From emotive voices to empathic brains

A neuropragmatic investigation of complaint processing

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Abstract

Many of our social interactions prompt us to detect emotional signals produced by others, which are designed to project ourselves into their feelings and understand their affective state; in other words, to empathize. Complaining, for example, aims to engage the social affiliation of listeners by conveying a feeling of (social) pain. This feeling is best conveyed by paralinguistic signals such as speech prosody - the "tone of voice" - but may also depend on a number of contextual and socio-cultural factors. In the present thesis, I investigated how the brain processes emotive signals in complaining speech, how these processes relate to the notion of empathy, and how they are affected by markers of cultural identity such as speaker accent. Chapters 1 and 2 describe the creation, validation, and analysis of a large stimulus set comprising complaints and neutral speech from French and Québécois (French-Canadian) speakers. They reveal characteristic acoustic and perceptual patterns when speakers adopt a complaining strategy, enhancing the expressivity of complaints through the emotive use of prosody. Chapter 3 assesses how the brain initially processes emotive prosody, using event-related potentials (ERPs) from electroencephalography (EEG) measures. It suggests that listeners rapidly detect salient emotive signals in the voice, especially when speakers share the same cultural affiliation, whereas listeners must engage in increased processing efforts for out-group complaints. Chapter 4 shows that this early appraisal of prosody constrains the interpretation of complaints at later stages, such that with the proper tone of voice, one can complain about anything. Finally, Chapter 5 uses functional magnetic resonance imaging (fMRI) to identify brain networks involved in the empathic processing of complaints. It reveals that emotive (complaining) prosody engages regions associated with emotion perception, affective empathy, and mentalizing;

meanwhile, accent-based group perception determines the empathic perspective of the listener, relying on sensorimotor resonance with in-group speakers and inferential processes with out-group speakers. Together, these chapters highlight the emotive role of vocal signals in complaints and social communication. Prosody operates as a reliable medium to convey feelings and elicit empathic processes, while speaker accent effects reveal how empathy is influenced by cultural constraints. Overall, this dissertation provides a unique neuroscientific perspective on everyday interpersonal communication, further elucidating mysteries of the emotional and social brain.

Résumé

La plupart de nos interactions sociales nous incitent à détecter les signaux émotionnels que produisent les autres afin de nous projeter dans ce qu'ils ressentent et comprendre leur état affectif. Se plaindre, par exemple, a pour but d'engager l'affiliation sociale de son interlocuteur en communiquant un sentiment de douleur, physique ou sociale. Ce sentiment est transmis principalement par des signaux paralinguistiques, comme la prosodie (ou "ton") de la voix, mais peut aussi dépendre de nombreux facteurs contextuels et socio-culturels. Au travers de cette thèse, j'ai étudié comment le cerveau perçoit et traite les signaux émotifs dans les plaintes, en quoi ces processus sont liés à l'empathie, et comment ils sont affectés par des marqueurs d'identité culturelle tels que l'accent. Les chapitres 1 et 2 décrivent la création, la validation et l'analyse d'un large corpus de stimuli comprenant des plaintes et des phrases neutres produites par des locuteurs français et québécois. Ils révèlent des motifs acoustiques et perceptuels caractéristiques des stratégies de plainte, passant notamment par une expressivité accrue grâce à l'utilisation émotive de la prosodie. Le chapitre 3 analyse le traitement initial de cette prosodie émotive à l'aide de potentiels cérébraux évoqués (PCE) de mesures électroencéphalographiques (EEG). Il suggère que les auditeurs détectent rapidement les signaux émotionnellement pertinents dans la voix, mais sont plus réceptifs à leur propre accent, tandis que les plaintes d'un autre groupe culturel requièrent plus d'effort de traitement. Le chapitre 4 montre que cette évaluation précoce de la prosodie restreint l'interprétation subséquente des plaintes, de sorte qu'il est possible de se plaindre de tout avec la bonne intonation. Enfin, le chapitre 5 utilise l'imagerie par résonance magnétique fonctionnelle (IRMf) pour identifier les réseaux cérébraux impliqués dans le traitement empathique des plaintes. Il révèle que la prosodie

émotive déclenche l'engagement de nombreuses régions associés à la perception des émotions, l'empathie affective, et la mentalisation. En parallèle, la perception d'accents détermine la perspective empathique de l'auditeur, basée sur une résonance sensorimotrice avec l'endogroupe et des processus inférentiels sur l'exogroupe. Ensemble, ces chapitres mettent en lumière le rôle émotif des signaux vocaux pendant les plaintes et la communication sociale. La prosodie s'avère être un moyen fiable de communiquer ses émotions et susciter l'empathie, tandis que les effets liés à l'accent sont révélateurs des influences culturelles de l'empathie. De manière générale, cette dissertation porte un regard neuroscientifique sur la communication interpersonnelle au quotidien et contribue à élucider les mystères du cerveau émotionnel et social.

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Preface

Contribution to original knowledge

The studies described in Chapters 1-5 are original contributions to knowledge. The first study (Chapter 1) is one of the first few quantitative, systematic, and cross-cultural acoustic analyses of complaints, creating a large corpus of utterances that will be used as stimuli in each following experiment. The second study (Chapter 2) is the first experimental assessment of the perception of complaints, as well as one of the first few studies to use multiple mediation analyses to assess direct and indirect relationships between many prosodic parameters and perceptual impressions of affective speech. The third study (Chapter 3 and 4) is the first neurophysiological investigation of complaints perception, and provides the first insight into how prosody, verbal content, and speaker accent elicit empathic processes in complaints. The fourth study (Chapter 5) is the first neuroimaging investigation of complaints perception, and the first to identify critical neural networks and their role in the empathic processing of complaints.

This dissertation is submitted as partial fulfillment for the Ph.D. program in the Integrated Program in Neuroscience at McGill University. It follows McGill University's guidelines for a manuscript-based thesis.

Contributions of Authors

Chapter 1

This manuscript, titled "The Sound of Complaints", has been submitted for publication in the Journal of Psycholinguistic Research. It is co-authored by M.D. Pell. M. Mauchand conceived and developed the experiment, collected the data, analyzed the data, and drafted the manuscript. M.D. Pell provided continuous supervision and guidance through each step and gave feedback and critical input on the manuscript.

Chapter 2

This manuscript, titled "Emotivity in the voice: prosodic, cultural, and lexical appraisal of complaining speech", has been published in Frontiers in Psychology, as part of the Research Topic "Effective and Attractive Communication Signals in Social, Cultural, and Business Contexts":

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M. Mauchand conceived and developed the experiment, collected the data, analyzed the data, and drafted the manuscript. M.D. Pell provided continuous supervision and guidance through each step and gave feedback and critical input on the manuscript.

Chapter 3

This manuscript, titled "Listen to my feelings! How prosody and accent drive the empathic relevance of complaints", has been published in *Neuropsychologia*:

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M. Mauchand conceived and developed the experiment, collected the data, analyzed the data, and drafted the manuscript. M.D. Pell provided continuous supervision and guidance through each step and gave feedback and critical input on the manuscript.

Chapter 4

This manuscript, titled "Complain like you mean it! How prosody conveys suffering even about innocuous events", has been submitted for publication in *Brain and Language*. It is co-authored by M.D. Pell. M. Mauchand conceived and developed the experiment, collected the data, analyzed the data, and drafted the manuscript. M.D. Pell provided continuous supervision and guidance through each step and gave feedback and critical input on the manuscript.

