Title
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Journal
Discourse Studies: an interdisciplinary journal for the study of text and talk, 22(2)

ISSN
1461-4456

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Publication Date
2020-04-01

DOI
10.1177/1461445619893796

Peer reviewed

HHS Public Access
Author manuscript
Discourse Stud. Author manuscript; available in PMC 2021 April 01.

Published in final edited form as:
Discourse Stud. 2020 April ; 22(2): 174–204. doi:10.1177/1461445619893796.

Let's talk about pain and opioids: Low pitch and creak in medical consultations

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Abstract

In recent years, the opioid crisis in the United States has sparked significant discussion on doctor-patient interactions concerning chronic pain treatments, but little to no attention has been given to investigating the vocal aspects of patient talk. This exploratory sociolinguistic study intends to fill this knowledge gap by employing prosodic discourse analysis to examine context-specific linguistic features used by the interlocutors of two distinct medical interactions. We found that patients employed both low pitch and creak as linguistic resources when describing chronic pain, narrating symptoms, and requesting opioids. The situational use of both features informs us about the linguistic ways in which patients frame fraught issues like chronic pain in light of the current opioid crisis. This study expands the breadth of phonetic analysis within the domain of discourse analysis, serving to illuminate discussions surrounding the illocutionary role of the lower vocal tract in expressing emotions.

Keywords

Doctor-patient interaction; Opioids; Chronic Pain; Creak; Pitch; Prosody; Discourse Analysis; Sociolinguistics

1. Introduction

Despite growing sociolinguistic interest in the study of intraspeaker voice-quality variation and the role that linguistic choices play in shaping identity and creating social meaning (Mendoza-Denton, 2011; Podesva, 2007; Wilce, 1997), there remains little research in the field of clinical sociolinguistics—the application of linguistic or phonetic techniques to the study of communication in the medical space (Ball *et al.*, 2008). This exploratory study attempts to fill this knowledge gap by conducting prosodic discourse analysis (Chafe, 1993) to describe the different vocal features that patients employ when discussing issues concerning chronic pain and opioids with their physician. We found that patients use both low pitch and creaky voice when (1) narrating symptoms or describing pain and (2) requesting opiates.

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Unlike bruises, the symptoms of chronic pain are not always visible, and so patients use "talk"—among other methods such as illustration and demonstration—to describe their suffering and express their complaints and symptoms to the physician (Heath, 2002). Linguistic practices are especially important in such discussions because there are no objective clinical tests to measure chronic pain (Sullivan and Ferrell, 2005). Consequently, clinical assessments and treatment decisions regarding pain are often based solely on the patients' verbal manifestations of pain and suffering (Burgess *et al.*, 2008; Turk and Okifuji, 1997; Henry and Eggly, 2013).

The current opioid crisis heightens the relevance of investigations focusing on verbal manifestations of pain. In 2011, the United States Center for Disease Control and Prevention (CDC) declared prescription drug abuse as a national epidemic after deaths from accidental overdose exceeded fatalities from vehicular accidents. Because complaints about chronic pain can be interpreted as drug-seeking behavior (Højsted and Sjøgren, 2007), the manner in which patients communicate their chronic pain to physicians may be different from how they discuss other types of pain. Merrill *et al.* (2002) found fear and mistrust as dominant themes in discussions of opioids for both physicians and patients. Roberts and Kramer (2014) expressed the need for analyzing linguistic practices in medical appointments where pain medications are discussed because issues related to controlled substances are fraught with questions of ethical and moral nature, as well as the potential for abuse and/or the fabrication of symptoms to justify drug-seeking behavior. Matthias *et al.* (2013) echo this point, calling for more direct explorations to better understand pain management communication. To meet this need, this study offers a phonetic perspective of how patients discuss chronic pain and opioids at a time of crisis. Moreover, because acoustic or prosodic analysis has mostly been used in clinical sociolinguistics to address pathological speech issues (Cernak *et al.*, 2017; Dudy *et al.*, 2018), this research further broadens the applicability of this method by examining actual doctor-patient dialogue.

2. Related Literature

2.1. Behavioral Manifestations of Pain

Pain research seeking to improve doctor-patient communication on chronic pain management is necessary; given that both patients and physicians have reported this dialogue to be challenging and frustrating (Henry *et al.*, 2016). Turk and Okifuji (1997) revealed that neither the severity nor duration of pain solely influence physicians to prescribe opioids. Their findings showed that it is, in fact, the behavioral manifestation of pain—which includes audible expression of distress—that impacts such important healthcare decisions. Subsequent studies on pain management (Hughes *et al.*, 2015; Matthias *et al.*, 2013, 2014) agree that there is value in investigating the prosodic nature of displaying pain in doctor-patient dialogue. This study does just that by bridging voice quality issues to their context-specific discourse functions in medical encounters.

2.2. Voice Quality: Modal versus Creak

Voice quality, as it is used here, refers to the type of phonation speakers produce in the larynx. A speaker, at will, can strategically assume different voice qualities like high or low pitch, whisper, falsetto, breathy, and creak to portray certain attitudes and emotions (Couper-Kuhlen, 2015; Esling, 2012).

Modal phonation refers to the neutral or typical form of speaking, in which speakers talk within the natural pitch range of their voice. The everyday use of the word "pitch" describes the degree of highness or lowness of a tone. Linguistically, pitch is the perception of the rate of vocal fold vibration and that targeting a remarkably low pitch may result in irregularly spaced vocal pulses known as creaky voice or "vocal fry" (Berry, 2001).

Creak and, to a certain degree, low pitch[1], are both products of epilaryngeal constriction—a process of the lower vocal tract that results in the shortening, bunching, and adduction of the vocal folds, leading to lower pitch frequencies and, consequently, the shifting from modal to non-modal phonations like creak[2] (Esling *et al.*, 2019).

2.3. Interpreting Use of Pitch in Discourse

The introduction of "contextualization cues" in the 1970s—fully interpretable and indexical linguistic signs that possess an embedded context—opened the idea that linguistic styles such as shifting of pitch and use of creak can carry information (Gumperz, 1982; see also Van Dijk 1999, 2011). Later research, including that of Tannen and Wallat (1987: 208), provided evidence that identifiable linguistic cues such as register—"prosodic choices deemed appropriate for the setting and audience"—could be used in the analysis of medical discourse. A speaker's register can also be described in terms of intonation, the variations in pitch often used in English to express the purpose of utterances as well as understand the attitudes and emotions of other speakers (Couper-Kuhlen, 2015). For example, the use of rising and falling intonation usually helps us understand the difference between statements and questions, among many other ways of regulating discourse.

Earlier studies on pitch and intonation elicited the help of actors to portray emotions because of the idea that neutral speech must also be gathered as a baseline for comparison. Using this method, Zetterholm (1998), as well as Bänziger and Scherer (2005), found that both pitch lowering and creak portray sadness. The design of this study expands on Cruttenden's (1997) work on intonation, which highlights the idea that a speaker's register is "marked" when the entire pitch configuration of an utterance is transposed towards the higher or lower limits of their vocal range. In this study, we illustrate "markedness" by using the speaker's average pitch as a baseline to assess instances in which their pitch deviates significantly from the typical. This method allows for the examination of linguistic style and the information that actual spontaneous speech carries without the need of actors or "neutral speech stimuli."

1. While epilaryngeal constriction passively lowers pitch, it does not necessarily constitute active pitch lowering. As Moisik (2013) puts it, the constriction synergizes with low pitch.

2. It is important to note that epilaryngeal constriction could result in different types of non-modal phonation, including varying degrees of creak like "harsh" and "pure" (Moisik, 2013). In the present study, we collectively use the term "creak" to refer to all of its variants.

2.4. Interpreting Use of Creak in Discourse

Creak is one particular stylistic feature used in creating social meaning that has sparked interest among sociolinguists and discourse analysts. Scholars have studied the relationship between the use of creaky voice and social class (Esling, 1978), gender and sexuality (Henton, 1986; Zimman, 2012, 2013), and stance (Grivicic and Nilep, 2004; Slobe 2018). According to Anderson *et al.* (2014), the use of creaky voice is becoming increasingly common among young American women and that listeners take the use of creak as untrustworthy and less educated. There are, however, several studies showing that young women's use of creak is perceived as more dominant and authoritative yet non-aggressive (Borkowska and Pawlowski, 2011; Yuasa, 2010).

While most studies on vocal fry have focused on linguistic attitudes towards young women, there are a few that have examined the contextual application of creak in discourse. More importantly, these studies have looked at the use of voice quality from an intraspeaker perspective —i.e., how an individual employs specific phonation styles in particular discourse contexts—as opposed to the essentializing nature of interspeaker research. Podesva (2007) is among the pioneers in exploring the situational use of creak by taking context, topic, and audience into account. Podesva has demonstrated how a speaker from Long Island named Heath manipulates pitch and strategically employs creak to construct a "diva persona." Similarly, Mendoza-Denton (2011) analyzed the speech of "Babygirl" and suggested that creak is a discourse-dependent variable employed in the construction of a Chicana hard-of-heart (hardcore) identity. The present study addresses the lack of similar research in realm of medical discourse.

