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Article

Engineering Power Attributions in Conversational Agents - The Unexplored Impact of Vocal Vibrato and Vocal Tract Length

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Conversational Commerce



Engineering Power Attributions in Conversational Agents

The Unexplored Impact of Vocal Vibrato and Vocal Tract Length

This work provides evidence for designing perceived power-related personality traits of conversational agents based on vocal features. The vocal vibrato and the vocal tract length of a female and a male humanlike voice, respectively, were systematically manipulated to derive recommendations for voice engineering.

Fotis Efthymiou



AI-driven conversational agents are popular devices that assist consumers in their daily routine in a number of different ways, from providing information to controlling other devices in a household. Lately, such conversational agents are also becoming part of the workforce in companies, establishing even more strongly their presence in people's lives. The more frequent interactions with conversational agents, combined with the advanced technology we currently possess as well as the strong tendency of humans to anthropomorphize non-human entities make consumers infer anthropomorphic information about these agents (Lee & Nass, 2005; Payr, 2013). In most cases, anthropomorphizing of conversational agents makes users perceive them as more likeable entities, extend the engagement with them (Saarem, 2016), and improves their overall experience while interacting (Wagner et al., 2019).

An increasing body of research suggests that different human traits (personality traits) can be expressed in conversational agents by altering characteristics such as their color, motion or vocal features (Lee et al., 2019). Extrovert (Nass & Lee, 2001), empathetic (Pereira et al., 2010) and humorous (Niculescu et al., 2013) are a few examples of personality traits that have been achieved by altering the aforementioned characteristics of conversational agents. However, many other personality traits have not been demonstrated by conversational agents yet. Fundamental to all social species is the expression of power traits that can be inferred by nonverbal behaviors such as rapid gait and erect postures as well as verbally through loud and deep-pitched voices (Burgoon & Dunbar, 2006). The current research focuses on vocal parameters, examining how manipulations of vocal vibrato or vocal tract length (one at a time) change people's perceptions of conversational agents' power-related personality traits in a female and a male voice, respectively.

This line of research combined with the voice analytics tools we possess can provide new insights on the consumer-technology relationship (Hildebrand et al., 2020). Conversational agents already play a role in customer service and advisory contexts and offer several benefits to companies as sleepless agents. In the near future it is very likely to see them in different industries as our colleagues in the workplace that we have daily interactions and need to cooperate with. Additionally, conversational agents could be used in voice-based advertising campaigns, representing products or brands. This study examines power in human-conversational agent interactions, a concept that has received great attention in human-human interactions due to the ability of power to influence behaviors in social relationships (Burgoon & Dunbar, 2006).

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The following paragraphs elaborate on the concepts of power, vocal vibrato and vocal tract length, review existent literature on conversational agents' personalities and, eventually, link the parameters of vocal vibrato or vocal tract length with specific power-related personality traits based on the empirical findings. Finally, managerial implications and avenues for further research are discussed.

Perceptions of Power and Interrelated Constructs

Power takes various forms and influences a wide array of dynamic social relationships by altering people's way of thinking, feeling and acting (Guinote, 2017). Power is closely linked to numerous constructs such as dominance, leadership, expertise and even neuroticism. Dominance and submissiveness are two sides of the same coin, very much related to power relationships and expressed in power moves (Tiedens & Fragale, 2003). Leadership has mainly been addressed in the context of a workplace where leaders hold power as a natural tool to enhance their effectiveness (Fuqua et al., 2000). Knowledgeability and expertise are forms of non-coercive power (Chapais, 2015) and neuroticism is a personality trait that has been negatively associated with referent power and positively associated with coercive power (Karkoulian et al., 2009).

The numerous psychological consequences of power lead to behavioral alterations. For example, power alters people's eagerness to take an action (Keltner et al., 2003), their capacity to adopt other people's perspectives (Galinsky et al., 2006), as well as their emotional experience, expression and responsiveness (van Kleef & Lange, 2020). People with a status of high power show increased self-importance and tend to rely on themselves, whereas people with a low status tend to strongly depend on others (Rucker & Galinsky, 2016). From a managerial perspective, the exercise of expert and referent power contributes to building trust relationships between a buyer and a seller (Busch & Wilson, 1976) as well as between

sales managers and salespersons (Busch, 1980). Moreover, the construct of dominance has been shown to play an important role in advice adherence in professional service conversations, with “dominance transition” (dominant provider in the pre-advice stage to dominant customer in the post-advice stage) leading to enhanced advice adherence due to customers’ increased perception of common ground (Wang & Yim, 2019).