Chapter 5

This manuscript, titled "The vocal side of empathy: neural correlates of pain perception in spoken complaints", has not yet been submitted for publication. It is co-authored by J. Armony and M.D. Pell. M. Mauchand conceived and developed the experiment, collected the data, analyzed the data, and drafted the manuscript. J. Armony provided critical help in designing the experiment, analyzing the data, and interpreting the results, and gave feedback and critical input on the manuscript. M.D. Pell provided continuous supervision and guidance through each step and gave feedback and critical input on the manuscript.

General Introduction and Discussion

M. Mauchand solely authored these chapters, with feedback from M.D. Pell.

GENERAL INTRODUCTION

As emotional and social animals, our lives are paced by our feelings, but also by others'. How many times have we initiated a conversation by complaining about something? And in turn, how many times have we sat down and empathized with someone's pain as they complained about things that we, in other circumstances, would not have cared about? As mundane as they may be, these social interactions shape the relationships we form with others; and as simple as they may seem, they hide complex cognitive, affective, and socio-cultural processes that can be observed on several scales of human cognition. This is the case of empathy: although it is often regarded as an extraordinary, exceptional phenomenon, empathy is a common human state that we experience every day, for example when listening to others' complaints. The present thesis aims to further explore this lesser-known aspect of empathy and reintroduce it to our daily social life.

Although the idea of sharing and understanding others' feelings is far from recent, the concept of empathy - originally "Einfühlung" in German - and its implications were largely developed in the early twentieth century through the philosophies of Lipps and Husserl. Their ideas of empathy rely on the fundamental notion that we "appresentatively" experience others - that is, we can project ourselves into what they feel without resorting to analogy (Kern, 2019). Hence, empathy implies not comparing other's feelings with our own, but directly experiencing them (or our representation of them) from their point of view (or our representation of it). Lipps and Husserl disagreed on how exactly this intersubjective experience comes to be: for Lipps, it occurs as a mechanistic response to what we observe; for Husserl, it occurs more indirectly through perception and embodied appraisal (Depraz, 2017).

These early philosophical notions (and divergences) are echoed in later neuroscientific approaches of empathy. Despite being a complex phenomenological concept, empathy drew a lot of attention from the scientific and neuroscientific community, perhaps because of its (deceptively?) intuitive simplicity; in broad terms, it can be described a collection of processes resulting from the attended perception of another's feelings (Preston & de Waal, 2002). As such, scientific inquiries of empathy only require two essential things: an observer and an observed, the latter experiencing a feeling - most often, pain. While making empathy a unifying concept, this apparent simplicity yielded a rich but chaotic research field, with many divergent methodologies, definitions, and perspectives. At the core of these divergences lies a debate on the nature of empathic processes, reminiscent of the Lipps-Husserl conflict. However, where Lipps and Husserl showed two perspectives, there are now as many perspectives as there are empathy researchers.

The following thesis draws influences from three main trends in these perspectives. The first one, possibly the most popular, divides empathy into two categories of processes: "affective" empathy, an automatic, vicarious experience of the feeling; and "cognitive" empathy, a slower, conscious understanding of it (Fan & Han, 2008; Preston & de Waal, 2002). The second one restricts empathy to the affective component, while acknowledging mediating effects of certain cognitive processes (de Vignemont & Singer, 2006; Lamm et al., 2011). What others describes as "cognitive" empathy is however categorized as Theory of Mind (ToM), or mentalization, and independent from empathy(Kanske et al., 2015). The last perspective, perhaps the most "Lippsian" of the three, describes empathy in terms of sensorimotor resonance, i.e., an internal mirroring of the expression of the feeling, linked notably to mirror neurons (Avenanti et al., 2005; Baird et al., 2011).

Across these multitudes of perspectives, common aspects remain fundamentally attached to empathy. As described earlier, it is not an inference by analogy, as it is rooted in an already-held belief that others feel as we feel. This entails two corollary characteristics: self-other distinction, and familiarity bias (Preston & de Waal, 2002). Self-other distinction implies the awareness that the feelings we empathize with are not our own; this usually distinguishes empathy from other processes such as emotional contagion[1]. Familiarity bias suggests that empathy depends, in one way or another, to how familiar the observed feeler is to the empathic observer. As such, empathic responses may differ based on social proximity, and in particular, in terms of culture. Culture-based investigations occupy a significant part of the current empathy literature (Cheon et al., 2010), and most reports clearly highlight an important role of in- and out-group perception in empathic mechanisms. There again, however, accounts diverge regarding the exact nature of this role, and which processes are affected by group- and culture-based biases (Cheon et al., 2011; Sessa, Meconi, Castelli, et al., 2014; Xu et al., 2009).

At its scale, the present dissertation does not have the ambition (nor the capacity) to provide a clear, definitive answer to these divisive theoretical concerns. In fact, the nature of what we understand as empathy may elude a concise formal definition, such that many do not risk trying and instead focus on specific processes encompassed within the umbrella of empathy (Cuff et al., 2016; Hall & Schwartz, 2018). As such, rather than

[1] Note that this aspect may be difficult, but not impossible, to reconcile with sensorimotor accounts of empathy

bringing further theoretical considerations to this debate, this thesis uses empathy as a general framework, to extend the empathy literature to our everyday social communication. To be clear, the following research is far from the first to introduce empathy in social communicative contexts. Large bodies of research on vocal emotion perception (Alba-Ferrara et al., 2011; Chun et al., 2012; Sachs et al., 2018), social decision-making (Feng et al., 2021; Jiang et al., 2020), and language (Esteve-Gibert et al., 2020; van den Brink et al., 2012) already include empathic perspectives. Several studies have also more directly explored how vocal signals may relate to empathy by highlighting shared circuits between their production and perception (Aziz-Zadeh et al., 2010; Gazzola et al., 2006), assessing their characteristics as biosignals for pain (Lautenbacher et al., 2017; Lerner et al., 2016), and determining their relative role to other affective cues in pain perception (Lang et al., 2011; Meconi et al., 2018; Regenbogen, Schneider, Finkelmeyer, et al., 2012). This dissertation builds on these efforts to provide a rich picture of everyday interpersonal interactions from a neuroscientific empathy perspective.

Third-party complaints appear as a subject of choice: as verbal expressions of suffering, they are *designed* to elicit empathy and obtain affiliation from listeners (Acuña-Ferreira, 2002; Selting, 1994). As will be made clear in the following chapters, the expression of suffering in complaints arises mainly through the use of the speaker's prosody, or tone of voice, which reconstructs their affective state related to the object of their complaint (Caffi & Janney, 1994; Selting, 2010). Prosody refers to supra-segmental signals of speech such as vocal pitch, voice quality, or rhythm; when modulated by speakers, it provides key information regarding conversational rules and pace, but also about the speaker's affective state and intentions (Frühholz et al., 2016; Pell & Kotz, 2021).

These last two aspects are critical during complaints, which are intentional expressions of affect, or *emotive* speech acts. By intentionally expressing their pain, complainers probe our empathy in a casual, yet unique way. Hence, complaints provide an example of how empathy is used in every-day interpersonal communication, embedded in complex social-relational contexts such as culture or speaker/listener relationship (Scarantino, 2017; Van Kleef, 2009). They constitute a perfect sandbox in which the processes underlying empathy can be investigated across pragmatic, psychological, socio-cultural, and neuroscientific perspectives. Although complaints are known to take the form of complex interactional structures (Drew & Walker, 2009), this thesis takes a narrower approach, boiling down the expression of complaints into single-sentence utterances describing a specific event. This allowed for greater control in manipulating stimuli during neurocognitive experiments, without losing the core nature of complaints - an emotive expression of suffering seeking listener affiliation.