Although creak has been generally understudied in the domain of doctor-patient interactions, there is a key study that provides valuable insight for the present analysis. Notably, Wilce (1997) wrote about the use of creak by Bangladeshi patients to signal weakness, low energy, and misery when interacting with biomedical doctors, herbalists, exorcists, and diviners. Wilce points out that the "markedness" or saliency of creak brings attention to the utterance and lends credibility to the speakers' reference to their own pain, therefore making vocal fry a learned and internalized social sign that carries particular discourse functions. Similarly, this study pays attention to "marked" speaking turns, in which the speaker's use of creak and low pitch are perceptually prominent.

3. Methodology

Using prosodic discourse analysis, this study narrows down the different vocal features employed by two patients as they discuss opioids and chronic pain issues with their physicians.

3.1 Participants

Both patients and their respective physicians were recruited from a hospital-based primary care resident clinic in California. Both patients are taking opioid for chronic pain. To account for individual sociolinguistic backgrounds, it is important to note that the participants self-identify as females and are native speakers of American English. Interlocutor information are presented in Table1.

The primary purpose of patient A's visit was to request a refill for her opioid prescription after being denied by a different physician due to recent revelations that another pain clinic was already prescribing her with opioids, among other reasons. The physician's attempt to steer patient A towards alternative means of pain management was met with resistance. On the other hand, Patient B's reason for scheduling a consultation was to switch to a different type of opioid.

The choice to look at a small number of participants is appropriate in investigations involving language-in-action as it allows for a thorough analysis of the discourse contexts that surround the style shifts in question (Schilling-Estes, 1998). Echoing Podesva's (2007: 498) perspective on voice quality being a vehicle for social meaning, examining the context-specific use of linguistic variables lends insight into speakers' intentions and the functionality of their utterances. In this case, analyzing patterns in which patients employ creak and low pitch informs us about their understanding of the discourse functions both variables serve in the medical space.

3.2. Dividing Discourse into Speaking Turns

To adequately and consistently quantify pitch, we separated the data in terms of individual speaking turns, which refers to the entire speech of a specific speaker before another interlocutor mediates and converses. In the following sequence, because of patient A's quick pause, the physician was able to inject a quick backchannel response. As much as patient A's second turn is a continuation of the first, we consider them as two separate turns.

1. P-A: But he wanted me to quit immediately, just like that.
2. DOC: Yeah.
3. P-A: And I told him, "I can't do that. You can't just quit -- methadone like that."

It is important to note that "overtalks"—situations in which more than one speaker is talking at once—were excluded from the analysis since they do not provide for an accurate pitch analysis. Brief backchannel responses such as "uh-huh," "okay," and "right," were not considered as well.

3.3. Measuring Pitch and Assessing Creak

Although pitch is the term regularly used in describing the listener's judgment of what they hear, it is also the perception of the rate of vocal cord vibration in Hertz (cycles per second). In other words, pitch is the subjective attribute of the voice's fundamental frequency (f0) estimate (Bendor and Wang, 2005). Though certain distinctions exist between the use of both pitch and fundamental frequency (f0), their relationship is established enough to allow us to talk about the speaker's pitch through f0 measurements (see Gerhard, 2003). This approach enables us to present auditory judgments in a quantitative manner. Pitch or f0 values were obtained using Praat® software (Boersma and Weenik, 2013). Recordings were extracted using Audacity® software (Version 2.1.2, freeware, ©1999–2014. Audacity Team. http://audacity.sourceforge.net/). Background noise was removed through spectral noise gating—a process that works well when the signal in the recording is much louder than the noise[3].

Unlike modal utterances, we cannot simply generate accurate pitch values for creak since its f0 is extremely low and the spacing between the pulses are too irregular (Keating *et al.*, 2015). Thus, creaky voice was distinguished from modal voice through perceptual identification followed by examining waveforms and spectrograms to guarantee accuracy. The acoustic analysis in determining creakiness employs the same criteria used by Henton (1986), Gordon and Ladefoged (2001), Podesva (2007), and Mendoza-Denton (2011). Creak is acoustically exemplified by one or more of the following: (1) the irregular spacing of the glottal pulses in wideband spectrographic displays, (2) inconsistencies in f0 values due to slowing of vocal fold vibrations, (3) the abrupt decline in f0, (4) irregularity in the period of each cycle (pitch perturbation or jitter), (5) irregularity in the amplitude of each cycle (amplitude perturbation or shimmer), (6) decreased acoustic intensity relative to modal phonation, and (7) fewer pitch periods per second relative to modal counterpart. For speaking turns that have both modal and creaky segments, only the modal segments were tracked for pitch. This information is summarized in Table 2.

Figure 1 summarizes the acoustic analysis section of our methodology.

The decision to represent pitch through f0 frequency is defensible because this technique can easily be replicated in the medical setting. For instance, if pitch were to be added to patients' medical notes in order to take records of how they speak in certain contexts, reporting f0 acoustic data would be viable rather than manually noting impressionistic data.

3.4. Coding of Speaking Turns: Pain-Related vs Non-Pain-Related

To point out the linguistic features both patients use to discuss opioids in light of the current crisis, each speaking turn was coded into different contextual categories using a modified version Chronic Pain Coding System (CPCS) developed by Henry *et al.* (2016). CPCS focuses on the objective characterization of utterances involving pain and opioids, making it appropriate for the current study. There are three main contextual categories included in the two doctor-patient interactions observed: (a) discussions about chronic pain and the opioid medication used to manage it; (b) discussions related to the other types of pain not involving opioids; and (c) discussions that are not about pain. Tables 3, 4, and 5 present the various subcategories under each of the three primary categories mentioned, together with sample excerpts from both patients.

Three coders coded for categories, including a physician and two sociolinguists trained in discourse analysis of medical interactions. The odd number of coders allows for a majority rule in cases of disagreements[4]. The Fleiss (1971) interrater reliability for these categories by three individual coders is 0.915.

3. Using a Fourier analysis of the first few seconds of the recording, Audacity creates a noise profile used in filtering out the rest of the recording. Both audio files were filtered using the following setting: a noise reduction of 12 decibels with a sensitivity parameter of 3 and frequency smoothing bands set at 0. Audacity can also generate the "noise residue," or the noise to be filtered out, which was useful in verifying that the audio was not compromised.

4. In the rare case where all three coders selected distinct codes, each made a case for their decision until an agreement was reached.

4. Results and Discussions

4.1. Acoustic Analysis

Table 6 shows Patients A and B’s individual average pitch as well as the mean pitch for the three major categories.

Both patients spoke with lower pitch in utterances that focused on pain, more so if the pain-related discussion involved opioids (including requests and positive assessments of opioids, as well as description of pain in relation to the prescribed opioid). The following diagrams provide a visual representation of each patients’ vocal range and the frequency at which each speaking turn’s average pitch occurs.

As shown in Figure 2, the speakers’ pitch in turns that were about pain and opiates were lower. Patient A’s pain-related utterances that were not in the context of opioids have speaking turns that are distributed towards the upper registers of her speaking voice. Towards the second half of her visit, patient A repeatedly raised her voice and over-enunciated some words for emphasis. Although pitch is not synonymous to volume, patient A’s pitch went up as she intensely argued. Nonetheless, it is in the context of pain and opioids in which she speaks in the lower range of her register. On the other hand, patient B’s use of low pitch is clearer. Table 7 provides a stratified list of results, specifying the average pitch for each subcategories.

After narrowing down the categories, we found that both patients had the lowest pitch when narrating or describing chronic pain or asking for the opioid medication they use to remedy that pain. Figure 3 demonstrates mean pitch distributions for both patients in the following discourse contexts: (i) request for opioid treatment and (ii) description/narration of pain.

It is important to note that the lowering of both patients’ pitch is not restricted to only the concluding segments of a speaking turn. Low pitch also occurs in other parts of the turn and are mostly sustained once initiated. Moreover, there is no correlation between the length of a turn and the potential for pitch lowering.

Examples of instances in which both patients lower their pitch when discussing chronic pain and opioids are shown in Figures 4a and 4b below.

In what follows, we present our findings on the use of non-modal phonation, creak.

4.2. Entirely Creaky Speaking Turns

Although pitch cannot be measured for creak, we still coded the entirely creaky speaking turns to study the context in which the feature is used by both patients (See Table 8).

Of all of the creaky turns, 65 percent of Patient A’s and 85 percent of Patient B’s were about pain. Figures 5 and 6 provide examples of waveforms and spectrograms of words articulated in both creaky and modal phonation. At the bottom of each figure are waveforms zooming into the beginning of the vowel to show the differences in periodicity.

The creak and modal examples above adhere to the characteristics outlined in the methodology section. Both creaky examples have aperiodic glottalization, lower acoustic intensity, and significantly lower amplitudes in comparison to their modal counterparts. The spacing between pulses is more regular with the modal examples. Figure 6a also has alternating longer and shorter pulses that is often characteristic of creaking (Keating *et al.,* 2015). Lastly, the pitch values are irregular in Figure 5a and completely undetectable in Figure 6a.

5. Discussion

Our study demonstrates that pitch or f0 values were lower and the use of creak was more apparent when both patients discussed chronic pain and opiates. Because both phonation styles are associated with the lower vocal tract and the use of lower register, it is not unexpected that creaky segments are detected in utterances with low modal pitch, as shown in the examples below.