The Concepts of Vocal Vibrato and Vocal Tract Length

Vocal vibrato is a pulsating sound effect produced by the consistent modulation of the vocal fundamental frequency (pitch) (Sundberg, 1995) which – when expressed in the voice – adds quiver. The role of vocal vibrato has been addressed in the context of singers’ voices and has been found to depend on different factors such as age, sex and emotionality, with higher emotional involvement of singers tending to increase the vibrato rate (Shipp et al., 1980). To the best of our knowledge, vocal vibrato has been largely unexplored in the field of digital conversational commerce. In this study the vocal vibrato of Amazon Polly’s female voice (Joanna) was set at three different levels (details are described below) and changes in the perceived power-related personality traits of each conversational agent’s voice were examined.

Another unexplored characteristic is the vocal tract length, which directly influences the timbre of the voice. By

definition, the vocal tract in humans and other animals is the anatomical structure that begins with the vocal folds, terminates at the lips and has the shape of a tube (Fitch & Giedd, 1999). The role of this tube is to filter the ascending frequencies that the vocal folds produce (Fitch, 1997). A longer vocal tract corresponds to a more resonant voice and vice versa. Vocal tract length is closely related with physical characteristics (e.g., height and weight) (Fitch, 1997) but also with personality traits (Armstrong et al., 2019; Holzleitner et al., 2014). Thus, the vocal tract length feature of Amazon Polly’s male voice was adjusted at five different levels (details below) and changes in the perceived power-related personality traits of each conversational agent’s voice were examined.

Perceived Personalities of Conversational Agents

As pointed out earlier, humans have the tendency to anthropomorphize non-human agents even in their most basic interactions (Heider & Simmel, 1944). It is therefore not surprising that in our interactions with conversational agents, we often ascribe qualities (e.g., personalities) to them in the same way we do for human beings, based on the expressed vocal features and gender of the agent. For instance, fast-paced female synthesized voices are perceived as more extrovert personalities, whereas fast-paced male synthesized voices as more neurotic (Lee et al., 2019). Furthermore, female conversational agents with high-pitched voices are perceived as having higher knowledgeability on topics related to love and relationships, male conversational agents with low-pitched voices as having higher knowledgeability on technical issues (Saarem, 2016). Here we examine additional vocal features and test how they influence perceived power-related personality traits of conversational agents.

Study Design and Results

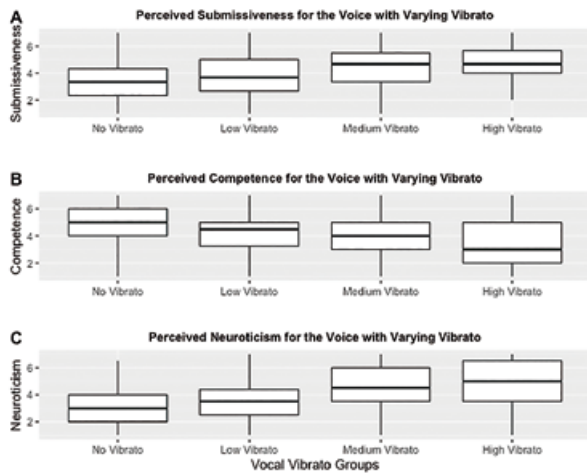
The following sections present two different studies where we systematically manipulated one vocal parameter (vocal vibrato or vocal tract length) and examined alterations in the conversational agent’s perceived power-related personality traits. We report the tools we used for the manipulations and our main findings.

Study 1 – Vocal Vibrato

Study 1 investigates how the increase of vocal vibrato influences the following perceived personality traits: submissiveness, competence and neuroticism.