The aim of the present thesis project can be summarized in a simple question: How do empathy-related processes arise in the context of vocal communication? As this question is broad enough that an answer could take several dozen doctoral theses, I focused on third-party complaints, with a particular emphasis on the role of the prosody in sharing feelings, and speaker accent as a marker for socio-cultural effects of empathy. From this point, the main research question can be broken down into three sub-questions:

- What processes underly the perception of emotive speech such as complaints?
- How – and how well – can listeners share and understand a speaker's suffering?
- What are the social and cultural implications of these processes?

Importantly, the goal is not to determine if complaints elicit empathy or determine conditions in which empathy is "present" or "absent". Rather, it is to explore in which form it manifests itself in complaining interactions depending on affective, contextual, and cultural constraints.

To this end, the following project explored how we and our brain process complaints, investigating these speech acts from their very production by speakers to the neural substrates underlying the perception of suffering in listeners. Conducted in Montreal, Canada, the experiments in his thesis focused on two francophone populations with peculiar intergroup relationships: French and Québécois (French-Canadian). This exploration comprised four experiments yielding five articles, each article composing a chapter of the thesis. The first two chapters detail a thorough characterization of complaints, first from an acoustic perspective in Chapter 1, and then from a more perceptual perspective in Chapter 2. They describe how stimuli were created, selected, and validated, and confirm the social-pragmatic role of speech prosody, together with speaker accent and verbal content, in the act of complaining. This initial description informed the subsequent neuroimaging investigations of empathy, which consisted of two experiments. The first one was an electro-encephalography (EEG) experiment, described in Chapters 3 and 4. Using event-related potentials, this experiment allowed the assessment of a time-course of empathic perception of complaints, from utterance onset to critical interpretative stages of speech processing. Finally, the last experiment (Chapter 5) used functional magnetic resonance imaging (fMRI) to establish the variety of neural networks and their associated processes at play when empathizing with a complaining speaker. Put together, these experiments aimed to provide a rich picture of how empathy may occur in spoken social interactions, centered around brain processes but encompassing pragmatic, interactional, and socio-cultural perspectives.

SECTION I: ACOUSTIC-PERCEPTUAL CHARACTERIZATION OF COMPLAINING SPEECH

Chapter 1. The Sound of Complaints

1.1. Introduction

A complaint is the verbal exposition of a painful or annoying situation to another person. The present paper focuses on third-party complaints, which are addressed to a person unrelated to the issue expressed (Drew, 1998; Kowalski, 2002). Contrary to direct complaints, which seek a cessation or apology (Laforest, 2002), many third-party complaints are non-instrumental in nature (Alicke et al., 1992; Traverso, 2009). Instead, they seem to serve a social purpose: that of creating empathy and affiliation (Drew & Walker, 2009). The social-expressive function of complaints is revealed by their interactional structure; they usually refer to bound, distinct topics in a conversation, introduced with no or very little context (Drew, 1998), and initiate a collaborative negotiation of listener affiliation (Drew & Walker, 2009).

An important question that has not yet been addressed is: what does a complaint actually sound like? Research suggests that a speaker's prosody is likely critical for communicating the speaker's social pain and for eliciting empathy (Meconi et al., 2018; Regenbogen, Schneider, Finkelmeyer, et al., 2012). However, very little is known about the acoustic-perceptual structure of (third-party) complaints. The objective of this study was to close this gap in the literature and assess how prosody is used in complaining speech. In social interactions, speech must effectively convey the affective state of the speaker in order to trigger empathic mechanisms, as exemplified in the Emotions As Social Information (EASI) model (Van Kleef, 2009). Beyond the verbal description of a situation, a powerful way to convey affective information is through prosody (Jiang & Pell, 2017; Truesdale & Pell, 2018). Prosodic variations have been associated with specific forms of emotional expressions and are also used to communicate affect in various ways (Eyben et al., 2016; Juslin & Laukka, 2003; Kreiman & Sidtis, 2011). For example, listeners use acoustic cues to evaluate the intensity or arousal level of the speaker in relation to their message (Juslin & Laukka, 2001; Scherer, 2003). Additionally, prosody can play an important role in processes underlying emotional mirroring (Aziz-Zadeh et al., 2010; Lang et al., 2011). These findings emphasize that prosody helps listeners to both *feel* and *understand* the speaker's affective state. Initial findings suggest that prosody serves a similar role in the communication of complaints; in a recent perceptual study, (Mauchand & Pell, 2021) reported that prosodic information is consistently used by listeners to infer whether (and how much) a speaker is complaining.

Although the "sound of complaints" is not clear, it has been suggested that complaints provide increased emotive intensity in their prosodic signal (Ogden, 2010). A few studies report increases in pitch and pitch variability when people complain (Acuña-Ferreira, 2002; Rao, 2013). Speakers may also modulate the rhythm and energy of their voice to accentuate certain words (Acuña-Ferreira, 2002; Mauchand & Pell, 2021). Some researchers have drawn parallels between the acoustic structure of complaints and certain emotional expressions, such as anger (Selting, 2010), sadness, or surprise (Rao, 2013). As an expression of (social) pain, the acoustic structure of complaints could also contain elements found in vocalizations of physical pain, such as increased pitch range, voice roughness, and intensity (Koutseff et al., 2018; Lautenbacher et al., 2017). However, concrete data on the acoustic properties of complaints is scarce, as most of the research is based on qualitative analyses of complaints in conversation (Acuña-Ferreira, 2002; Selting, 2010). To date, quantitative analysis of complaining prosody in a controlled testing environment has only been performed by Rao (2013), who focused on intonational contours, and by Mauchand & Pell (2021) who identified certain acoustic measures as mediators of complaint perception. A complete, thorough assessment of the acoustic profile of complaints is therefore overdue.

Although complaints may resemble emotions in some manner, they are socially complex expressions in which affect is intentionally reconstructed, one aspect of *emotive* communication (Acuña-Ferreira, 2002; Selting, 2010). They are highly dependent upon social-relational factors (Van Kleef, 2009), which may include cultural-specific norms in language usage (Rao, 2013). Emotive strategies are likely rooted in the speaker's social and cultural experience; indeed, empathy is a cultural process and its expression and effects vary across groups and individuals (Cheon et al., 2010; Chopik et al., 2017). The way individuals apprehend others' feelings may have major impacts on how they use prosody to elicit empathy in others. The importance of the sociocultural context in complaining speech thus makes it crucial for an acoustic and perceptual characterization of complaints to consider these factors, as they will not only enrich the surface knowledge about complaining prosody but may also reveal deeper processes that govern the production of everyday speech acts across individuals, cultures, and social groups.

The present study aimed to establish acoustic and perceptual patterns associated with complaining speech, based on a robust set of complaining and neutral utterances that are likely to occur in everyday conversations. Potential socio-cultural effects were also assessed by studying two distinct cultural groups, French and Québécois, a francophone group from the province of Québec in Canada. The choice of these two groups was motivated by their common language (French), which allowed the creation of verbally identical stimuli, thus ensuring consistency and control in both acoustic and perceptual measures. As a secondary goal, we aimed to capture basic information about the perceived emotional characteristics of complaints and how these features may differ between the cultural groups. Based on the small existing literature, we predicted that complaints would resemble vocal expressions of negative emotion associated with pain or high arousal, characterized by increases in pitch and pitch variability, as well as alterations of voice quality. It was expected that major acoustic strategies used to express complaints would be relatively similar for the two cultural groups, although some group variation could emerge given the importance of social-relational factors in complaining behavior.