In excerpt (1), patient A informs the doctor about not being prescribed with opioids by another physician. The primary reasons for the denial include patient A’s toxicology results and the fact that she is already taking another opioid from another pain clinic. (The numbers in parenthesis represent the mean pitch of each turn’s modal segment while utterances in bold denote creak).

(1)

1. Physician: Alright. So -- um -- alright, let’s start with what you would like to talk about.
2. Patient A (139.9 Hz): Okay, and I was very upset with my last visit with Dr. <name>.
3. Physician: M-mm.
4. Patient A (136.1 Hz): He wouldn’t prescribe any an- -- any meds, any pain medication that day, so I’ve been without Norco for almost two months now.
5. Physician: Hm-mm.
6. Patient A (181.4 Hz): I’ve been in extreme pain, with my shoulder that is still hurting. I can’t do physical therapy, because my -- I might even need to have surgery. **I wanna see the s-, the surgeon again, because it’s just not healing.**
7. Physician: Hm-mm.
8. Patient A (169.5 Hz): **It’s not healing at all**. And, I mean, he’s with me day and night practically when he’s not at work, and for the past four years we’ve been together, and **he can verify** -- **um -- the pain that I’m going through -- with all this.**

Lines 6 and 8 are examples of turns in which patient A describes her pain using low pitch and creak. In both turns, the patient’s pitch is seven and thirteen percent lower, respectively, compared to her overall average of 195.298 Hz. In line 4, patient A proves that not all requests have to take the interrogative form. According to Robinson (2001), implicit or indirect requests can take any grammatical form as long as the utterance performs its soliciting function in the context of the medical visit. Line 4 is coded as an opiate request because the purpose of the turn was not only to inform the physician that no opiate has been prescribed but also to suggest that the situation must be addressed. In this turn, the patient's pitch is 30 percent lower than the baseline.

The pairing of low pitch and creak in opiate requests is also discernible in patient B's speech as shown in excerpt (2) below. In the beginning of this exchange, patient B asks to be prescribed with Cymbalta, Neurontin, and Lyrica, none of which are opiates. She proceeds to talk about the main reason for her visit, which is to get the opiate, Dilaudid, added into her pain contract.

(2) (Utterances in bold denote creaky voice)

1. Physician: How can I help you today?
2. Patient B (166.0 Hz): Uh, there's a few things. Uh, the <u>Cymbalta</u> that—I don't remember his name, but the last doctor I saw—put me on the <u>Cymbalta</u>.
3. Physician: Yeah.
4. Patient B (152.6 Hz): Uh, I don't have any more and there was [*sic*] no refills, so -- I've still got that.
5. Physician: I can certainly refill that for you if that seems to be helping.
6. Patient B (160.7 Hz): Okay. Yeah, I think it does help a little bit with **the anxiety and stuff.** I don't know if it's helping with the pain, **um—**
7. Physician: The, the effect on the pain might be sort of subtle... it may, it may be helping to reduce the amount of other pain medicines you require.
8. Patient B (172.2 Hz): **Unless—my—cuz [*sic*] I did pretty good, I think—-with the <u>Dilaudid</u> they did give me.** And also, uh, I took the <u>Neurontin</u> three times a day. I really have a hard time remembering to do that three times a day all the time.
9. Physician: Uh huh.
10. Patient B (184.5 Hz): And I, I have taken <u>Lyrica</u> before. It was just a two-week trial...

In the example above, patient B lists four medications she wants to be filled, yet it's worth noting that creak was only employed in the discussion of pain and Dilaudid in lines 6 and 8. In line 6, patient B introduces the idea that Cymbalta does not address her chronic pain, which consequently leads to the reveal that it is the opiate Dilaudid that helps in line 8. The comments on lines 6 and 8 are coded as requests—implicitly delivered through negative evaluation of a non-opiate drug in line 6 and a positive assessment of the opiate in line 8. Starting in line 10 up until opiates are discussed again, patient B goes back to speaking with her regular modal voice, making the use of low pitch on discussions about controlled substances and chronic pain more apparent.

Irvine (2001) suggests that we could interpret the motivations behind the use of certain linguistic styles by examining situations in which it is absent. We found that requests for non-opiate medication have no semblance of low pitch and creak, as shown in the example below:

1. Patient B (193.4 Hz): Oh, the Robaxin. Um, could you guys change that from 100 to 120 tablets for a month?

In this excerpt, the request for the muscle relaxant, Robaxin, takes the conventional interrogative form. Such straightforward request contrasts the suggestive opiate requests presented earlier. In fact, both patients started the discussion on opioids by "reporting" its effectiveness while simultaneously highlighting the presence and severity of their chronic pain. According to Robinson (2001) and Gill *et al.* (2001), reporting—in the form of assessments—is used by patients to implicitly make sensitive requests like asking for addictive medications, without revealing their position towards the request[5].

Excerpt (3) below illustrates an exchange in which patient B neither uses creak nor lowers her pitch to discuss a condition that is not addressed by an opioid.

(3)

1. Physician: Anything else that uh I can help you with today?
2. Patient B (193.0 Hz): Uh, my asthma. I live in Sunnyville, and it was pretty much fogged in smoke.
3. Physician: Okay.
4. Patient B (190.5 Hz): And it started bothering my asthma right away.
5. Physician: Oh.
6. Patient B (194.7 Hz): My sat was 95, but—I've been using my inhaler a lot.

Our data show that both patients find value in switching to a distinct register when discussing chronic pain and opiates. Going back to Cruttenden's (1997) notion about register, the salient shifting in pitch indicates emphasis to what is being said. Considering that both patients overwhelmingly use low pitch and creak in very specific contexts tells us that both linguistic variables are being employed for stylistic work. Specifically, both phonation styles serve as pragmatic resources used to express pain as well as to request the medication that they believe best manages their misery.

5.1. The Nature of Opioid-related Utterances

These findings raise a significant question: what is distinct about the topics of chronic pain and opiates that motivate the change in vocal style? The opioid crisis has brought stigma to the discussion of controlled substances, which has made requesting opioids a fraught process within the medical setting. We already witness such effect in this study, through both patients' suggestive framing of requests. Roberts and Kramer (2014) found that patients

5. Our data also shows that both patients resort to more straightforward demands only when implicit requests are left unaddressed.

orient issues surrounding pain medications as problematic, morally suspect, and easily refusable. Patients have to confront the effects of the opioid crisis by increasing their sensitivity towards the potential concerns that doctors may have about dependency and addiction when prescribing opioids. Frequently, patients find it necessary to defend their moral character and present themselves as credible, responsible, and aware when the topic and requests are sensitive, challenging, have high chances of denial, potentially controversial, and morally fraught. It is evident from our findings that such tasks are accomplished by both patients through the situational use of low pitch and creak.

What sets opioid-related conversations further apart is the fact that it could be a source of disagreement because patients and physicians often do not share the same priorities when it comes to managing chronic pain (Henry *et al.,* 2017). In fact, a post-visit survey given to the participants in this study reveal that both patients ranked “reducing pain intensity” as their most important goal while their respective physicians placed higher emphasis on improving the patient’s overall function. Alerting physicians about the use of specific vocal features in disagreeable discussions like opioids, could alert them to confront the disagreement by returning the conversation to goal setting.

Clearly, our findings show that the dynamics involved in medical encounters involving chronic pain and opiates are indeed different from other primary care visits. If the entirety of patient A’s appointment were about her constipation while patient B’s were about her asthma, the linguistic practices they would employ throughout their consultation would less likely involve creak and pitch lowering, as suggested by the way they discussed these same concerns in this study.

5.2. Discourse Functions: Expressiveness of Low Pitch and Creak

Patients cannot always show visible evidence of chronic pain, therefore their only recourse is to express their symptoms using the primary activity that takes place in medical interactions: talking. This raises the question as to why creak and low pitch are used in conjunction with requests for opiates. What do these variables index? We already know that low pitch/f0 and creak collaboratively portrays sadness, misery, weakness, certainty, and credibility (Bänziger and Scherer, 2005; Borkowska and Pawlowski, 2011; Wilce, 1997; Yuasa, 2010). According to Podesva (2007), the common denominator that describes the polysemic functions carried by a linguistic variable is its “expressiveness”—indexed within the particular discourse contexts in which the variable is repeatedly employed. As such, our analysis of the conversational contexts suggests that the discourse functions low pitch and creak serve include: (a) addressing medical issues that are delicate, important, morally fraught, bound to receive an assessment, and could possibly be refuted; (b) self-reporting chronic pain symptoms, which could be difficult to prove and easily questioned due to lack of methods to properly evaluate it; and (c) requesting addictive painkillers that could easily be refused or interpreted as drug-seeking behavior.

6. Conclusion

This exploratory study examined important linguistic features present in two doctor-patient interactions on chronic pain management. Through discourse analysis, we found that the patients lowered their pitch and employed creak when discussing chronic pain and opioids with their physicians. Both features are associated outcomes of epilaryngeal constriction, which in itself carries paralinguistic functions (Moisik, 2013). This study expands the breadth of phonetic analysis within the domain of discourse analysis, leading to the need to explore topics involving the illocutionary role of the lower vocal tract in expressing emotions.