Management Summary

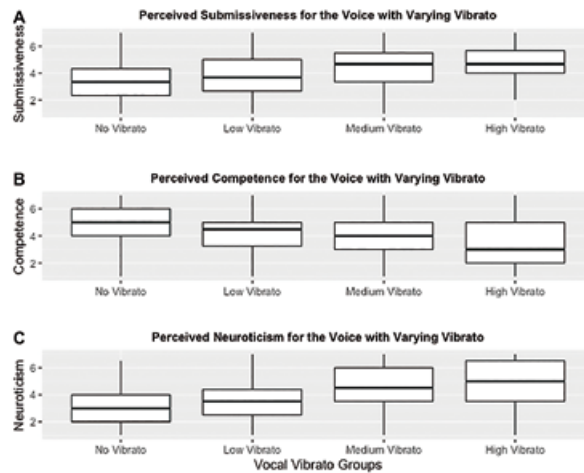
People around the globe frequently use AI-driven conversational agents (e.g., Amazon’s Alexa or Apple’s Siri) for personal and professional purposes. Consumers have a tendency to anthropomorphize these conversational agents, ascribing human attributes to them including emotions and fundamental personality traits. While human-to-human interaction research underscores the importance of vocal features on perceptions of power-related personality traits (e.g., dominance, competence, leadership styles), research on conversational AI has not progressed toward a more fundamental understanding of how subtle cues in the humanlike voice of an agent impact consumer perceptions of power. This study addresses this gap by systematically altering the vocal vibrato and the vocal tract length feature of conversational agents’ voices and measuring their impact on power attributions. Potential practical implications of the manipulation of the aforementioned vocal parameters are discussed.

Fig. 1: Personality Perceptions for a Human-like Voice with Varying Vocal Vibrato

Source: Own illustration.

In this study, a total of $N = 379$ participants ($M_{Age} = 31.69$, 51.45% male) were randomly assigned to four conditions differing in the extent of vocal vibrato of a conversational agent's voice. We used the AWS Amazon Polly interface for speech formation (Amazon, 2020) and the PRAAT vocal toolkit as an established tool to manipulate the conversational agent's voice (Corrette, 2012). The vocal vibrato of the original voice was used as a baseline whereas in the three other groups the extent of vibrato was systematically increased such that all voice output was scaled up by one semitone each (from semitone = 2 to semitone = 4). We refer to the voice with semitone = 2 as "low vibrato", the semitone = 3 as "medium vibrato" and the semitone = 4 as "high vibrato". Participants were asked to listen to five randomly generated sentences with a duration of 2–4 seconds and were subsequently requested to answer questions about the perceptions they formed with regard to the conversational agent while listening to the voice.

The results of this study showed that voices with increased vocal vibrato were perceived as significantly more submissive ($F(3,375) = 17.95$, $p < .001$) (Fig. 1A), less competent ($F(3,375) = 12.13$, $p < .001$) (Fig. 1B), and greater in neuroticism (Chi square = 68.51, $p < .01$, $df = 3$) (Fig. 1C) compared to the baseline voice. In addition, people who listened to the conversational agents with the additional vocal vibrato reported feelings of high power towards them compared to the ones who listened to the original voice

Fig. 2: Personality Perceptions for a Human-like Voice with Varying Vocal Tract Length

Source: Own illustration.

($F(3,375) = 4.36$, $p < .01$), without any power manipulation from our side beforehand.

Study 2 – Vocal Tract Length

Study 2 investigates how the manipulation of vocal tract length influences the perception of the following personality traits: leadership, dominance and strength of personality.

In this study, 243 participants ($M_{Age} = 39.37$, 56% male) were recruited from an online panel. A between-subjects design was used, randomly assigning participants to one out of five conditions that differed only in terms of the vocal tract length feature. The stimuli were created using the AWS Amazon Polly text-to-speech interface, a service that turns text into lifelike speech (Amazon, 2020). Specifically, the integrated synthesized male voice of "Matthew" was used and the vocal tract length (VTL) feature derived from the Speech Synthesis Markup Language (SSML) which is integrated in the Amazon Polly interface was systematically manipulated. Specifically, VTL was increased and decreased in steps of 10% to create two longer VTL conditions (+10%, +20%) and two shorter VTL conditions (–10%, –20%). Participants were asked to listen to five randomly generated sentences (the same as in the previous study) with a duration of 2–4 seconds and were subsequently requested to answer questions about the perceptions they

formed while listening to the voice regarding a number of different personality traits.