1.2. Methods

1.2.1. Materials

Eighty-four (84) short sentences describing the behavior of a hypothetical person (third-party) were written in French. The sentences all started with a personal pronoun followed by an action, e.g., "Il a dit que j'étais stupide" (*He said I was stupid).* The complete list of sentences can be found in Table A1 of Appendix. For the purposes of another experiment, these sentences were constructed in pairs that differed only in their final word ("Il a dit que j'étais stupide/sorti" -- *He said I was stupid/outside*). The last word dictated whether the sentence had direct negative consequences for the speaker based on the linguistic message. As the present study focuses on prosodic properties of the stimuli, distinctions in the linguistic message will not be examined here. Prior to recording the sentences, each written sentence was evaluated by two Québécois and two French speakers to confirm that the lexical content and phrasing of the utterance was natural to orally express in both dialects. Note that sentences were somewhat variable in length; this variability was corrected during the analysis step by implementing by-Statement random intercepts and slopes.

1.2.2. Speakers

Four Québécois (2 males, 2 females, age: M = 24.00, sd = 4.24) and four French Speakers (2 males, 2 females, age: M = 23.25, sd = 2.87) were recruited in the Montreal area to produce complaining and neutral utterances. Speakers were recruited on the basis of having acting experience; in each group, two speakers were undergraduate students doing part-time acting and two were young actors in early career. All speakers in the French group were born and lived in France until adulthood and had moved to Montreal to pursue education or employment opportunities (Mean time in Quebec: 3-8 years). All speakers in the Québécois group were born and living in Québec. Each speaker was raised in a francophone-only environment and were using French as their main everyday language at home and at work. Speakers gave informed consent before participating, and the experiment was approved by the Institutional Review Board of McGill Faculty of Medicine.

1.2.3. Recording

Speakers completed the recordings in pairs during a single session, involving one male and one female from the same cultural group. In total, four recording sessions were held (two per cultural group). Recordings were digitally captured in a sound-attenuated chamber with a high-quality head-mounted microphone onto a Tascam recorder (sampling rate of 44.1 kHz, 16-bit, mono, .wav format). During a session, each speaker was assigned half of the utterances and produced each utterance in the direction of their partner, in order to simulate natural conversation and to minimize input from the experimenter. Since each speaker in the pair produced a different half of the utterances, they could not directly imitate the other speaker when it was their turn. Speakers were presented the sentences individually on a tablet computer and were asked to first produce it in a neutral way, as if simply reporting a past event that was already familiar to the listener ("Neutral" prosody condition). Then, they were instructed to produce it as if complaining to their interlocutor ("Complaint" prosody condition). While sentences were presented as written text, speakers were asked not to read out the sentences but instead direct their speech to their interlocutor. A basic definition of third-party complaints was provided at the beginning of each recording session, but no advice or model demonstrating how to produce the utterances was given by the experimenter. Each utterance was repeated at least twice, and speakers were allowed to continue until both communication partners were satisfied with the production. The same utterances produced by a female (or male) speaker in one group were randomly assigned to a speaker of the same sex from the other cultural group when their session was held. Thus, each utterance was produced by one male and one female speaker from each of the two cultural groups. Each speaker was given the same instructions.

Each utterance was then edited in Praat (Boersma & van Heuven, 2001) into short .wav audio files. Since each utterance was repeated multiple times, only the "best" version was kept; by default, this was the last production of the speaker, except in cases of noisy recordings or unclear pronunciation when another version was chosen by the examiner. A total of 672 utterances were selected, 84 per speaker (2 groups (French, Québécois) x 4 speakers x 42 sentences x 2 prosody types (Neutral, Complaint). Exemplars of the stimuli are available through the Open Science Framework (Foster & Deardorff, 2017)[2]

1.2.4. Acoustic measures

Acoustic features of each of the 672 selected utterances were extracted using the Geneva Minimalistic Acoustic Parameter Set - GeMAPS (Eyben et al., 2016). This parameter set, found in the publicly available openSMILE toolkit (Eyben et al., 2010), has been developed as a standardized baseline set of affect-related acoustic measures (for more details on the computation and implementation of the measures, see Eyben et al., 2016). Parameters were selected based on what could be applied to the stimuli and the comparisons of interest. Except for F0 SD, F0 range, Loudness SD, and utterance/final word duration, all parameters were averaged over the utterance. The following parameters were gathered:

1) Fundamental frequency parameters:

a) F0 M, fundamental frequency, indexing mean pitch on a logarithmic semitone scale.
b) F0 SD, standard deviation of the fundamental frequency, indexing pitch variability on a logarithmic semitone scale.
c) F0 range, range between the 20th and 80th F0 percentile, indexing pitch range on a logarithmic semitone scale.

2) Voice quality parameters:

[2] https://osf.io/w4e7p/?view_only=2ec429b5cd0047c4baba11c92ab209ca

a) F1, first formant center frequency, indexing resonance of the vocal tract in Hertz.
b) Jitter, indexing aperiodicity (instability) of the vocal signal - voice "creakiness".
c) Shimmer, the difference of the peak amplitudes of consecutive F0 periods, indexing voice roughness indexing voice roughness, in dB.
d) Harmonics-to-Noise Ratio (HNR), indexing the relative amount of additive noise in the voice.

3) Amplitude parameters:

a) Loudness M, indexing mean loudness in a more perceptually relevant manner than intensity or amplitude measures, on a logarithmic scale
b) Loudness SD, indexing loudness variability on a logarithmic scale

4) Spectral parameters:

a) Mean spectral slope in the 500-1500 Hz range, indexing energy as a function of frequency in these ranges.
b) Hammarberg index, the difference between the strongest energy peaks in the 0-2000 Hz and 2000-5000 Hz ranges, indexing energy at very high frequencies compared to lower frequencies.

5) Temporal parameters:

a) Number of voiced segments per second
b) Mean length of voiced segments (s)
c) Utterance total duration (s)

d) Final Word Duration (s)[3]

The last two parameters, which were not part of the GeMAPS, were extracted using Praat software (Boersma & van Heuven, 2001).

1.2.5. Emotional association task

To capture basic information about the perceived emotional characteristics of complaints between groups, a separate group of participants judged which emotional qualities they associated with the prosody of the stimuli. Participants assessed the perceived intensity of 6 basic emotions (happiness, sadness, anger, surprise, fear and disgust) in complaining and neutral utterances. This procedure was conducted to better understand how acoustic features of our stimuli may refer to subjective impressions of basic emotions.

1.2.5.1. Participants. 20 Québécois (11M, 9F, age: M = 28.05, sd = 4.15) and 20 French (10M, 10F, age: M = 24.75, sd = 3.42) participants were recruited via the online recruitment platform Prolific Academic (Peer et al., 2017) to judge the emotional characteristics of the stimuli. All had French as their mother tongue and were born and living in Québec or France, respectively.

1.2.5.2. Selected stimuli. A subset of 48 utterances was selected, 6 utterances (3 complaints and 3 corresponding neutral) from each speaker, ensuring sentences were the same between groups. To ensure that differences in verbal content would not bias emotion ratings, only statements describing a painful situation were selected for this part of the study. As the goal of this analysis was to determine if complaints are associated with particular emotional

[3] A temporal measure of the sentence-final word was added due to our manipulation of this word in the broader stimulus set, allowing us to explore whether speakers provided local acoustic cues to mark complaints in this position.

qualities, it was reasoned that individual speakers were relatively homogeneous in their strategies for expressing complaints (and neutral utterances), allowing us to focus on only a subset of items for each speaker.

