changing how the person perceives their own voice;
- Third, we present two laboratory studies that show how the approach of changing voice self-perception can be used to regulate people's emotions and feelings.

BACKGROUND AND MOTIVATION

In the studies presented in this paper, we investigate the effect of changing people's voice self-perception in their feelings during interpersonal conflicts. The studies were inspired by previous work on conflict management, nonverbal signals, self-attribution theories, and emotion regulation.

Interpersonal Conflicts

Conflicts "exist whenever incompatible activities occur [17] p.10." Deutsch [17] distinguishes between international, intergroup, and interpersonal conflict dependent on the actors between which such incompatible activities occur: nations, groups, or individuals. In this paper we focus on interpersonal conflict.

Interpersonal conflict can emerge in dyads, and larger groups or teams. Interpersonal conflict among members of groups and teams is often referred to as intra-group conflict [36]. Researchers agree that all conflict is to some degree emotional [8]. While verbal cues and topics of conflict play an important role in how conflicts unfold, recent research has revealed the important role of emotions as determinants of conflict outcomes. For example, in several studies, Gottman and Levenson demonstrated that marital satisfaction and divorce can be predicted years in advance based on the emotional interaction dynamics occurring during a fifteen minute conflict episode [23]. A recent study by Jung [37] demonstrated that the same patterns of emotional interaction dynamics during conflict that predict marital outcomes are also highly predictive of team performance.

Research often associates negative and highly aroused emotional states such as anger and stress with conflict [20][10][10]. Negative emotions, when expressed, have the tendency to be reciprocated in others, and escalate into further negativity with often harmful consequences for relationships [3]. It is therefore important to find ways to down-regulate, which means reducing negative emotions during interpersonal conflict.

Nonverbal Signals and Perception

A major part of the communication process is nonverbal language, which are the messages that individuals send beyond the words themselves, such as facial expressions and tone of voice. These micro-level aspects represent an often unconscious aspect of communication between people, as they elicit direct reactions in observers and provide a source of social information about the expresser [68].

Among the nonverbal signals, one of the most relevant is prosody, which refers to voice features that accompany the spoken words, such as loudness, pitch and pace [16]. We can use our voice to emphasize words, express confidence, or communicate our feelings about something [63]. This nonverbal signal is so important that researchers found that it is possible to predict outcomes of job interviews, speed dating encounters [52], and even voting behavior [65], by analyzing only the prosody of individuals' voices during social interactions.

One voice feature that has been extensively studied is pitch. Pitch represents the number of vibrations per second produced by the vocal cords to produce a sound [66]. Depending on the pitch, a voice can be perceived as higher or lower. Interestingly, the pitch of a person can influence how she is perceived by others. For instance, low-pitch voices are associated with physical and social dominance [54], while high-pitch voices are linked to powerlessness and words like "weak" [67].

Although prosody is often studied in the context of interpersonal perception, the way individuals perceive their own voice can also affect other aspects of their self-perception [6]. In fact, people's voice self-perception can even influence their emotions [5].

Self-Perception and Emotions

Common sense holds that first we feel an emotion, and then we express a behavior and have the appropriate physiological changes. However, experimental evidence indicates that our emotions and behaviors can activate one another in a dynamic fashion [49]. In this case, by adopting particular facial expressions, voice tones, and body postures, we can activate congruent emotions.

The theory that expressive behavior and physiological changes can trigger subjective feelings was initially proposed by William James and Carl Lange [35]. Two more recent theories of emotion are the Schachter-Singer two-factor theory [60] and Lazarus theory [42]. Both acknowledge that behavior and physiological changes can influence our emotions, but they state that our emotions are affected by the way we cognitively appraise our behavioral and internal cues. A fast heart rate can be appraised as anxiety during a public speaking situation, but it can also be appraised as a sign of attraction if it happens when an individual talks to an attractive person. Similarly, a raised voice can be interpreted as a sign of negative arousal during a relationship conflict, but it can also be appraised as positive excitement if the context is watching the final match of a soccer championship. Therefore, emotions are the perceptions of our behaviors and internal cues, given the contexts in which they are performed.

The work of Schachter and Lazarus can also be interpreted in the context of self-attribution theories [6][39]. As stated by Bem, "individuals come to "know" their own attitudes, emotions, and other internal states partially by inferring them from observations of their own overt behavior and/or the circumstances in which this behavior occurs". Bem stated that in several circumstances we act as an outside observer, who have to rely upon external cues to infer internal feelings [6].

Emotion Regulation

Emotion regulation refers to "the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions" [27]. These processes are pivotal to understanding the quality of a relationship and its future prognosis [25].

Emotion can be regulated from the input stage, in which an emotion arousing stimulus is detected, to the output stage, where the emotional response is manifested [26]. In the current research, we focus on response modulation, which represents the regulation of emotion at the output stages.

One of the most common forms of response modulation is expressive suppression. Expressive suppression consists of attempts to suppress or reduce the expression of an affective experience. For instance, a person may suppress their desire to shout at another [29]. Research on suppression shows that although this strategy is effective in inhibiting expressive behavior, it actually increases cardiovascular arousal at the same time, due to the conscious effort involved in concealing emotion-related responses [30][47]. Furthermore, suppression may not be helpful in reducing negative emotions, since they are not directly targeted by suppression [28].