Studying micro-linguistic practices in the medical space may improve the overall efficacy of health communication, which is vital for setting shared pain management goals and reducing inappropriate opioid prescribing (Henry *et al.*, 2017). The situational use of low pitch and creak tells us about how patients frame conversations on opioids in light of the current medical climate. Patients, regardless of intention, are tasked with navigating the challenging and fraught discussion of opioids, knowing well that their requests could be refused or their symptoms questioned. Awareness of the discourse functions of low pitch and creak during discourse may alert physicians about the possible concerns of patients. Recognizing such discernible shift in register could also signal the physician into bringing the discussion back towards their shared goals.

Additional investigations would allow us to discover whether men use the same vocal features when interacting with doctors. Lastly, examining the correlation between auditory judgments and prescribing decisions through a perception test could also further this study.

Acknowledgements:

We would like to express our sincere gratitude to Teun Van Dijk and anonymous reviewers for their expert feedback. Their incisive and thoughtful comments helped reconceptualize several parts of this exploration. Of course, all remaining faults are our own.

Funding: The videos analyzed in this study were collected with funding from the National Institutes of Health (grants KL2TR000134 and UL1TR000002) and the University of California, Davis Department of Internal Medicine.

Appendix A:: Coding Scheme

R1A	**Request for Non-Opioid treatment**
R1B	**Request for Opioid treatment** Request for opioid increase. Request for routine opioid refill. Patient request for opioid switch.
R1C	**Unclear request regarding Prescription**
R2	**Request for information and logistics** Request related to logistics. Patient requests for information. Patient request for non-opioid pain treatments.
T2D	**Opioid related threats/red flags** Patient statements about serious opioid side effects and red flags. Statements about less serious opioid side effects. Opioid-related threats.
E2	**Narration of pain and description of symptoms**
T1A	**Positive assessments /satisfaction with non-opioid treatments.**
T1B	**Negative assessments / dissatisfaction with non-opioid treatments.**

T1C	**Expressions of uncertainty or ambiguity about a non-opioid treatment plan.**
T2A	**Positive assessments / satisfaction with opioids.**
T2B	**Negative assessments /dissatisfaction with opioids.**
T2C	**Expressions of uncertainty or ambiguity about opioids.**
N1	**Disagreement or resistance.**
N3	**Agreement**
X	**Non Pain Related Utterances**
H	**Other Pain Related Utterances**

Appendix B:: Pitch Tracking Data for Patients A and B (Summaries at the end)

Patient A

Speaking Turn	Context	Mean	Min	Max	Range	Opioid Context	Pain Context
9	H	164.783	120.73	208.855	88.125		✓
12	H	163.907	130.007	204.602	74.595		✓
	H	184.007	128.17	246.504	118.334		✓
14	H	184.689	135.189	228.14	92.951		✓
	H	186.901	138.096	214.035	75.939		✓
	H	183.109	125.165	300.135	174.97		✓
16	H	179.63	145.518	218.222	72.704		✓
22	R1B	136.113	119.113	283.215	164.102	✓	✓
24	E2	177.309	125.172	246.814	121.642	✓	✓
24	E2	185.491	135.693	233.374	97.681	✓	✓
26	E2	169.521	136.813	204.808	67.995	✓	✓
28	H	174.096	129.277	219.569	90.292		✓
30	H	173.692	121.563	264.423	142.86		✓
32	H	193.155	157.114	262.798	105.684		✓
34	H	183.187	158.745	214.013	55.268		✓
45	H	197.092	115.095	324.744	209.649		✓
47	H	200.927	149.362	335.386	186.024		✓
49	H	191.869	115.343	298.943	183.6		✓
53	H	192.296	150.457	227.269	76.812		✓
67	H	206.175	134.382	303.281	168.899		✓
69	H	186.492	147.243	255.286	108.043		✓
71	H	195.17	144.291	274.186	129.895		✓
73	H	203.499	169.799	249.01	79.211		✓
75	H	190.273	144.114	253.458	109.344		✓
102	H	190.403	144.018	251.154	107.136		✓
104	H	173.239	125.369	246.372	121.003		✓

Speaking Turn	Context	Mean	Min	Max	Range	Opioid Context	Pain Context
106	H	214.232	142.61	266.435	123.825		✓
108	R1B	182.516	139.534	243.977	104.443	✓	✓
110	R1B	157.005	137.904	198.482	60.578	✓	✓
118	R1B	184.221	159.142	280.263	121.121	✓	✓
120	R1B	185.716	155.096	251.27	96.174	✓	✓
122	R1B	187.532	155.309	306.435	151.126	✓	✓
124	H	205.96	134.761	301.223	166.462		✓
126	H	173.122	152.454	273.56	121.106		✓
128	H	186.943	154.141	239.359	85.218		✓
130	H	210.177	142.305	265.149	122.844		✓
132	E2	168.11	111.353	246.173	134.82	✓	✓
136	H	210.058	163.922	248.125	84.203		✓
138	E2	149.553	130.15	165.406	35.256	✓	✓
140	H	193.969	143.913	256.311	112.398		✓
142	H	189.595	130.251	212.011	81.76		✓
144	H	192.092	167.696	228.539	60.843		✓
146	H	171.283	121.216	222.346	101.13		✓
148	H	192.422	146.019	259.952	113.933		✓
158	H	183.827	158.028	216.97	58.942		✓
169	H	196.024	157.312	233.51	76.198		✓
171	H						✓
173	H						✓
186	X						
188	X	206.509	125.535	221.292	95.757		
193	X						
208	X						
216	X	209.451	142.896	256.617	113.721		
218	H	189.623	160.729	212.696	51.967		✓
221	X						
231	X						
239	H	203.089	122.546	317.979	195.433		✓
247a	R2	205.438	140.842	259.43	118.588		✓
247b	R2						✓
254	H	193.994	167.462	214.392	46.93		✓
260	H	203.373	155.662	313.438	157.776		✓
262	H	197.593	168.619	232.01	63.391		✓
271	H	186.351	115.262	252.639	137.377		✓
273	X	201.51	143.765	244.479	100.714		
275	X	203.438	136.561	216.375	79.814		

Speaking Turn	Context	Mean	Min	Max	Range	Opioid Context	Pain Context
279	X						
303	H						✓
305	H						✓
307	H						✓
311	H						✓
313	H						✓
315	H						✓
317	H						✓
319	H						✓
325	H	168.923	115.235	220.667	105.432		✓
341	H	179.78	129.131	219.357	90.226		✓
357	R1C	199.216	154.459	270.33	115.871		✓
359	T2D	190.259	145.832	238.316	92.484	✓	✓
361	T1B	190.415	157.972	242.936	84.964		✓
363	H	192.312	157.468	273.975	116.507		✓
365	H	195.694	147.233	274.21	126.977		✓
369	H	204.48	126.311	285.751	159.44		✓
371	H	215.318	161.889	270.477	108.588		✓
373	H	203.487	168.835	253.628	84.793		✓
375	H	219.21	141.131	279.262	138.131		✓
377	T2D	200.914	143.658	250.758	107.1	✓	✓
379	H	219.21	131.131	289.22	158.089		✓
381	R1B	180.93	146.658	228.98	82.322	✓	✓
383	E2	167.792	127.175	232.103	104.928	✓	✓
387	E2	169.769	132.357	207.39	75.033	✓	✓
389	H	197.88	145.9	289.67	143.77		✓
399	T2A	187.040	142.160	235.904	93.744	✓	✓
401	H	181.878	155.250	252.788	97.538		✓
407	H	200.035	124.344	253.802	129.458		✓
411	H	199.921	161.501	267.553	106.052		✓
425	H	200.073	130.863	284.587	153.724		✓
427	**H**	199.385	156.325	290.202	133.877		✓
443	X	200.899	140.533	238.628	98.095		
447	X	202.271	143.439	247.937	104.498		
451	X	198.665	137.752	287.606	149.854		
453	X	199.63	168.179	291.13	122.951		
491	H	180.386	159.74	263.798	104.058		✓
493	H	169.453	134.69	231.948	97.258		✓
495	N1	201.775	155.35	279.71	124.36		✓

Speaking Turn	Context	Mean	Min	Max	Range	Opioid Context	Pain Context
499	H	192.941	145.153	295.153	150		✓
503	N1	196.534	149.131	253.357	104.226		✓
505	T1B	181.846	155.153	257.07	101.917		✓
507	H	180.464	165.953	253.843	87.89		✓
509	H	202.224	156.481	274.004	117.523		✓
511	T2D	187.441	143.887	251.711	107.824	✓	✓
513	T2D	192.885	136.668	255.098	118.43	✓	✓
517	H	203.678	134.614	287.051	152.437		✓
521	H	197.946	163.413	286.381	122.968		✓
523	H	228.889	154.041	373.66	219.619		✓
525	H	207.04	162.16	305.904	143.744		✓
527	T2D	199.972	155.253	292.426	137.173	✓	✓
529	T1B	208.439	155.087	296.758	141.671		✓
531	N1	203.858	156.22	278.364	122.144		✓
533	E2	180.552	128.571	218.881	90.31	✓	✓
535	H	210.425	151.954	302.841	150.887		✓
537	H	219.52	138.365	276.878	138.513		✓
539	R1C	212.914	156.313	302.98	146.667		✓
541	R1C	196.888	134.199	302.186	167.987		✓
543	N1	195.955	134.43	288.258	153.828		✓
545	H	211.177	174.251	294.834	120.583		✓
547	T2D	204.082	174.684	285.723	111.039	✓	✓
549	H	198.736	173.114	290.267	117.153		✓
551	R1B	188.943	130.45	265.995	135.545	✓	✓
553	N1	201.676	166.885	292.605	125.72		✓
555	H	213.585	140.02	294.485	154.465		✓
557	H	184.469	132.948	225.704	92.756		✓
559	R2	187.834	152.264	221.348	69.084		✓
562	R1C	225.412	177.142	285.305	108.163		✓
564	N1	203.757	150.412	292.27	141.858		✓
566	H	208.579	138.25	288.655	150.405		✓
568	T1B	203.338	135.995	300.237	164.242		✓
570	R2	213.39	154.772	284.089	129.317		✓
572	H	235.596	156.295	310.296	154.001		✓
574	H	214.883	169.737	313.636	143.899		✓
576	H	221.902	152.495	279.186	126.691		✓
578	H	220.564	169.27	292.588	123.318		✓
596	E2	179.961	119.002	215.887	96.885	✓	✓
598A	E2	170.218	138.593	204.603	66.01	✓	✓