1.2.5.3. Procedure. For each utterance, participants were prompted to evaluate the perceived intensity of 6 basic emotions (happiness, sadness, anger, surprise, fear, and disgust) using sliders. Each slider ranged from 0 (emotion absent) to 10 (emotion perceived as extremely intense). Participants could listen to each stimulus as many times as they wanted. After hearing a stimulus, the 6 emotion sliders appeared, and participants were to freely position each slider to what was appropriate to them. For example, if they perceived a lot of anger and a bit of surprise, they could position the "anger" slider at 8, the "surprise" slider at 4, and leave all other sliders at 0.

1.3. Results

1.3.1. Acoustic Analysis

A summary of the acoustic features of complaints compared to neutral utterances produced by each group is displayed in Table 1.1. Linear Mixed-Effects Models were built to fit the results (Bates et al., 2015; Kuznetsova et al., 2017). Models compared complaints to neutral utterances for each acoustic parameter, and how it differed between the two cultural groups. For each acoustic measure, a model was built with Prosody and Culture as fixed factors and Speaker and Token as random intercepts. To first assess how the participants responded as a whole, regardless of culture, fixed factors were rescaled: for Prosody, Neutral was coded -.5 and Complaint was coded .5; for Culture, French was coded -.5 and Québécois was coded .5. Summaries of the models for each parameter are displayed in Table A2 of the Appendix. Complaints were significantly differentiated from neutral utterances in terms of fundamental frequency parameters (increased F0M, F0SD, F0 range), as can be visualized in the pitch contours from Figure 1.1. Complaining was also marked by significant changes in loudness (increased loudness M and SD), voice quality (decreased shimmer, increased HNR, increased F1M), spectral profile (increased energy at higher frequencies), and temporal parameters (decreased voiced segments per seconds, increased unvoiced segment length and final word duration).

When data for the two cultural groups were compared, results suggest that speakers from each culture employed slightly different acoustic strategies when complaining: French complaints showed greater increases in F0M, loudness and HNR, and a decrease in Shimmer, compared to Québécois complaints. In addition, the total duration of French complaints was greater than corresponding neutral utterances. In contrast, Québécois complaints showed greater increases in F0 variability (F0 SD, F0 range) and F1 M compared to French complaints.

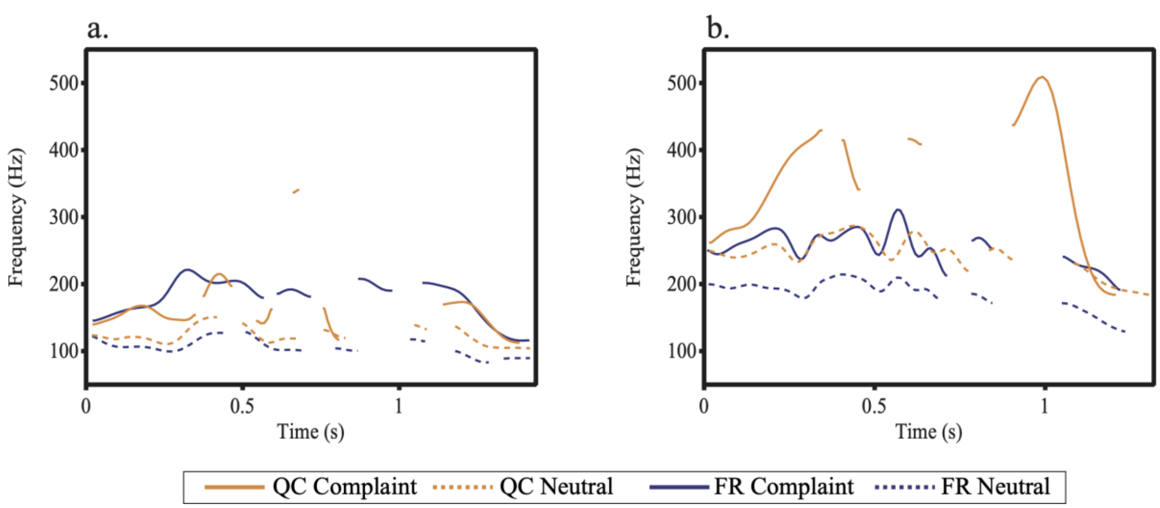

Figure 1.1. Example of pitch contours extracted from complaining and neutral versions of two sentences, uttered by one speaker from each group. **Left:** *He said I was stupid*, uttered by male speakers. **Right:** *They asked me to leave*, uttered by female speakers.

Table 1.1. Summary of acoustic measures from neutral and complaining utterances, averaged for all speakers and for French and Québécois speakers separately. F0: fundamental frequency; F1: first formant center frequency; Slope: spectral slope in the specified bandwidth; Voiced per sec: number of voiced segments per seconds; mean voiced/unvoiced length: mean length of voiced/unvoiced segments.

	All speakers		French		Québécois	
	Neutral	Complaint	Neutral	Complaint	Neutral	Complaint
F0 parameters						
F0 M	29.77	35.35	29.04	34.92	30.50	35.78
F0 SD	.10	.12	.10	.11	.10	.13
F0 range	3.50	5.73	3.40	4.45	3.60	7.00
Loudness parameters						
Loudness M	.19	.21	.19	.22	.18	.19
Loudness SD	.57	.60	.52	.54	.62	.65
Voice quality parameters						
HNR	7.29	9.07	7.10	9.63	7.47	8.51
Jitter	$4.19*10^{-2}$	$4.17*10^{-2}$	$4.24*10^{-2}$	$3.67*10^{-2}$	$4.15*10^{-2}$	$4.66*10^{-2}$
Shimmer	1.21	1.04	1.22	.99	1.20	1.10
F1 M	513.60	542.01	529.02	542.82	498.17	541.19
Spectral parameters						
Slope 500-1500Hz	$-2.05*10^{-2}$	$-1.87*10^{-2}$	$-2.08*10^{-2}$	$-2.06*10^{-2}$	$-2.03*10^{-2}$	$-1.69*10^{-2}$
Hammarberg index	30.95	30.38	32.36	31.84	29.54	28.91
Temporal parameters						
Voiced per sec	3.29	3.13	3.35	3.08	3.24	3.18
Mean voiced length	.25	.26	.26	.28	.24	.24
Mean unvoiced length	.09	.10	.08	.09	.09	.11
Duration	1.30	1.38	1.17	1.31	1.44	1.46
Final word duration	.42	.50	.39	.46	.46	.54

1.3.2. Emotional Association

Inter-rater reliability was high among French listeners (ICC = .93) and Québécois listeners (ICC = .94). The average emotional ratings of the utterances are displayed in Figure 1.2. Linear Mixed-Effect Models were fitted on R (R Core Team, 2018) with the packages lme4 and lmerTest (Bates et al., 2015; Kuznetsova et al., 2017) to compare the emotion ratings of complaints to those of neutral utterances by cultural group. For each emotion, a model was built with Prosody, Speaker Culture and Listener Culture as fixed factors and Listener and Token as random intercepts. Summaries of the models are displayed in Table A3 of the Appendix.