Technologies for Emotion Regulation

A common strategy used by researchers and designers that develop technologies for emotion regulation is the focus on reflection [46][48]. Examples of technologies that use this approach include biofeedback devices that encourage users to reflect about their stress [59][45], visualizations that show estimated affective states over time [48], and interfaces to support reconciliation [72]. These technologies can help users to reflect about their experiences so that they can take actions to better regulate their emotions in future situations [13]. However, this reflective practice cannot be performed concurrently with some tasks, since they require the focused attention of the user. If, for instance, a person is involved in an intense conflict with her partner, it is unlikely that she will pause or stop the conversation to use a technology. Indeed, technologies that focus on reflection are not designed to help users regulate their current emotions [13].

Another approach used in the design of technologies for emotion regulation is to provide real-time feedback. In some cases, the feedback is not designed to regulate an emotion itself, but it can help in this process. Examples include technologies that provide linguistic feedback about conversations [18], and robots that provide feedback about people's aggressive behavior [38][33]. However, this approach has the same issue of technologies that rely on reflection: users have to drift their attention away from their current task to pay attention to the technology.

REGULATING EMOTIONS BY CHANGING SELF-PERCEPTION

Although real-time feedback can be distracting, there are ways of providing feedback that do not interrupt people's activities. Previous research shows that it is possible to change user's behavior without requiring their focused attention [1]. Using this same principle, but for emotion regulation, Costa et al. developed a wearable device called EmotionCheck, which can regulate user's anxiety through false heart rate feedback [13][14]. The technology was developed based on previous studies that showed that the way people perceive their bodily signals, such as their heart rate, can influence how they feel. Since there are also studies that show that the perception of our own behavior can affect our emotional experience, one question that arises is: Is it possible to regulate people's emotions by changing their behavioral self-perception? With this question in mind, we propose a new technological approach for regulating emotions: change how a person perceives their own behavior.

In order to evaluate the potential of this approach in emotion regulation, in this work we evaluated one particular form of influencing user's self-perception: change the sound produced by a person's voice. Since the way a person perceives their own voice can affect their emotions [31], we expected that by influencing user's self-perception we could change people's emotional experience. In order to change how a user perceives their voice, we used software that can manipulate a sound captured through a microphone and play back via headphone in less than 20 milliseconds [55]. Since the delay is minimum, the person attributes the sound that she hears through the headphone as her own voice [5]. With this approach, users should focus on their conversations without moving their attention away to the technology. Therefore, the technology would act peripherally and in parallel to user's actions [1].

Using software that modulates people's voice, we conducted two studies to investigate the possibility of regulating people's emotions during interpersonal conflicts by changing their

voice self-perception. We present each study in the following sections.

STUDY 1: CONFLICTS BETWEEN DATING COUPLES

In this study, we investigated the possibility of regulating the emotions of dating couples during interpersonal conflicts by allowing only one partner of each couple to hear their voice with a calmer tone through a headphone.

Participants were asked to engage in audio-only conversations via Skype with their partners using a laptop, headphone and microphone. One conversation was neutral, while the other was about a topic to elicit conflict. We will refer to the partners in each couple as A and B. Partner A interacts normally via Skype, without any voice feedback or manipulation by software. Meanwhile, partner B uses a computer with a software in the background that can provide voice feedback via headphone with or without manipulation. We divide our couple population in two sub-groups. In the no-manipulation sub-group, partner B hears their own voice; in the manipulation sub-group, partner B hears their voice modified to sound calmer. The type of voice feedback partner B receives is randomized. Partner A hears the voice of partner B without any manipulation. We run our two-way analysis as Partner Type{A, B} X Manipulation{None, Calmer}.

We used the computer application to manipulate the voice with pitch-shifting (-30 cents), a low shelf filter (cutoff frequency of 8000 Hz and high-band roll off of 10 dB per octave), and a formant shifter (tract ratio of 0.9). These values for voice modulation were used because in a previous study it was found that they lead to a perception of low arousal and calmness [5].

Research Questions

Previous research shows that the way the voice is perceived can affect people's emotions. When individuals speak with voice tones that resemble expressions of emotions, they tend to have congruent emotional experiences [31][5]. For instance, when producing sound patterns of joy, people tend to feel happier [31]. Similarly, people are more likely to feel sadder when they hear their voices with a sad emotional tone [5]. This leads to our first research question:

RQ 1: How does providing voice feedback with a calmer tone during a relationship conflict influence the emotions of the person?

If participants perceive their voice as calmer, this might influence the way they perceive the social interaction itself. By noticing their voice in a less arousing tone, the participant might perceive the interaction as more positive. This leads to the second research question:

RQ 2: How does providing voice feedback with a calmer tone during a relationship conflict influence the perception of the person about the conflict?