Speaking Turn	Context	Mean	Min	Max	Range	Opioid Context	Pain Context
598B	T2D	244.784	158.553	397.457	238.904	✓	✓
600	H	202.84	171.158	298.37	127.212		✓
602	H	214.079	153.633	290.977	137.344		✓
604	T2A	213.443	148.843	282.315	133.472	✓	✓
606	T2D	200.694	181.216	282.63	101.414	✓	✓
608	H	190.604	155.014	287.312	132.298		✓
610	H	191.14	163.84	261.937	98.097		✓
614	N1	180.394	152.649	267.89	115.241		✓
618	N1	198.061	177.285	302.704	125.419		✓
620	N1	214.741	174.543	292.981	118.438		✓
622	H	199.76	171.271	302.349	131.078		✓
626	T1B	206.748	162.679	290.65	127.971		✓
628	E2	187.54	142.816	260.246	117.43	✓	✓
630	N1	199.482	158.285	289.327	131.042		✓
632	H	206.054	178.051	308.142	130.091		✓
634	H	204.211	176.155	311.083	134.928		✓
636	H	209.86	158.6	311.024	152.424		✓
638	H	207.745	166.702	314.258	147.556		✓
642	H	192.382	154.829	292.289	137.46		✓
644	H	183.437	173.388	281.969	108.581		✓
646	R2	199.755	163.888	267.17	103.282		✓
654	H	212.745	166.702	314.258	147.556		✓
658	X	202.745	146.702	242.258	95.556		
660	R2	202.366	145.511	304.686	159.175		✓
664	H	182.366	145.511	244.686	99.175		✓
674	N1	219.293	157.325	282.693	125.368		✓
676	H	205.766	174.508	310.662	136.154		✓
678	H	203.675	143.088	316.62	173.532		✓
680	T2D	218.837	151.444	306.27	154.826	✓	✓
686	H	207.516	137.65	271.281	133.631		✓
688	H	219.621	197.805	279.329	81.524		✓
690	H	189.258	168.801	297.935	129.134		✓
692	H	180.787	160.833	198.839	38.006		✓
696	H	190.905	180.207	273.403	93.196		✓
698	H	198.72	156.461	290.714	134.253		✓
700	H	190.164	169.417	282.201	112.784		✓
702	R2	187.912	149.705	226.951	77.246		✓
704	R2	184.456	133.748	229.723	95.975		✓
706	R2	183.906	143.671	205.45	61.779		✓

Speaking Turn	Context	Mean	Min	Max	Range	Opioid Context	Pain Context
708	T2D	183.333	170.926	283.102	112.176	✓	✓

Shaded rows denote entirely creaky speaking turn.*

Patient B

Speaking Turn	Context	Mean	Min	Max	Range	Opioid Context	Pain Context
8	X	166.005	140.428	235.628	95.2		
10	H	152.624	125.386	173.289	47.903		✓
12	R1A	138.099	121.188	159.123	37.935		✓
16	H	199.853	100.725	305.317	204.592		✓
18	T1C	160.675	134.325	186.21	51.885		✓
26	T2A	177.498	157.108	198.591	41.483	✓	✓
28	T2A	172.222	141.605	300.588	158.983	✓	✓
30	H	179.623	138.108	241.546	103.438		✓
32.1	H	184.535	100.304	287.728	187.424		✓
32.2	H						✓
34	H	145.018	114.272	162.64	48.368		✓
36	R2	176.542	135.526	197.539	62.013		✓
38	R1B	162.562	122.836	194.049	71.213	✓	✓
40	H						✓
42	H	158.633	119.406	230.721	111.315		✓
44	H						✓
54	H	141.135	118.557	156.776	38.219		✓
56	H						✓
58	H	177.983	122.46	195.193	72.733		✓
60.1	H	161.995	101.918	261.306	159.388		✓
60.2	H	129.865	106.853	152.301	45.448		✓
64	T1C	178.737	119.766	285.424	165.658		✓
66	H	139.418	123.954	154.07	30.116		✓
76	H	156.025	111.376	187.743	76.367		✓
78	H	154.524	115.797	368.434	252.637		✓
80	H	147.852	134.949	177.544	42.595		✓
82.1	T1A	179.491	104.647	288.368	183.721		✓
82.2	T1A	151.381	109.638	261.261	151.623		✓
88	T1B	155.842	121.583	181.912	60.329		✓
90	X	167.448	103.391	170.093	66.702		
94	X	176.489	108.333	183.876	75.543		
98	X	168.945	132.691	185.592	52.901		
102	X	214.178	147.974	308.762	160.788		

Speaking Turn	Context	Mean	Min	Max	Range	Opioid Context	Pain Context
104	X	194.182	101.334	326.326	224.992		
106	X	153.429	100.17	199.934	99.764		
108	X	162.764	114.468	163.471	49.003		
110	X	160.113	114.763	170.869	56.106		
122	N3						✓
126	T1A						✓
128	R1B	146.012	121.302	195.268	73.966	✓	✓
130	R1B					✓	✓
132	T2A	168.296	127.908	208.535	80.627	✓	✓
142	H	214.225	117.833	302.108	184.275		✓
144	R1B	165.902	106.659	298.712	192.053	✓	✓
148	H	166.445	111.287	243.513	132.226		✓
150	R1B					✓	✓
156	T2A	185.18	143.841	278.464	134.623	✓	✓
158	H						✓
160	H						✓
162	H	182.424	140.498	210.107	69.609		✓
168	H	195.336	133.528	277.355	143.827		✓
170	H						✓
172	E2	154.31	128.947	184.763	55.816	✓	✓
174	E2	139.91	129.548	176.8	47.252	✓	✓
182	H	148.48	117.604	195.388	77.784		✓
184	H	136.775	113.395	163.366	49.971		✓
186	H	142.943	116.584	181.127	64.543		✓
188	H						✓
190	H	180.28	115.232	208.892	93.66		✓
192	H	156.778	121.067	184.443	63.376		✓
196	X	166.715	137.05	183.725	46.675		
198	X	161.427	137.1	223.511	86.411		
202	X	177.771	135.833	196.231	60.398		
206	X	178.27	140.421	205.967	65.546		
212	X	183.598	141.789	217.686	75.897		
218	T2C	195.333	130.635	316.825	186.19	✓	✓
220	H	170.216	120.906	317.006	196.1		✓
222	H						✓
226	T2D	188.009	150.631	229.475	78.844	✓	✓
228	T2D	133.578	118.2	152.534	34.334	✓	✓
230	H	142.084	110.959	179.786	68.827		✓
232	T1A	141.32	115.79	155.252	39.462		✓

Speaking Turn	Context	Mean	Min	Max	Range	Opioid Context	Pain Context
234	H						✓
236	T1A						✓
238	T1A	146.74	120.588	163.096	42.508		✓
242	H	166.32	143.79	202.252	58.462		✓
244	H	147.206	115.181	197.838	82.657		✓
246	E2					✓	✓
248	T2C	146.941	128.79	167.802	39.012	✓	✓
250	E2					✓	✓
254	T2C	184.612	148.452	226.275	77.823	✓	✓
256	H	149.581	131.797	181.258	49.461		✓
258	H	163.581	135.16	227.925	92.765		✓
262	X	187.25	153.025	216.713	63.688		
264	H						✓
266	X	184.591	145.828	200.406	54.578		
268	X	211.534	189.824	293.409	103.585		
270	X	176.493	134.692	182.49	47.798		
274	H	165.194	152.004	197.879	45.875		✓
276	H	207.691	154.513	268.775	114.262		✓
280	H	196.265	146.468	236.122	89.654		✓
282	H						✓
284	H	172.484	124.512	191.048	66.536		✓
288	T1B	174.823	120.912	240.868	119.956		✓
294	T1B						✓
296	T1C	172.266	136.523	249.397	112.874		✓
306	R1B	135.04	111.836	175.426	63.59	✓	✓
308	R1B	145.448	130.644	196.753	66.109	✓	✓
310	H						✓
312	H						✓
314	X	185.551	142.377	194.58	52.203		
316	X	192.964	125.025	237.809	112.784		
320	X	190.5	119.506	270.648	151.142		
322	H						✓
324	X	194.728	144.047	281.585	137.538		
328	X	175.73	149.311	326.779	177.468		
336	H	147.309	110.679	223.24	112.561		✓
338	X	180.55	128.311	191.98	63.669		
342	X						
344	X	191.532	122.608	205.782	83.174		
346	X	170.863	145.521	173.785	28.264		