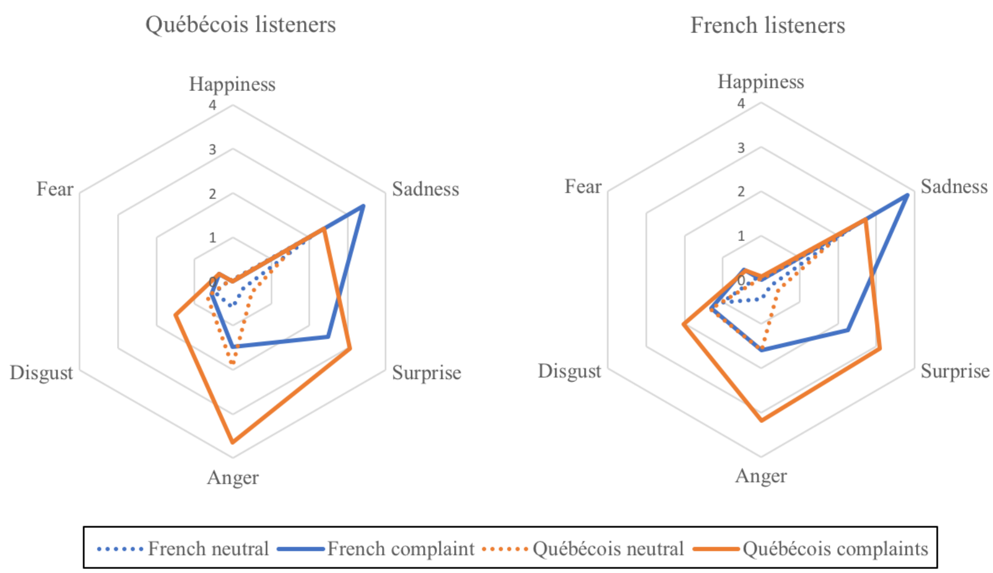

Figure 1.2. Mean emotional ratings assigned by Québécois and French listeners to complaints and neutral utterances produced by Québécois and French speakers.

<u>Anger</u> - Participants rated complaints as more angry than neutral utterances overall, and Québécois speakers were generally rated as more angry than French speakers. These two variables interacted, as Québécois complaints were perceived as more angry than French complaints whereas neutral utterances showed only marginal cultural differences. An interaction of Speaker x Listener Culture was also found, as Québécois listeners rated Québécois speakers more angry than French speakers, but this difference was less pronounced for French listeners.

Surprise - Listeners perceived more surprise in complaints than in neutral speech. This effect tended to be larger for complaints expressed by Québécois versus French speakers.

Sadness - Complaints were generally rated as more sad than neutral utterances. This difference was more pronounced for French utterances than for Québécois utterances.

Fear - Complaints were overall perceived as containing more fear than neutral utterances.

Disgust - Listeners perceived more disgust in complaints than in neutral utterances, and perceived Québécois speakers as sounding more disgusted than French speakers. These two factors interacted, showing that only Québécois (and not French) complaints differed significantly from neutral utterances along this dimension. Interestingly, French listeners gave higher disgust ratings than Québécois listeners overall.

Happiness - Effects for happiness were negligible as all utterances were almost systematically rated 0 on this dimension.

1.4. Discussion

Based on a newly created corpus of utterances in which French speakers from two cultures expressed third-party complaints, our acoustic analyses provide new details about the “sound of complaints” and their perceptual features. As reported previously (Acuña-Ferreira, 2002; Ogden, 2010; Rao, 2013), complaints were distinguished by large increases in F0 mean, variability and range; our results extend these findings to a new linguistic context (French) and to a richer set of third-party complaints. While modulation of F0 parameters is critical in many forms of affect expression, simultaneous increases in F0 mean and range, together with higher amplitude, is often linked to increased muscle tension associated with a speaker's arousal (Juslin & Laukka, 2003; Scherer & Bänziger, 2004). Complainers may exploit this mechanism to strategically communicate affective arousal to their listeners, as described by the Frequency code (Ohala, 1984). Speakers may also increase their F0 to mimic signals of non-aggression and submissiveness (Frick, 1985a; Gussenhoven, 2004) as another means for gaining empathy from listeners.

Complaints may be encoded by other acoustic cues that speakers appear to selectively provide in this social context. High-frequency energy, indexed here by an increased spectral slope, low Hammarberg index, and increased first formant frequency, have been frequently linked to vocal expressions of negative emotions, especially anger and despair (Banse & Scherer, 1996; Eyben et al., 2016). Interestingly, this acoustic profile exhibits important similarities to pain vocalizations (Lautenbacher et al., 2017; Raine et al., 2019), re-emphasizing that complaints embody an expression of pain. Temporal modulations also contributed to how complaints were communicated, with a slower speech rate than neutral utterances reminiscent of sadness or disgust (Laukka et al., 2016). Additionally, we observed systematic elongation of the final word which, in the present design, carried crucial semantic information about the complaint. While final emphasis may not be a generic characteristic of complaints, it could indicate a tendency for speakers to intentionally accentuate relevant emotional content (here, the final word). Although our study was not designed to examine the local emphatic structure of complaints, these temporal changes suggest an important interplay between lexical-semantic and prosodic information in the communication of complaints (Pell & Kotz, 2021).

Social-pragmatic influences on complaint expression may also be revealed by voice quality measures, as we noted significant reductions in shimmer and noise in the speech signal when complaints were compared to neutral utterances. Shimmer is usually taken to index voice control, showing large values for irregular and rough speech (Latoszek et al., 2018). Increases in Harmonics-to-Noise Ratio tend to indicate less noisy, more harmonic speech. The observation that vocal control and clarity were greater when speakers complained seems to contrast with other acoustic tendencies linked to arousal (e.g., increased F0, amplitude), as it is typically expected that speech produced in conditions of high arousal exhibits increased shimmer and noise (Juslin & Laukka, 2003; Laukka et al., 2016). This could exemplify that complaints are by nature a *controlled* expression of affect. Interestingly, a recent study by Raine et al. (2019) on simulated pain also found that while most acoustic measures were consistent with natural pain, indexes of voice control decreased with the intensity of the pain intentionally conveyed by speakers. Alternatively, reduced shimmer and noise have been attributed to vocal expressions of sadness (Laukka et al., 2016), an emotional quality that was often associated with complaints according to our new data.

Complementing the acoustic findings, the emotional association task revealed that complaining prosody is *perceptually* associated with a range of negative emotional qualities. Based on a representative sample of complaining and neutral utterances, we found that complaints were associated with discrete emotional qualities consistent with their prosodic attributes (Acuña-Ferreira, 2002; Ogden, 2010). Listeners perceived mostly sadness, anger, and surprise in complaints. While the perceived intensity of certain emotions varied somewhat between speaker groups (see below), the emotional associations attributed to complaints by French and Québécois listeners were qualitatively similar, reinforcing that complaining prosody was perceived as strongly *emotive* and *negative* in a systematic manner by all participants. These results exemplify that speakers can intentionally display emotion-related signals to trigger affective reactions (the perception of emotions) and inferential processes (the recognition of a complaint) as described, for example, in the Emotions as Social Information Model (Van Kleef, 2009)

In terms of culture, French and Québécois speakers alike produced a consistent set of acoustic features associated with complaints, with a few potential cultural-specific strategies. Québécois speakers, when complaining, were perceived as angrier and more surprised than French speakers; in contrast, French complaints evoked more sadness. Acoustically, this was paralleled by changes in F0: Québécois complaints displayed greater F0 variation and larger range, denoting increased expressivity and arousal, whereas French complaints displayed larger increases in mean F0 with less variability, potentially reducing any perceived aggression associated with these utterances (Frick, 1985a). Certain differences in voice quality and temporal/rhythmic differences were also observed (e.g., French speakers produced complaints more slowly relative to neutral statements, whereas Québécois speakers seemed to alter their speech rate within the utterance). These differences underscore that complaining is a socialized form of affect expression that, while meant to communicate pain (Lautenbacher et al., 2017; Raine et al., 2019), is shaped by pragmatic conventions which dictate how members of a particular culture communicate their emotions for expressive purposes (Van Kleef, 2009). However, given the small number of speakers we examined in each cultural group, our conclusions regarding the cultural aspect of complaining remain tentative and await further investigation.