Participants

We recruited 54 individuals (27 couples) from a large research university to participate in the study. They were between 18 and 24 years of age (M = 20.61, SD = 1.42). Only individuals who have been in a relationship for longer than 6 months participated in the study. Participants were informed that the goal of the study was to understand how couples interact when using communication technologies. The true purpose of the study and the voice manipulation was not disclosed to prevent any bias in their behavior and answers. All participants received either 15 dollars in cash or course credit for their participation. Three couples were removed from the analysis because of issues in the heart rate collection.

Setup

We conducted the experiment in two sound-treated rooms at Cornell University. Each room contained a small table, three chairs, one laptop, one headphone (Audio-Technica ATH-M20x), one microphone (Fifine K668) and one heart rate monitor (Polar H7). Partners stayed in different rooms during the conversations, and used the laptop to answer the questionnaires and interact with each other via Microsoft Skype. Each heart rate monitor was connected to an Android application to save the heart rate and interbeat intervals. The application has two buttons to start and pause the recording, and these buttons were used to ensure the synchronization and to collect the data only during the relevant phases of the study. We ensured that participants stayed at an appropriate position of the microphone to avoid the voice getting too loud or too low. Video recording software ran in the background and recorded all conversations. Finally, on one of the laptops we used software to modulate one of the user's voice during the conversations via Skype [55]. The voice of only one partner was modulated, and the kind of modulation (normal or calm tone) differed according to the randomized condition.

Measures

We used the following measures for each participant of the study. All partners answered the same questionnaires.

Emotions - Self-report

To measure how participants' emotional states were affected by the feedback, we employed a self report measure previously used for studying emotions during conflicts in dating couples [56][7]. Participants were asked to rate for 5 positive emotions (pride, joy, amusement, pleasure, love) and 5 negative emotions (disgust, annoyance, anxiety, sadness, embarrassment) to what degree they experienced each emotion on a scale from 1 (not at all) to 5 (a great deal). To account for baseline differences, we calculated a delta value which reflected the difference between the scores after the main conflict interaction and a neutral interaction. This approach is commonly used to analyze how emotions change from one experimental task to another [7][13].

Emotions - Physiological

Six physiological measures were computed from the heart rate data to assess participant's emotional reactions: average heart rate, mean interbeat interval, and the following heart rate variability (HRV) measures: rMSSD, HF, LF, LF/HF. The data collected was preprocessed and analyzed using the package RHRV [58]. Different from some physiological signals that can be used to infer only arousal, such as galvanic skin response, HRV is widely used to analyze the interplay between sympathetic and parasympathetic dominance, and the capacity

for regulated emotional responding [4]. Previous research has found correlations between HRV measures and emotional states, including stress [64] and anxiety [11]. In particular, high LF and LF/HF indicates sympathetic dominance, which represents higher stress and anxiety [21][32]. Conversely, high rMSSD and HF often indicates parasympathetic dominance, which is associated with a calm and relaxed state [34]. Similar to the questionnaires, delta values were calculated for each heart rate measure by calculating the difference between the scores of the conflict interaction and the baseline interaction.

Perception of the interaction

We used an adaptation of the Communication Patterns Questionnaire, Short Form (CPQ-SF) [12] to measure the perception of how positive the interaction was. The questionnaire is traditionally used to measure perceptions about conflicts in general, and we adapted it to refer to the specific conflict participants got involved in during the study. The questionnaire uses a 7-point Likert scale that ranges from 1 (Strongly Disagree) to 7 (Strongly Agree).

Procedure

After participants read and signed the consent forms, each participant was led to a separate experiment room. We adapted the dyadic emotion elicitation protocol for our study [57]. This protocol has been extensively used to elicit emotions by eliciting conflict interactions among couples. The protocol has been found to allow ecologically valid assessments of conflict within couples. We modified the protocol to allow for remote, voice-only interactions via Skype. Since we were interested in studying the effect of voice perception, the video was turned off to eliminate facial expressions as a potential confound. Our procedure involved 5 steps.

1. **Baseline and survey measures**: Before the experiment, participants were instructed to wear a heart rate sensor on their chest. Participants were then instructed to sit quietly for five minutes to record the heart rate in resting state. Afterwards, we asked participants to fill out several survey measures including the Areas of Disagreement questionnaire. The Areas of Disagreement questionnaire is typically used to identify a topic for the conflict conversation [22].

2. **Neutral interaction**: After filling out the questionnaires, participants were asked to have a normal conversation focusing on events of the day for 10 minutes. This discussion was used as a baseline. Participants were aware that their conversations were monitored. After the conversation, participants were asked to complete the self report emotion measure.

3. **Conflict Topic Selection**: During the neutral interaction phase, one of the researchers (unaware of the current condition of the study) reviewed the answers of the couples in the Areas of Disagreement questionnaire, and selected two discussion topics that both partners identified as a source of conflict. Immediately after the neutral interaction phase, the researcher brought both partners together in one experiment room to discuss the selected topic of disagreement. One partner after the other was asked to talk about a particular situation where a conflict related to the selected topic had happened. By judging how couples reacted while speaking, the researcher determined if the discussed topic was indeed a conflict laden one. If not, the researcher suggested a second topic for partners to talk about. The researcher followed the recommendations provided in [57] to prevent the couples from engaging in an argument during this period. This phase was typically completed within 5 minutes, upon which participants returned to their separate experiment rooms.