Significant differences in perceptions were found between the short vocal tract length conditions and the baseline. Both conditions with decreased vocal tract length (−10% and −20%) were perceived as having weaker leadership qualities (Chi square = 33.43, $p < .001$, $df = 4$) (Fig. 2A), a less strong personality (Chi square = 48.79, $p < .001$, $df = 4$) (Fig. 2B), and less dominant traits (Chi square = 36.85, $p < .001$, $df = 4$) (Fig. 2C) compared to the baseline voice. One of the conditions with increased vocal tract length (+20%) was perceived as a more dominant entity compared to the baseline (Chi square = 36.85, $p < .001$, $df = 4$) (Fig 2C).

Discussion and Conclusions

With the rapid increase of conversational agents and their progressive usage for numerous applications in both domestic and professional contexts, there is no question that they will shape the way we work and interact in the future. Different conversational agents are designed to support different activities and assume different roles. Supporting healthcare professionals, providing financial advice, or promoting a product or brand in an advertising campaign are some examples of daily applications conversational agents are currently used for.

This study investigated the perceived power-related personality traits (leadership, dominance, etc.) of two different conversational agents by manipulating their vocal vibrato or the vocal tract length. The findings suggest two different ways of designing power-related personality traits of conversational agents by exclusively manipulating their voices. Furthermore, we break new ground regarding the question how pow-

er can influence the dynamics of human–conversational agent interaction by linking vocal parameters to certain power-related personality traits. Further research should investigate the exact transition points where people’s perceptions towards the personality of a conversational agent start changing.

Managerial Applications

The subject of power in relationships between humans has been extensively investigated. Lately, there has been increasing interest regarding the role of power in interactions with conversational agents. For instance, people in a state of high power perceive interactions with anthropomorphic conversational agents as low-risk, whereas people in a state of low power perceive such interactions as high-risk (Kim & McGill, 2011). Additionally, power has been found to shape the interactions between consumers and conversational agents in a shopping paradigm (Tassiello et al., 2021). With the increasing availability and use of conversational agents, the concept of power could be of great importance in dyadic human–conversational agents relationships.

To leverage their full potential, managers should design conversational agents’ personalities according to the purpose they want to accomplish and the role they want to assign to the agent. Personality can be expressed effectively through vocal features; thus, managers should carefully examine the specific vocal characteristics of conversational agents. For instance, in scenarios where conversational agents assist people with their investment plans, or with navigation directions while driving, it would be preferable to utilize a voice that transmits a strong and competent personality that humans can trust; potentially a voice with a long vocal tract. On the other hand, in scenarios


Main Propositions

1. Linking specific vocal features to certain personality traits allows us to design the desired traits and avoid the unwanted ones.
2. Conversational agents’ personality traits should be designed according to a company’s brand personality or the role they are intended to accomplish.
3. Further research on the design of conversational agents’ personalities based on vocal features is necessary.

Lessons Learned

1. Conversational agents’ vocal vibrato and vocal tract length play a pivotal role in how they are perceived by humans in terms of power-related personality traits.
2. Conversational agents’ power-related personality traits can be engineered by voice manipulation.
3. Conversational agents should not be treated by managers as a “black box” but rather as a malleable entity that can be shaped according to their roles.

where conversational agents are getting utilized as medical assistants it would be preferable to use a caring and less dominant voice; potentially a voice with either a shorter vocal tract or additional vocal vibrato. Similar to conversational agents, products and brands also have personalities. Congruency between conversational agents' vocal features and product or brand

traits could be beneficial and might be used in advertising contexts as a cheap and fast way of promotion. Tailoring humanlike voices according to their role exploits the full potential of making conversational agents even more valuable and vital for companies. Further investigation is needed on what kinds of humanlike voices best match different roles. 

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