Our study is one of the few quantitative analyses of complaints in a controlled environment (Mauchand & Pell, 2021; Rao, 2013) and our results generally align with qualitative descriptions of spontaneous complaints derived from natural discourse contexts. For example, our stimuli were characterized by pitch-related emotivity (Acuña-Ferreira, 2002), displays of anger and surprise (Selting, 2010), emphatic accentuations (Selting, 1994) and a general hyperbolic style (Drew & Walker, 2009) over many acoustic dimensions. Moreover, our results are novel in demonstrating that changes in voice quality are systematically associated with complaining speech, which could not be identified in previous qualitative work.

1.5. Conclusion

Our data show that complaints are speech acts with ostensive emotive qualities, perceptually associated with negative valence/increased arousal, with features resembling anger, sadness, and/or surprise. Moreover, there appears to be a characteristic "sound of complaints", which exhibit differences in fundamental frequency and voice quality when compared to statements produced in a neutral tone. These acoustic-perceptual attributes appear to reinforce the expressive function of complaints to elicit empathy; this idea is supported by recent evidence that complaining voices are perceived as more salient and increase early cortical responses in listeners when compared to identical utterances produced in a neutral manner (Mauchand & Pell, 2022). Our conclusions are limited by the fact that we examined complaints outside of natural interactions; since complaining depends highly on context and can yield heterogeneous types of interactions, our acoustic and perceptual data may not fully capture this variability in more ecological settings. Still, our study highlights one of the ways that speakers use prosody as an emotive device to guide the listener's response in a quest to promote interpersonal affiliation.

1.6. Acknowledgements

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Preface to Chapter 2

Before tackling a phenomenon as complex as empathy in a context as rich as cross-cultural vocal interactions, it is critical to clearly understand and characterize the material that will be the object of study - here, complaints. Hence, the previous chapter provided a comprehensive answer to the question "What does a complaint sound like?". These answers constitute a first insight into the form of prosody, as well as the role of culture, in the production of complaints. It was important to begin this investigation from the speakers' perspective, since complaints begin, first and foremost, as an expression of the speaker's suffering. Within the context of the thesis, the role of Chapter 1 was twofold. First, it validated the creation of a large and robust stimuli set constituted of complaints that were acoustically and emotionally marked and distinct from neutral speech, in both cultural groups of interest. This validation provided a methodological justification for using these stimuli in every subsequent experiment of the project. Second, it confirmed the critical role of speech prosody in conveying emotivity and began to highlight culture-sensitive effects on how complaints are realized, laying the path for further investigations regarding how this emotivity is processed.

The following chapter builds on this initial acoustic characterization, this time through the listener's perspective. In other words, it aims to assess how complaints as they are produced relate to complaints as they are perceived. Besides investigating the roles of prosody and culture, this chapter also introduces a new variable, the *topic* of complaints. Manipulating this more objective communication of pain (either the topic is painful, or it is not) will shed light on potential interplays between *what* a complaint is about (the statement) and *how* it is produced (the prosody). More generally, this chapter will complete a thorough definition of complaints and their expressive role in social interactions and shed light on direct and indirect ways by which verbal, prosodic, and cultural signals allow us to form social impressions of complaining speakers.

Chapter 2. Emotivity in the voice: Prosodic, Cultural, and Lexical appraisal of complaining speech

2.1. Introduction

While the role of the voice in social interaction has been receiving growing interest over the last decades, literature on the topic has been scattered across research fields. On the one hand, experimental psychology has been focusing on affective speech and emotions (Frick, 1985b; Juslin, 2013; Scherer, 2003); on the other hand, intentionality, speech acts, and attitudes have been mostly addressed by pragmatics and theoretical linguistics (Culpeper & Terkourafi, 2017; Grice, 1989; Searle, 1965; Wichmann, 2002). A large part of our daily social interactions is inherently *emotive*, relying on the attitudinal, intentional use of emotional signals (Caffi & Janney, 1994). These interactions, involving both speaker and listener in a complex collaborative timeline, remain poorly understood. The nature and components of emotive interactions can be investigated through an intersectional approach, embedding social and affective psychology methods into the theoretical pragmatics framework of emotivity through the Emotions As Social Information (EASI) model (Van Kleef 2009). Focusing on the case of complaints, the present study examines how emotivity is conveyed through speech, and how affective signals in the voice are processed in different social and cultural contexts.

Complaints are intentional verbal expressions of social pain, distress, or displeasure (Boxer, 1993; Drew, 1998; Laforest, 2002), and are usually divided in two categories. *Direct* complaints are addressed directly to the source of the issue, with the purpose of terminating or solving the issue (Laforest, 2002; Trenchs, 1994). The present study focuses on *indirect* or *third-party* complaints, which are addressed to a third party usually unrelated to the issue (Drew, 1998; Edwards, 2005). Third-party complaints are non-instrumental in nature (Alicke et al., 1992); they do not aim to solve the problem they address, but have a more indirect function of promoting social affiliation though affectivity and empathy (Drew & Walker, 2009; Ogden, 2010). In what follows, the term complaint will be used to refer exclusively to third-party complaints.

The social importance of complaints is implied by their frequency; it is said that individuals complain more than four times a day on average (Alicke et al., 1992). While many types of speech acts can lead to a strengthening of social bonds, complaints appear to directly serve this purpose; this is accomplished through long, interactive sequences in which the complainer negotiates the affiliation of their listener (Drew & Walker, 2009; Selting, 2010). Complaints are usually defined by tightly bounded topics with a clear beginning and end (Drew, 1998), often used as ice-breakers or conversation openers (Boxer, 1993; Kowalski, 2002). Complainers may open with an initial complaint to probe the affiliative response of their listener, which will determine the course of the negotiation (Traverso, 2009). Ultimately, it is the listener who chooses whether or not to collaborate and affiliate with the speaker (Edwards, 2005; Selting, 2010).

Beyond describing a negative situation, a core function of complaints is to provide evidence of how the speaker *feels* about the situation (Drew, 1998). In order to gain affiliation, a complaint should allow the listener to share the affective state of the speaker and empathize with them (Acuña-Ferreira, 2002; Edwards, 2005). Since most complaints describe a past event involving felt pain or distress, it is unlikely that the speaker is fully experiencing these emotions as they complain; rather, these expressions may be viewed as instances of "reconstructed affect" (Selting, 2010). Complaining is thus an *emotive* or *expressive* speech act (Scarantino 2017), a type of social performance in which the speaker intentionally displays affective markers to achieve interactive goals (Acuña-Ferreira, 2002; Caffi & Janney, 1994). These markers are the negotiating products of a complaint, informing the listener of the complainer's emotions (Edwards, 2005) and sharing these emotions through mood contagion (Kowalski, 2002). The affective component of a complaint is usually more important than the object of the complaint itself, from which the interaction can drift off while remaining a complaining collaboration (Edwards, 2005; Traverso, 2009).

The Emotions as Social Information (EASI) model (Van Kleef, 2009) provides a useful framework for investigating the perceptual and social dimensions of complaining speech in greater depth. The EASI model emphasizes that affective displays are more than biological symptoms and can be used to influence others by triggering inferential processes and affective reactions. For complaints to succeed (i.e., promote social affiliation and strengthen bonds), complainers and listeners need to effectively display, perceive and respond to communicative signals of affect and emotivity, which are frequently marked through a complainer’s voice, or *speech prosody*. Here, we refer to prosody as suprasegmental acoustic features of speech - pitch, loudness, voice quality, rhythm - that speakers modulate, intentionally or not, to express meanings, emotions, and attitudes in their voice (Pell, 2001; Scherer, 2003). The manner in which prosody is used in complaining interactions and its impact on listeners has seldom been explored.