4. **Conflict conversation**: Once a conflict topic was identified, participants were led back to separate rooms, and asked to discuss the conflict topic for 10 minutes via Skype. Immediately after, participants were then asked to complete the self report emotion measure, and the measure that assesses the perception of the interaction (CPQ-SF).

5. **Final interview**: Finally, participants were asked after the study about their conversations, feelings, and about the study itself. The questions were asked to find out if participants were able to guess the purpose of the study, if they noticed anything odd during the tasks, and if they noticed any change in their voices. The responses from the participants were recorded by audio and written notes.

Results

Participant responses during the post-experiment interview were analyzed by the experimenters. None of the participants that received voice feedback with manipulation noticed the manipulation. Some participants reported that their voice seemed different, but they attributed the change to other causes. For instance, one participant mentioned "It sounded like my voice was getting lower, maybe because I'm getting sick, though".

The responses of the questionnaire measures and the HRV measures deviated from normality, so we conducted the analysis using the nonparametric Aligned Rank Transform (ART) procedure [70]. We examined the effects of manipulation type (normal voice; manipulated voice), feedback presence (no feedback; feedback), gender (male; female) and the interactions of these variables on the measures of emotion and perception of the interaction. We included couple as random factor to account for possible inter-dependency between data points caused by the social interactions [41][43][53].

Emotions - Self-report

The ANOVA analysis revealed a main effect of the voice feedback on self reported anxiety changes, $F(1, 18.80) = 10.83$, $p < .01$. Similarly, there was a main effect of the manipulation on anxiety changes, $F(1, 19.81) = 4.85$, $p < .05$. Figure 1 shows how the anxiety of the participants changed in each condition. As the figure shows, in all conditions participants' anxiety increased, except when participants received voice feedback with a calmer tone, in which the anxiety decreased (M = -0.41).

There was no significant effect of the manipulation, feedback or gender on the other emotions, and no interaction effects.

Emotions - Physiology

The ANOVA analysis revealed a main effect of the manipulation on the delta score of the LF/HF ratio. Participants in the manipulation group had lower LF/HF (M=-1.48) in comparison to the participants in the normal group (M=1.05), $F(1,$

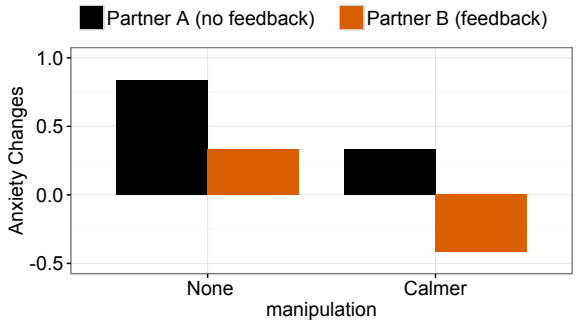

Figure 1. Changes in anxiety based on manipulation and feedback

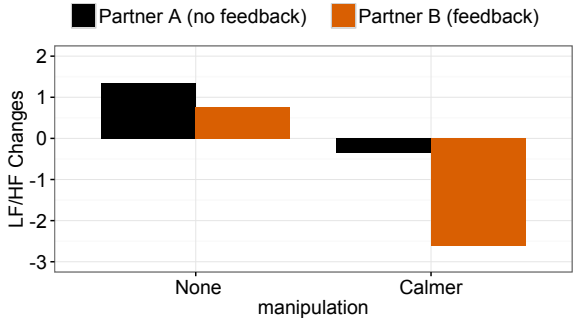

Figure 2. Changes in the HRV measure LF/HF based on manipulation and feedback

19.26)=5.57, p<.05. Figure 2 shows how the LF/HF ratio of the participants in the manipulation group decreased during the conflict, while the ratio increased for the other participants. No significant main effect of voice feedback or gender was found. Similarly, there were no interaction effects.

There was no effect of the manipulation, feedback or gender on the other heart rate measures, and no interaction effects.

Perception of the Interaction

The analysis of the Communication Patterns Questionnaire did not reveal any main effects or interaction effects. Although the average score of the manipulation group for "positive interaction" was higher (M=17.29, SD=1.96) in comparison to the group who did not receive the manipulation (M=16.50, SD=2.79), the differences were not statistically significant, F(1, 20.52)=0.28, p=0.60. Similarly, there was no effect of voice feedback, F(1, 18.39)=2.20, p=0.15, and gender, F(1, 26.16)=1.12, p=0.29, on people's perception of the interaction.

Discussion

The results of the study show that the manipulation was effective in regulating the anxiety of the participants who received voice feedback. While participants in the control group increased their anxiety after the conflict, the participants who received voice feedback with a calmer tone felt less anxious. Furthermore, there was a statistically significant decrease in the LF/HF ratio, which is a common measure used to estimate stress [32][64]. The results also indicate that the partners in the manipulation group who did not receive voice feedback were also affected by the manipulation, which can be seen in Figure 2.