Speaking Turn	Context	Mean	Min	Max	Range	Opioid Context	Pain Context
350	X	178.061	128.689	196.973	68.284		
352	X	183.844	133.152	203.237	70.085		
354	X						
358	X						
360	X	184.729	117.03	190.83	73.8		
362	X	191.642	121.77	289.364	167.594		
370	X	190.976	122.748	296.334	173.586		
372	H	169.734	113.919	212.009	191.09		✓
374	T2A					✓	✓
376	T2C					✓	✓
380	X	193.931	118.783	216.974	98.191		
382	X	187.229	129.394	221.764	92.37		
384	X	192.489	133.18	197.468	64.288		
386	X	187.489	123.18	207.468	84.288		
390	X	180.862	120.746	214.232	93.486		
392	X	191.623	126.211	205.629	79.418		
406	X	176.623	123.211	225.629	102.418		
412	R1A	193.426	120.306	281.224	160.918		✓
414	T1B	182.169	113.654	227.654	114		✓
416	R1A	170.456	112.05	219.238	107.188		✓
420	X						
422	X						
426	X	176.332	144.982	200.638	55.656		
428	X	178.467	112.391	208.232	95.841		
432	X	172.776	119.618	192.262	72.644		
442	H	190.682	145.073	287.774	142.701		✓
446	E2					✓	✓
448	X	209.309	155.192	297.991	142.799		
450	X	199.723	125.112	310.076	184.964		
464	H	160.604	119.066	193.752	74.686		✓
466	E2					✓	✓
470	H	143.25	116.832	166.954	50.122		✓
472	E2	163.308	119.957	187.37	67.413	✓	✓
474	H	163.476	121.175	171.586	50.411		✓
476	T1B	208.878	144.578	295.197	150.619		✓
478	T1B						✓
481	H	189.654	122.573	290.198	167.625		✓
485	T1C	194.172	161.523	296.41	134.887		✓
487	H	165.668	116.098	299.208	183.11		✓

Speaking Turn	Context	Mean	Min	Max	Range	Opioid Context	Pain Context
491	N3						✓
493	T1C	196.118	118.226	283.964	165.738		✓
495	H	172.827	160.222	200.849	40.627		✓
507	X						
526	H	181.551	123.824	219.34	95.516		✓
528	R2	177.551	113.924	199.324	85.4		✓
532	H	155.571	137.435	193.596	56.161		✓
534	H						✓
536	E2					✓	✓
538	H	162.539	115.185	195.999	80.814		✓
540	H	178.268	142.035	280.391	138.356		✓
544	H	172.569	116.159	203.385	87.226		✓
548	H						✓
554	H	198.014	112.315	205.929	93.614		✓
556	T2D	134.136	110.134	164.631	54.497	✓	✓
558	E2					✓	✓
560	H						✓
564	N3	164.302	135.567	187.228	51.661		✓
574	H						✓
578	H	145.543	114.816	185.662	70.846		✓
582	H	145.782	112.054	188.418	76.364		✓
584	H	171.92	118.073	198.94	80.867		✓
586	H	188.267	120.89	192.344	71.454		✓
588	H	142.464	127.835	163.073	35.238		✓
592	R2	198.572	150.694	308.15	157.456		✓
598	H	130.993	115.929	163.524	47.595		✓
598	H	150.993	120.855	203.446	82.591		✓

Shaded rows denote entirely creaky speaking turn.*

Appendix C

Patient A Summary

	Mean	Min	Max	Range
Overall Mean :	195.298	148.785	266.402	117.617
Pain	194.868	149.127	267.366	118.238
Pain: Opioid	184.919	142.710	253.420	110.709
Pain Non-Opioid	197.316	150.706	270.797	120.090

	Mean	Min	Max	Range
Non-Pain	202.791	142.818	249.591	106.773
Pain: Opioid	**Mean**	**Min**	**Max**	**Range**
Narration of pain and description of symptoms	173.256	129.790	221.426	91.635
Request for Opioid treatment	175.372	142.901	257.327	114.426
Positive assessments / satisfaction with opioids.	200.242	145.502	259.110	113.608
Opioid related threats/red flags	202.320	156.212	284.349	128.137
Pain: Non-Opioid				
Unclear request regarding Prescription	208.608	155.528	290.200	134.672
Request for information and logistics	195.632	148.050	249.856	101.806
Negative assessments / dissatisfaction with non-opioid treatments.	198.157	153.377	277.530	124.153
Disagreement or resistance	201.411	157.501	283.651	126.149
Other Pain Related Utterances	196.490	149.827	269.928	120.101

Patient B Summary

	Mean	Min	Max	Range
Overall Mean :	171.108	126.549	220.609	94.744
Pain	165.816	124.725	219.141	95.416
Pain: Opioid	161.017	129.391	214.048	84.657
Pain Non-Opioid	166.968	123.606	220.363	97.998
Non-Pain	182.552	130.493	223.785	93.291
Pain: Opioid	**Mean**	**Min**	**Max**	**Range**
Narration of pain and description of symptoms	152.509	126.151	182.978	56.827
Request for Opioid treatment.	150.993	118.655	212.042	93.386
Positive assessments / satisfaction with opioids.	175.799	142.616	246.545	103.929
Expressions of uncertainty or ambiguity about opioids.	175.629	135.959	236.967	101.008
Opioid related threats/red flags	151.908	126.322	182.213	55.892
Pain: Non-Opioid				
Request for Non-Opioid treatment.	167.327	122.899	219.862	102.014
Request for information and logistics.	184.222	133.381	235.004	101.623
Positive assessments /satisfaction with non-opioid treatments.	154.733	112.666	216.994	104.329
Negative assessments / dissatisfaction with non-opioid treatments.	180.428	125.182	236.408	111.226
Expressions of uncertainty or ambiguity about a non-opioid treatment plan.	180.394	134.073	260.281	126.208
Agreement	164.302	135.567	187.228	51.661
Other Pain Related Utterances	164.747	122.899	215.644	94.436

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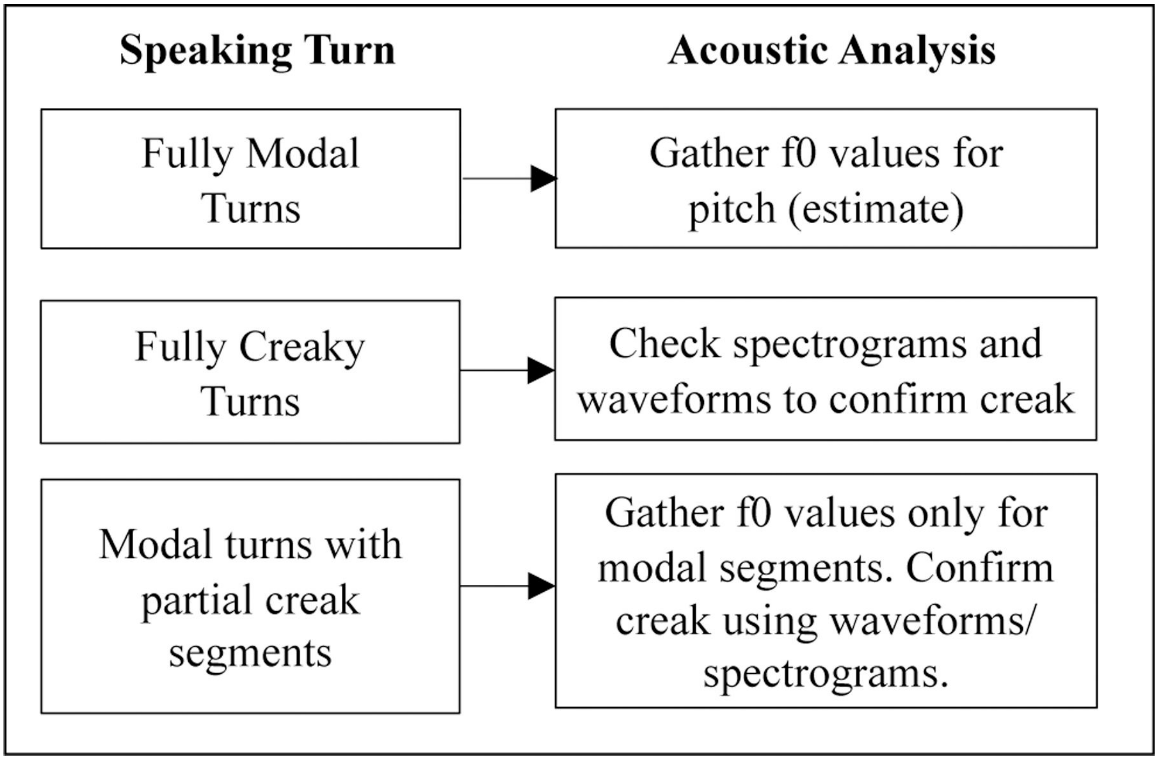


Figure 1.
Diagram showing how the data were analyzed acoustically.