Interestingly, none of the participants of the study noticed the voice manipulation. In the work from Aucouturier et al. [5], only three out of 109 participants detected that something was done with their voices when the same voice manipulation used in our study was applied. Our results corroborate the findings from Aucouturier et al. [5], and show that the intervention is so subtle that individuals remain unaware of it.

STUDY 2: CONTENTIOUS DEBATES

In Study 1, the goal was to influence emotions directly by changing voice self-perception. However, a technology can also elicit a particular mental state that indirectly affects people's emotions. This was the goal of our second study, in which we aimed to elicit the feeling of power, and in turn increase positive emotions.

We designed a three-condition (low pitch-self, high pitch-other, control) within-subjects study in which participants engaged in three short contentious debates seemingly with another person. However, unbeknownst to the participants, pre-recorded speech was used to represent the other person. In a randomly selected debate, participants received voice feedback with a 5.5% lower pitch (low pitch-self condition). In the control condition, the participants heard their own voice without any manipulation, and the pre-recorded speech was re-played as is. In the high pitch-other condition, the participant also heard their own voice, but the pre-recorded voice was re-played with a 5.5% higher pitch. In this way, we could examine if the effects of the low pitch-self feedback could generalize to different partner voices.

Research Questions

Power is an integral part of social life, and it is the primary method of organizing social relations [62][19]. During social interactions, people make quick judgments about their own and other people's power, and they rely on various cues to make these evaluations [62]. Previous research shows that low-pitch voices lead to the perception of dominance and power [54], while high-pitch voices are linked to perceptions of powerlessness [67]. One of the reasons is because pitch is associated with physical size, so a lower pitch suggests that the person producing the vocalization is bigger. Hence, the perception of a bigger size leads to the perception of related characteristics such as strength, power and dominance [50][54]. Interestingly, studies also show that individuals feel more powerful when speaking with a lowered voice pitch [63]. Since previous studies have not examined possibilities to affect power-perceptions through voice feedback, we wanted to examine the following research question:

RQ 1: How does providing voice feedback with a lower pitch influence a person's feelings of power during an interpersonal conflict?

Based on the research cited above, we expected that the voice feedback with a lower pitch would lead to higher self-perception of power when compared with the other conditions.

According to the approach/inhibition theory of power, high power is also associated with more positive mood and fewer negative emotions [40]. Furthermore, there is evidence that high power can reduce negative feelings during stressful situations [73][61]. Because of this reported relationship between power and emotion, we were interested in the following research question:

RQ 2: How does providing voice feedback with a lower pitch influence the emotions of the person during a conflict?

Participants

22 individuals were recruited via a large recruiting company (11 female). They participated in all conditions of the study and were paid $120 for taking part in the experiment. All participants completed a questionnaire that was used to screen who could participate in the study. We selected only the participants that had a liberal political view and that answered No, Yes, and Yes to the following questions: Is gay marriage wrong? Is racial profiling wrong? Should USA accept Syrian refugees? These questions were the topics of the debates, and they were asked in advance in the screening questionnaire to make sure that all participants would defend positions that they indeed believe. Before the experiment, all participants were informed that the goal of the study was to investigate how people respond to different forms of providing audio feedback via headphones.

Setup

We conducted the experiment in a sound-treated room at a large technology company. Each room contained a small table, two chairs, one desktop computer, one headphone (Howard Leight Sync Stereo Earmuff), and one microphone (Fifine K668). Participants used the computer to answer the questionnaires, created with SurveyGizmo, and used the headphone, microphone and computer to have a quick "debate with another participant". Unbeknownst to the participant, the other participant was actually a pre-recorded "rant" by an individual with experience in voice-overs. We used pre-recorded speeches to ensure that the conflict elicitation would be the same for all participants. The content of the speech was extracted from conservative postings on the web, including from the website debate.org and comments presented on news websites. The content was selected to represent an extremely conservative point of view, and it included sentences with personal attacks such as "You are stupid" and "You are seriously delusional". A pilot study revealed that the content selected for the debate topics were upsetting to those of liberal persuasion, and approximately equally so. We also conducted Flesch-Kincaid readability tests to ensure that each pre-recorded topic had a similar language (reading) level. In order to manipulate the voice of the participant, we used a software developed to elicit specific emotional tones [55]. Since the headphone used was noise isolating, we used the software to provide voice feedback during the other conditions with the same loudness used during the low pitch-self condition. In this way, we could ensure that the loudness of the voice feedback would not be a confounding factor.

Measures

Feeling of power

In order to measure people's feeling of power, we employed the same questionnaire as used by Marianne et al. [61] but with a 7-point scale. Participants were asked to indicate to what extent they experienced the following power-related feelings: strong, superior, dominant, weak, and powerless. Using these 5 measures, we computed a composite score for total power, by summing the scores of feelings positively correlated with power (strong, superior, dominant) and subtracting the feelings inversely correlated with power (weak, powerless).

Emotions

Emotions were measured using the Positive and Negative Affect Scale (PANAS) [69], a widely used survey instrument to measure both positive and negative affect.

Procedure

After signing the consent forms, participants were instructed that they would participate in short online debates about controversial topics with a conservative person.

In the beginning of the experiment, all participants answered questions about their demographics, emotions using the PANAS [69] and feeling of power [61]. After that, they watched a calming video for 3 minutes. The same video was reintroduced after each debate, so that the participant could calm down before the next debate, therefore reducing the possibility of a carry-over effect.

Before each debate, there was a preparation phase of 4 minutes. In this phase, the participant was assigned to one of the following topics: Is gay marriage wrong?; Is racial profiling wrong?; and Should the USA accept Syrian refugees?. The topics were randomly assigned across study sessions to counterbalance order effects. The participant had to defend the same liberal position he informed previously in the screening questionnaire, but he had to read predefined arguments for both positions (Yes and No). Paper and pen were provided so that the participant could write notes for the debate.

The debate started after the preparation phase. Participants were informed that they would have a quick debate with another participant, which was covertly a pre-recorded speech. Each debate had three turns of 1 minute and 30 seconds. The first and last turns were always for the in lab participant, while the second turn was the pre-recorded speech. The purpose of having only one turn for the "other participant" was to reduce the chances of the participant finding out that it was a pre-recorded speech.

After each debate, each participant answered questions about their emotions (PANAS), and their feelings of power during the debate.

Finally, a semi-structured interview was conducted after the study. We asked how participants were feeling, what they believed the study was about, and if there was anything unusual in the voice feedback they received through the headphone. Based on their responses, follow-up questions were asked. All responses were saved with written notes. After the interview, we explained the study and its true purpose in details.

Table 1. Descriptive statistics of the power questionnaire

	Control (n=22)	High Pitch -Other (n=22)	Low Pitch -Self (n=22)
	Mean (SD)	*Mean (SD)*	*Mean (SD)*
Feeling of Power	7.68 (6.91)	6.86 (6.54)	**10.32 * (4.80)**

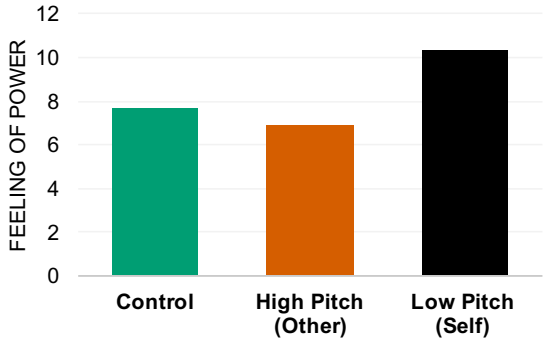

Figure 3. Feeling of power in each condition (control, high pitch-other, and low pitch-self)

Results

Participant responses during the post-experiment interview were analyzed by the researchers. None of the participants correctly guessed the purpose of the study, but four participants found that the "other participant" was a pre-recorded speech. Therefore, we removed these four participants from the analysis. Different from study 1, in this study all participants noticed the voice manipulation, by stating that their voice was "deeper", "lower" or "darker". A follow-up question revealed that 5 out of the 22 participants got distracted with the voice manipulation. These participants informed that the voice was too different from their own, and it seemed like another voice was being played back instead of their actual voice. However, all 5 participants mentioned that they became less distracted after getting involved in the debate. The remaining 17 participants did not report being distracted by the voice manipulation.

The responses of the questionnaires did not meet the standards of normality, so we conducted the analysis using the nonparametric ART procedure [70]. The experimental condition (low pitch-self, high pitch-other, control) and gender were included as fixed effects. Participant and debate topic (syrian refugees, gay marriage, racial profiling) were added as random factors to account for the repeated measures and the variation based on the topics.

Feelings of Power

Lowering the pitch of the participants resulted in an observed increase in people's feelings of power, $F(2, 39.16) = 3.87$, $p < .05$. Separate ANOVAs for each measure present in the power questionnaire revealed that participants felt stronger, $F(2, 39.16) = 5.27$, $p < .001$, and more dominant, $F(2, 39.18) = 4.31$, $p < .05$. Table 1 summarizes the results for each group, and Figure 3 shows a graph with the differences across conditions.

There were no effects of the low pitch manipulation on the other power measures, and no interaction effects.

Table 2. Descriptive statistics from the PANAS questionnaire

	Control (n=22)	High Pitch -Other (n=22)	Low Pitch -Self (n=22)
	Mean (SD)	*Mean (SD)*	*Mean (SD)*
Positive Emotions	29.41 (9.60)	29.59 (8.74)	30.73 (8.88)
Negative Emotions	13.91 (4.83)	14.05 (4.15)	12.73 (3.32)
Positive/Negative	2.28 (0.87)	2.23 (0.84)	2.49 (0.77)

Emotions

Although participants felt more powerful when listening to their voices with a lower pitch, this change did not affect their emotions, according to the responses provided with the PANAS questionnaire. There was no effect of the condition on positive emotions, $F(2, 39.30) = 0.90$, $p = .41$, negative emotions, $F(2, 39.25) = 1.68$, $p = .19$, or on the ratio of positive to negative emotions, $F(2, 39.30) = 2.31$, $p = .11$. Table 2 shows descriptive statistics of the emotions for each condition.