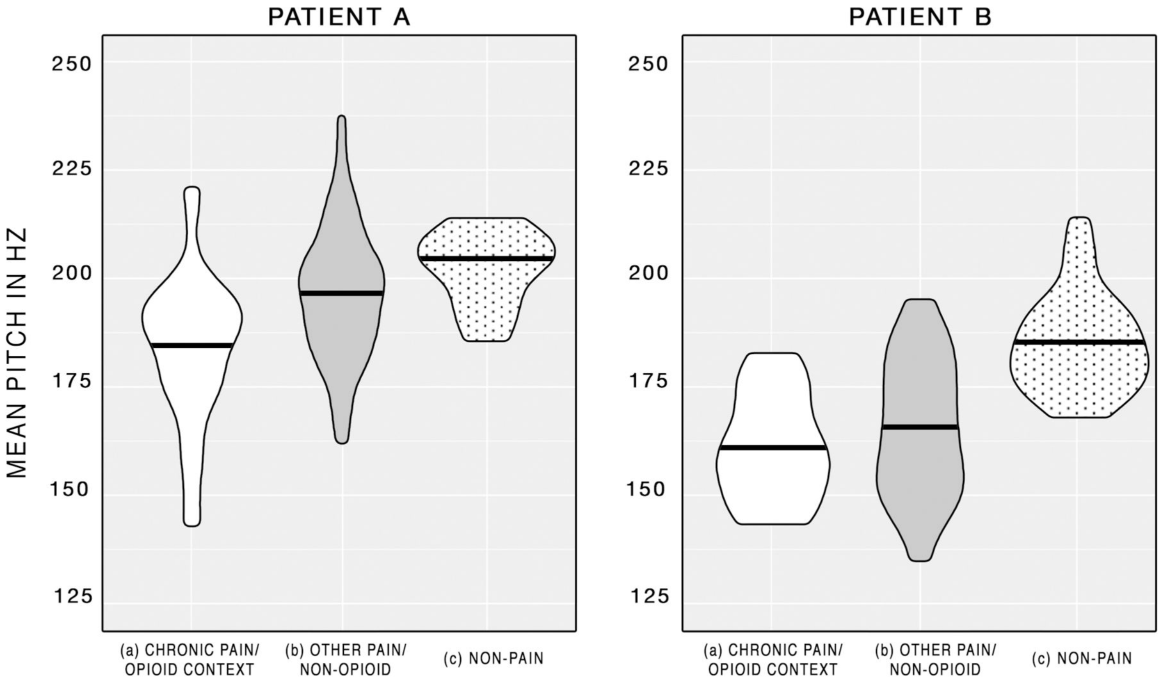


Figure 2.

Mean pitch distributions for each of the three coding categories. The width of each violin plot indicates the distribution of the mean pitch located at that point, while the bar shows the overall average for that category.

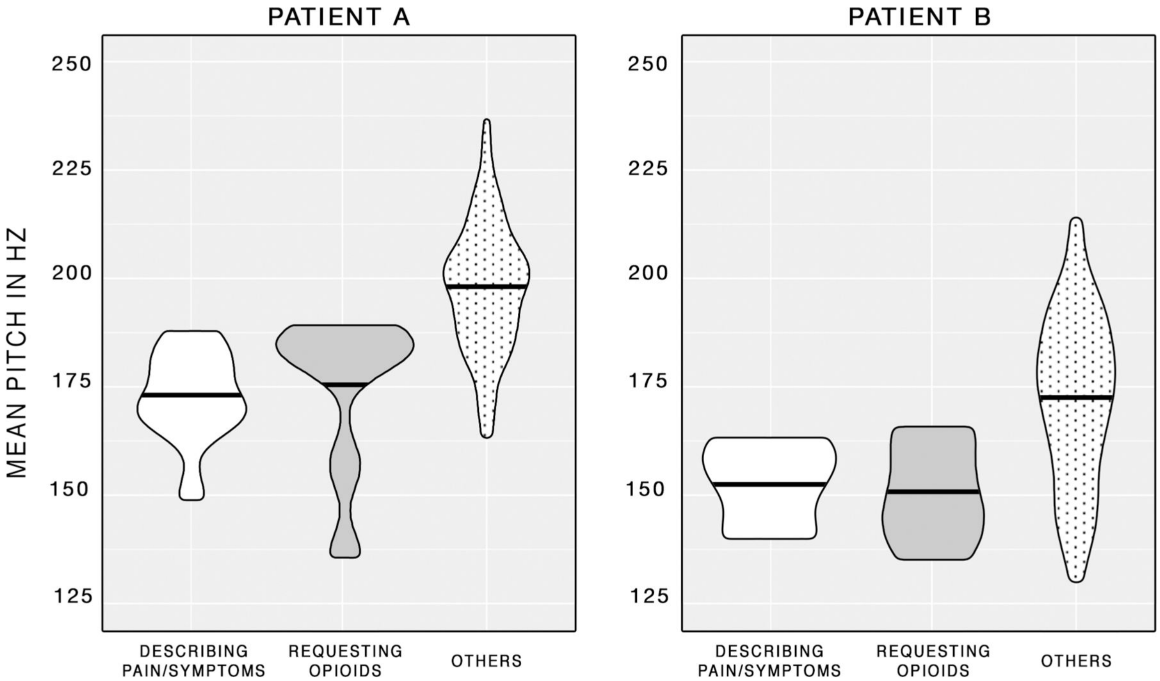


Figure 3.

Mean pitch distributions of opioid requests and pain narration separated from the rest of the speaking turns. The width of each violin plot represents the pitch distribution located at that point while the bar represents the average pitch for that category.

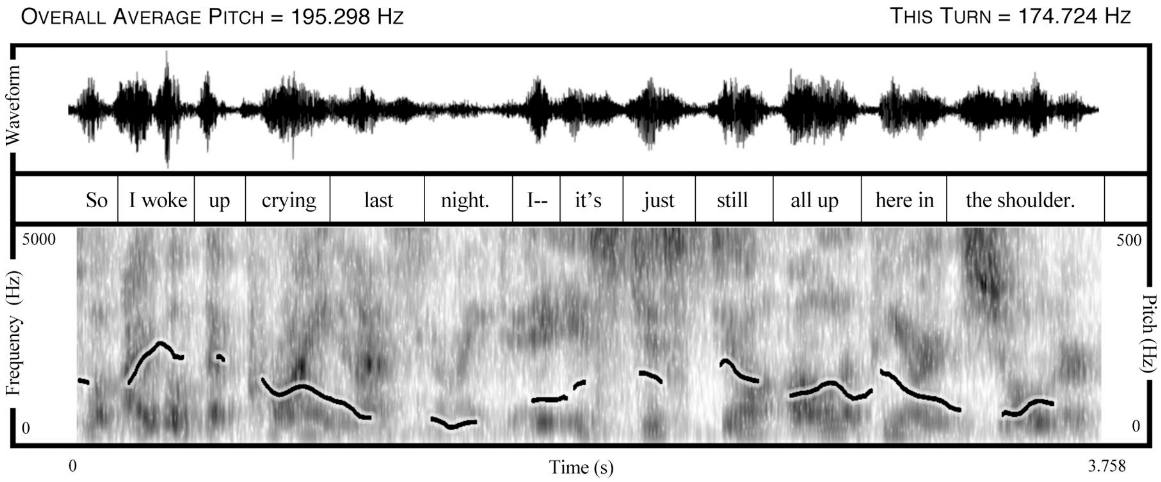


Figure 4a. Example of pain narration from Patient A

Waveform and spectrogram of a turn in which patient A discusses pain. The dense line on the spectrogram represents pitch. The mean pitch of the present turn is below her overall average and covers only the lower 22 percent of her vocal range.