Discussion

The results of the experiment show that the manipulation was effective in increasing feelings of power. After the debates in which participants listened to their voices with a pitch 5.5% lower, they reported an average feeling of power of 10.32, which is higher than the feeling of power perceived in the control condition (M=7.68) and the condition in which the pre-recorded speech was played with a higher pitch (M=6.86). The analysis of each measure from the power questionnaire revealed that participants felt stronger and more dominant.

The results of this study extend the results from Stel et al. [63]. In [63], the authors found that people can feel more powerful by consciously lowering the pitch of their voice. In this study, we showed that it is also possible to increase individuals' feeling of power by automatically manipulating their own voices with a lowered pitch, and playing it back to them through a headphone.

Although the power elicitation was effective, it did not lead to changes in participants' emotions. The ratio of positive over negative emotions was slightly larger during the debates with low pitch feedback, but the change was not statistically significant. It is possible that the context of the study, in which participants had a heated "interaction" with a person that they did not know, did not encourage participants to have more positive emotions. If the study had been designed to have people that know and care about each other as participants, such as romantic couples, maybe the results would have been different.

Finally, all participants in this study noticed that their voices were changed, and 5 out of 22 participants got distracted with the voice manipulation, particularly in the beginning of each debate. The voice manipulation in this study was more evident

than in Study 1, so although it did not distract most of the participants, it was still noticeable and distracting for some people.

GENERAL DISCUSSION

Our studies examined the emotions and perceptions of individuals during interpersonal conflicts as a function of whether participants listened to their own voice with or without a voice tone manipulation. In this section, we discuss our findings and suggest possible implications for theory and design.

Implications for Theory

In the first study, dating couples engaged in conflicts via Skype. Within each couple, one person received their own voice feedback through headphones. Among the persons who received voice feedback, some received feedback without any manipulation, while other partners listened to their own voice with a calmer tone. The results show that participants who perceived their own voice with a calmer tone felt less anxious and stressed during and after the interpersonal conflict, which was revealed through self-report and physiological changes. Moreover, the results show that the partners of the individuals who received the manipulation were also affected by the manipulation, since they also felt less anxious after the conflict, although the change was not as large as for the participants who received manipulated voice feedback.

In the second study, participants engaged in contentious debates while receiving voice feedback through headphones with a 5.5% lower pitch. The results reveal that in the debates where participants perceived their voice with a lower pitch, they felt more powerful, dominant, and strong.

The findings of the two studies contribute to the literature on self-perception theory [6]. According to Bem, individuals determine their attitudes, emotions and other internal states by interpreting the meaning of their own behavior given a particular context [6]. In both studies, we changed how some participants perceived their own vocal behavior, and we found that the feelings and emotions of the participants changed in a congruent direction with the manipulation. Although previous studies have provided experimental evidence of the self-perception theory [5], our study is the first to evaluate the theory in the context of interpersonal conflicts using an automated method.

Although some of our findings were consistent with our expectations and previous research, some questions remain to be resolved. In study 1, for instance, it is unclear why participants who did not receive voice feedback were also affected by their partners, who did receive the manipulation. One hypothesis is that the participants who perceived their voice as calmer, changed their behavior in a way that was perceived and reacted to by their partners. In this case, this would be consistent with previous research that shows that the effects of one person's emotion regulation efforts can affect the cardiovascular arousal, emotional behavior and emotional experience of their corresponding partners, even when the partners are oblivious to those regulation efforts [9] [7].

Implications for Design

In this section, we discuss some design considerations regarding the use of the method of changing voice self-perception to regulate emotions. Furthermore, we present some potential scenarios where the method can be used, including contexts that do not involve interpersonal conflicts.

Keeping it Subtle

One limitation of emotion regulation systems is that they often require conscious attention and effort from users, so it can be unfeasible to use these technologies during interpersonal conflicts or in any other scenario in which individuals have to focus on their current tasks. The findings of the studies described in this paper show that it is possible to regulate user's emotions and feelings without requiring user's conscious attention and effort. This approach is different from current technologies for emotion regulation, which either prompt users to perform certain tasks or rely on reflection.

The results of study 1 show that none of the participants noticed the voice manipulation, so they were able to talk with their partners without having to focus on any technology to regulate their emotions. In study 2, however, some participants got distracted by the technology, mentioning that the voice manipulation made their voices sound very different from their own. These findings suggest that it is important to consider user's perception thresholds when deciding the voice manipulation to apply. A voice manipulation that it is too distracting can harm more than help the user, so it is crucial to identify the tipping point in which the technology is effective without being disruptive.