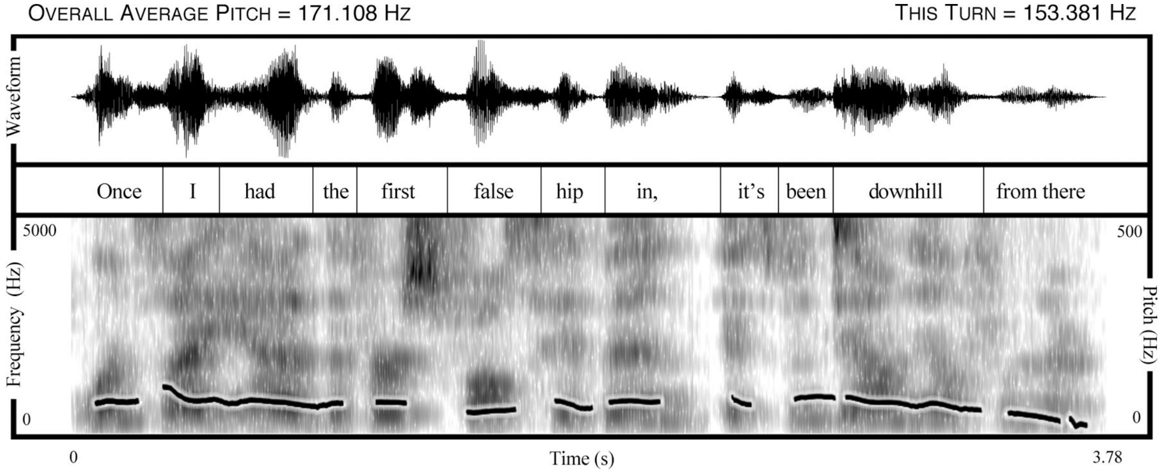
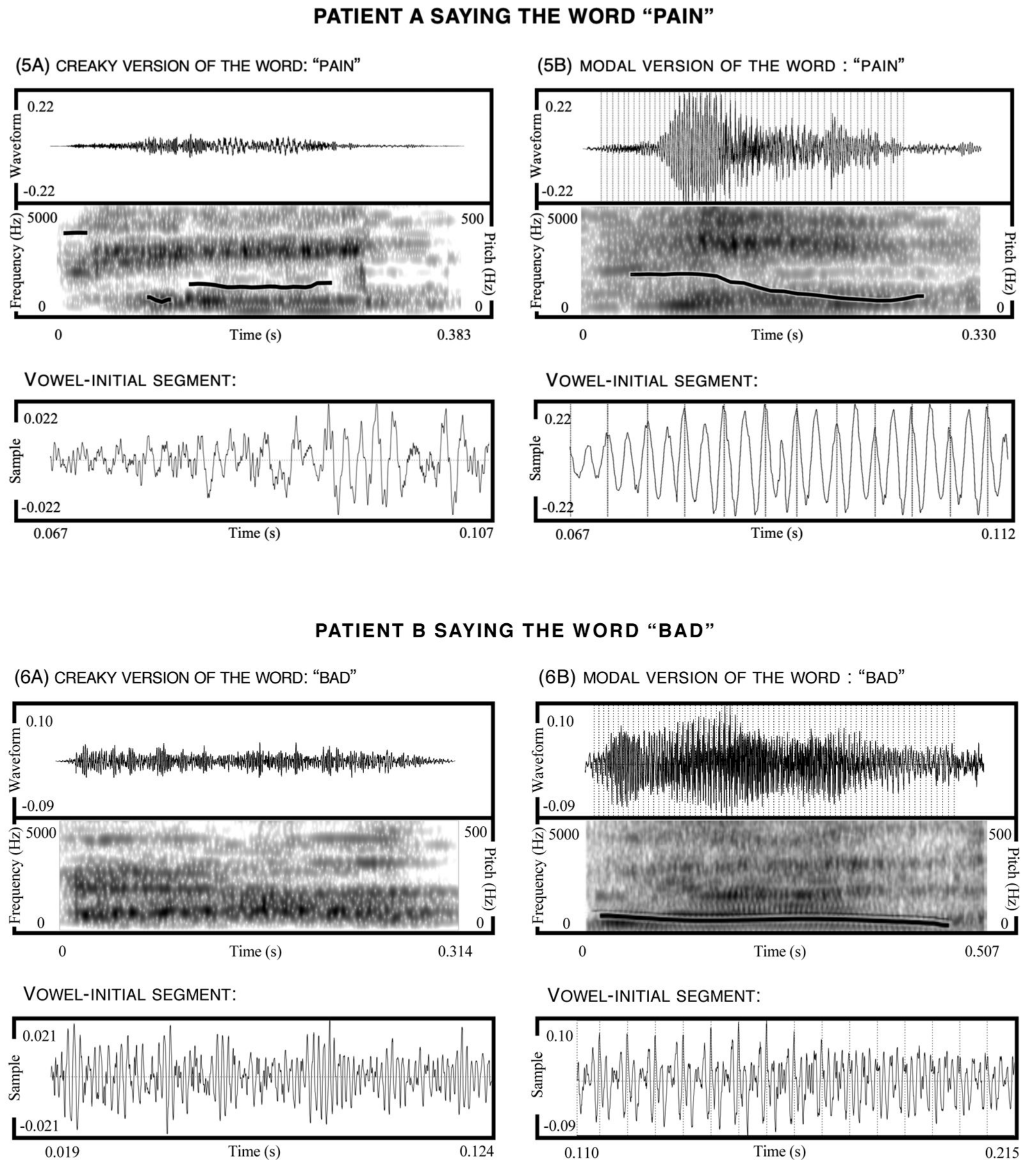


Figure 4b. Example of pain narration from Patient B

Waveform and spectrogram of a turn in which patient B discusses pain. The dense line on the spectrogram represents pitch. The mean pitch of the present turn is below her overall average and covers only the lower 20 percent of her vocal range.



Figures 5 and 6. Creaky and modal versions of the same word

Waveforms and spectrograms illustrating the creak and modal versions of the word "Pain" and "Bad" spoken by Patients A and B, respectively. The line on the spectrogram refers to pitch. The waveform for the beginning of the vowel is also presented.

Table 1.

Patient-physician information taken from their pre-consultation questionnaire.

Patient			Resident Physician		
Pseudonym	**Gender**	**Age Range**	**Pseudonym**	**Gender**	**Age Range**
Patient A	Female	Late 50s	Physician A	Female	Mid 20s
Patient B	Female	Mid 40s	Physician B	Female	Early 30s

Table 2.

Distribution of speaking turns collected and analyzed.

Speaking Turn	Patient A	Patient B
Modal turns (analyzed for pitch)	166	136
Entirely creaky (not analyzed for pitch)	17	41
Total number of speaking turns	183	177

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Table 3.

(a) Chronic pain (Opioid context)

Discussions about chronic pain and the opioid medication used to manage it.

	Patient A	Patient B
Request for opioids	If you could give me methadone pills. I would be happy with that.	I just feel like it [Dilaudid] should be put on there [Pain Contract].
Narration/description of chronic pain (Treated with opioids)	I woke up crying last night. I--it's just still all up here in the shoulder.	I've been miserable the last couple days from my neck and shoulders.
Positive assessment of opioid treatment	I know what is safe for me. I've been prescribed with Norco, and it has been working. I'm still alive.	I haven't been needing Zofran as much since they switched me to that Dilaudid.
Negative assessment of opioid treatment	None	None
Ambiguous assessment of opioid	None	(On effectiveness of opioid) It depends on the day, it depends on what I'm doing.
Opioid-related red flags and threats.	I'll self-medicate if I have to. I'll go on the streets. I'm not gonna go through withdrawals.	I probably take more (opioid) overall than I would normally, when I'm in a lot of pain.

Table 4.

(b) Other pain (Non-opioid context)

Discussions about other types of pain that does not involve opioids

	Patient A	Patient B
Request for non-opioid medication	I think I need a refill on Dulcolax.	The Robaxin. Um, could you guys change that to 120 tablets a month?
Unclear requests	So are you gonna prescribe me anything?	None
Request for information	How many refills do I have on the ibuprofen?	Would it be okay if my daughter picks the prescription up?
Positive assessment of non-opioid treatment	None	Neurontin does help with some of the um, like my skin or my hair hurting,
Negative assessment of non-opioid treatment	Ibuprofen is not good for my stomach.	I've tried it all. I've tried a party bag of ice until I can't even feel it anymore.
Ambiguous assessments of non-opioid treatment	None	Robaxin doesn't really help, but it does
General agreements	None	Yeah, especially right in here. I would definitely try trigger point injections
General disagreements	No, I'm not gonna do Tylenol, because it's not good.	None
Other pain-related utterances	I've had constipation.	I'm kinda worried about asthma.

Table 5.

(c) Non-pain

Discussions that are not about pain

	Patient A	Patient B
Non-pain	We can do Rite-Aid, yeah.	Honestly, it’s just to go to Taco Bell—

Table 6.

Average pitch of all modal speaking turns per category.

	Patient A	**Patient B**
Overall average pitch	195.298 Hz	171.108 Hz
All pain-related utterances	194.868 Hz	165.816 Hz
(a) Chronic pain (Opioid context)	184.919 Hz	161.017 Hz
(b) Other Pain (Non opioid-context)	197.316 Hz	166.968 Hz
(c) Non-pain	202.791 Hz	182.552 Hz

Table 7.

Average pitch for each subcategory

	Average Pitch (in Hz)	
	Patient A	**Patient B**
Baseline: overall average pitch	**195.298**	**171.108**
(a) Chronic pain (Opioid context)		
Request for opioids	175.372 *	150.993 *
Narration/description of chronic pain	173.256 *	152.509 *
Positive assessment of opioids	200.242	175.799
Negative assessment of opioids	--	--
Ambiguous assessment of opioids	--	175.629
Opioid-related red flags and threats.	202.320	151.908 *
(b) Other pain (Non-opioid context)		
Request for non-opioid medication	--	167.327 *
Unclear requests	208.608	--
Request for information	195.632	184.222
Positive assessment of non-opioid treatment	--	154.733 *
Negative assessment of non-opioid treatment	198.157	180.428
Ambiguous assessment of non-opioid treatment	--	180.394
General agreements	--	164.302 *
General disagreements	201.411	--
Other pain-related utterances	196.490	164.747 *
(c) Non-pain		
Non-pain	202.791	182.552

(*) Asterisk indicates that the average pitch of that category is lower than the speaker’s overall average pitch.

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Table 8.

Distribution of completely creaky speaking turns

	Number of creaky turns	
	Patient A	**Patient B**
Context: Pain	11	35
Context: Non-pain	6	6

None of the completely creaky turns were measured for pitch.