Triggering the Intervention

One important question about the application of the method described in this paper is: When to trigger the intervention? The most obvious way of doing that is by triggering the intervention manually. For instance, users could manually start whenever they believe that a conflict may arise during an online conversation. However, this approach contrasts with one of the main goals of the method, which is keeping the intervention subtle and effortless. Therefore, one alternative approach is to trigger the intervention automatically. In this case, a technology could analyze the behavior or emotions of the user, identify if the user may need to regulate their emotions, and automatically start the intervention. The technology could rely on signals such as users' voice [44], facial expressions [51] or physiological signals [32], and automatically adjust the voice feedback accordingly. If, for instance, a user starts to demonstrate anger during an online video call, by raising their voice and furrowing their eyebrows, the technology could then start to play back their voice with a calmer tone. To avoid a sudden change in user's voice and potentially disrupt the conversation, the technology could start with a small change and subtly keep increasing the manipulation as required.

Being Aware of its Purpose

In both studies described in this paper, participants were not informed about the true purpose of the study. This was done to avoid biased responses from participants, which could jeopardize the results. Therefore, one question that remains is if the intervention is also effective when users know that their voice

is being manipulated to elicit a particular emotional response. This is an important question to focus on in order to understand if this kind of technology can also be effective in real life. We believe that if a technology that changes user's self-perception is used outside of the laboratory, the user should always be aware of the purpose of the technology and how it works. This is crucial to ensure that the technology is being used to help the user achieve their own goals.

In order to investigate if the technology works even when users are aware of its purpose, we seek to conduct another study in which participants are explicitly informed about the purpose of the voice feedback before the experiment. Although this may bias the responses in the questionnaires, we could focus on indirect measures of emotional experience, including behavioral expressions (e.g. prosody, facial expressions) and physiological signals (e.g. galvanic skin response, heart rate variability).

Making it Ubiquitous

Although the software that we used in the studies was not developed for mobile devices, previous research has shown an iPhone application developed for similar purposes [1]. If a mobile application to regulate how a user perceives their voice is used in combination with earphones, this could potentially be used as a tool to regulate people's emotions in any setting, and not only in computer-mediated communication. This is an interesting direction to explore, since most social interactions happen face-to-face. The technology could then be used in several contexts, including therapy sessions, training scenarios, or even during daily interactions.

Usage Scenarios

The findings of the study focusing on contentious debates show that our method can be used to boost people's self-perception of power and dominance, which may be useful in some contexts in which individuals aim to express these characteristics, such as during business meetings, public speaking presentations, or negotiations. Furthermore, since previous studies found that vocal behavior can predict job interviews, salary negotiations and speed dating encounters [52], it would be interesting to investigate if it is possible to positively influence the outcomes of social interactions by changing how individuals perceive their voice in these contexts. By feeling more powerful as a consequence of the voice feedback, people might improve their confidence and performance during social-evaluative situations.

It is important to note that the method of altering user's voice self-perception could be applied in other contexts besides interpersonal conflicts. One interesting possibility is regulating the emotions of individuals with mental health conditions. Previous research shows that individuals with mood disorders such as social anxiety, bipolar disorder, and schizophrenia, are more sensitive to the way they perceive their own behavior and bodily signals. A person with social anxiety, for instance, is very self-conscious during social interactions, and is constantly looking for cues, including their own voice, gestures and body movements, to infer how well she is doing. By noticing signals such as a jittery or creaky voice, the person is more likely to feel anxious, and this negative self-perception can even trigger panic attacks. However, despite how anxious the voice of the person may actually sound, a technology could override their voice with another one that makes the person perceive their voice as calm and confident. Thus, the person could feel less anxious during social interactions, which could potentially have a huge impact on her everyday life.

Limitations and Future Work

In this paper, we focused our attention on the influence of voice self-perception on emotions and feelings. However, one aspect that remains to be explored is if the behavior of individuals that perceive their voice in a different way is also affected. In the future, we seek to analyze the behavior of the individuals that participated in the two studies, in order to investigate if some our findings can be explained by differences in behavior. In particular, the finding that partners who did not receive voice feedback felt less anxious after the conflict, suggests that participants who received the manipulated voice feedback changed their behavior in a way that affected their interacting partners. By analyzing the behavior of the participants, such as their prosody, facial expressions, and spoken words, we should be able to identify the effect that the manipulation had in their expressive behavior.

One limitation of the first study is that participants were mostly students, who have been in a relationship for less than a year. Although young couples also have disagreements, our results could have been different if we had recruited married couples instead.

CONCLUSION

In this paper, we presented a subtle approach for regulating emotions during interpersonal conflicts, which consists in changing how people perceive their own voice. By leveraging theories and findings from emotion regulation, conflict management, nonverbal signals and self-perception, we conducted two studies focusing on interpersonal conflicts, in which participants received voice feedback through headphones with a specific emotional tone. In the first study, romantic couples had conversations about conflicts via Skype, and we found that individuals who perceived their voice with a calmer tone felt less anxious and stressed. In the second study, participants who got involved in contentious debates felt more powerful when they heard their voices with a lower pitch. In both studies, participants were able to focus on their conversations without drifting their attention away to any emotion regulation technology, showing that the intervention does not require attention or effort to be effective. These findings offer promising opportunities for the design of technologies for emotion regulation.

ACKNOWLEDGMENTS

This material is based upon work supported by the NSF IIS under grants #1344587 and #1421929, and by the Swiss NSF under grant #1344587.

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