According to Brunswikian lens models of speech, the emotions of speakers are encoded by a constellation of acoustic cues that are then decoded by listeners into emotional representations (Brunswik, 1956; Grandjean et al., 2006; Laukka et al., 2016). A number of studies have reported that vocal expressions of basic emotion (e.g., anger, sadness, happiness) show specific patterns of pitch, loudness, rhythm, and voice quality that yield successful recognition of these emotions by listeners (see Juslin and Laukka 2003 and Scherer and Bänziger 2004 for reviews). However, vocal changes are not always symptoms of the speaker's internal emotional state; for example, prosody can be intentionally used as an expressive device to elicit empathy in the listener, allowing interactants to experience (Aziz-Zadeh et al., 2010; Rodero, 2011) and understand (Ong et al., 2018; Regenbogen, Schneider, Finkelmeyer, et al., 2012) the speaker's feelings. This combination of affective and inferential processing of prosody provides the speaker with important emotional influence and bolsters supportive behavior from the listener, with potential social benefits for both parties (Pell & Kotz, 2021; Van Kleef, 2009).

It has been reported that prosodic features of complaints signal increased affectivity through elevated mean fundamental frequency and frequency variability, syllable elongation, and emphatic accentuations (Acuña-Ferreira, 2002; Ogden, 2010; Rao, 2013; Selting, 2010). In emotional contexts, these acoustic changes are often associated with negative and high arousal emotions, like anger, sadness, surprise and indignation (Drew, 1998; Selting, 2010). Complaints may also be viewed as expressions of pain and suffering, which are associated with specific forms of vocal expression (Lerner et al., 2016; Raine et al., 2019). The present study is based on a large set of complaining utterances that display many of the acoustic and emotional properties described above, as well as voice quality patterns that resemble expressions of simulated pain (Mauchand and Pell in review a; Raine et al. 2019).

While the role of prosody in communicating the emotive involvement of complainers is heavily suggested, most of the literature on complaints comes from the pragmatics field, based largely on descriptive and qualitative analyses of conversations (Acuña-Ferreira, 2002; Boxer, 1993; Drew, 1998; Edwards, 2005; Ogden, 2010; Rao, 2013; Selting, 2010; Traverso, 2009). No experimental investigation has been conducted to establish how prosody affects the perception of complaints, especially with respect to other lexical or contextual cues that complainers often provide. As mentioned above, the emotive involvement of the speaker is often more important than the object of the complaint, meaning that even innocuous topics can be the focus of valid complaints (Boxer, 1993). Still, the preference of complainers to provide specific descriptions (Alicke et al., 1992), expletives (Drew, 1998), and extreme-case formulation (Selting, 2010) suggest that complaining emotive interactions depend on both linguistic and paralinguistic cues, albeit in an unclear manner.

The integration of prosodic and verbal affective signals and their combined impacts on social perception can be complex. The relative effects of cues in each channel may vary at different stages of perception, processing, and evaluation (Meconi et al., 2018; Paulmann & Kotz, 2008a; Pell et al., 2011), and likely depend heavily on task demands (Regenbogen, Schneider, Finkelmeyer, et al., 2012) and the emotional salience of cues (Wambacq & Jerger, 2004). In expressive speech acts, the role of prosody is traditionally described as an indirect, illocutionary force that can only convey meaning with the appropriate verbal statement (Grice, 1989; Wichmann, 2000). However, recent studies suggest that prosody alone can reveal the intentions of a speaker in a powerful manner (Caballero et al., 2018; Hellbernd & Sammler, 2016; Truesdale & Pell, 2018). For example, in motivating and persuasive speech, prosody can "tag" verbal information as important and increase the persuasiveness of a speaker even when the verbal information is not credible (Van Zant & Berger, 2020; Zougkou et al., 2017). Prosody is thus an important emotive *and* persuasive device in low-involvement communicative situations (Gelinas-Chebat & Chebat, 1992), which is often the case of third-party complaints (Alicke et al., 1992; Boxer, 1993).

The use of affect as social information further depends on a number of social-relational factors, such as cultural display rules, familiarity, or group biases (Van Kleef, 2009). Indeed, if the traditional view of emotions as genuine biological responses could imply a universal consistency in their expression (Ekman et al., 1987; Frick, 1985b), describing affective displays as social tools implies investigating how social and cultural contexts affect their usage (Scarantino, 2017; Van Kleef, 2009). Several studies already suggest that despite a basic universality, emotional communication can be affected by cultural in-group advantages (Elfenbein & Ambady, 2002), depend on cultural proximity (Laukka et al., 2016) and seem to mainly affect positive rather than negative emotions (Sauter, Eisner, Ekman, and Scott 2010; Scherer, Clark-Polner, and Mortillaro 2011; see Laukka and Elfenbein 2020 for a review). Often, out-group accent perception does not impede how well emotions are recognized but does affect perceived intensity, empathic arousal or physiological responses from listeners (Mac et al., 2010; Soto & Levenson, 2009; Thierry et al., 2015). Beyond emotions, a speaker's accent is a marker of identity: the information (or lack thereof) that it carries is known to interfere with speech processing

(Floccia et al., 2006; Sumner & Samuel, 2009), create biases and stereotypes (Heblich et al., 2015; Kuiper, 2005; Lev-Ari & Keysar, 2010), and affect the appraisal of diverse pragmatic cues (Jiang et al., 2020; Yuan et al., 2019). Cultural factors may thus affect numerous stages of production, perception, and interpretation of emotive speech.

Complaining appears to be a convention rooted in a number of cultures. Be it the French *se plaindre* (Traverso, 2009), the Australian *whinge* (Edwards, 2005), the German *Jammern* (Winchatz, 2016), or the Israeli *kiturim* (Katriel, 2013), many societies have defined complaining as a cultural custom, each with their own specificities and social implications. These potential cultural specificities raise the question of what constitutes a complaint across cultures. Yet, few studies have directly investigated the cross-cultural aspect of complaints. An investigation by Rao (2013) reported that Mexican Spanish complaints showed intonational variation typical of European Spanish complaints, but in a more accentuated manner. Similarly, Mauchand et al. (in review b) reported that Canadian French (Québécois) and European French complaints show strong acoustic similarities but sometimes differ in the weight given to certain prosodic cues and the emotional representations they convey. Parallel work on direct complaints also show some pragmatic differences between native and non-native complaints (Kraft & Geluykens, 2002; Trenchs, 1994). Beyond the definition of complaints, these acoustic differences could affect cross-cultural understanding of complaining speech, individuals being potentially more sensitive to emotive prosodic signals from their own group. To date, work which sheds light on these questions has not been undertaken.

The goal of the present study was to give insight on how third-party complaints are perceived from affective prosody and other cues that mark a speaker's "complaining intentions", using the Emotions as Social Information (EASI) model as a general reference (Van Kleef, 2009). Furthermore, we explored the role of social-relational variables in this context by studying two francophone groups: French (i.e. European French) and Québécois (i.e. French Canadian). While mutually intelligible, these two groups have different cultural backgrounds and distinct accents, thus allowing the isolation of cultural group (dis)advantages in the processing of complaints in the absence of language barriers. French and Québécois participants listened to pre-validated utterances that varied in prosody, verbal content, and speaker accent, and evaluated "how complaining" each utterance sounded. The study also investigated the relationship between encoding and decoding processes by analyzing how the perception of expressive speech acts, such as complaints, is driven by particular acoustic features of vocal affect signals. It was predicted that a speaker's tone of voice would be the main marker of a complaining intention, especially when verbal cues did not convey high emotive involvement, i.e. when speakers complained about innocuous rather than explicitly pain-related topics. The detection of complaints was expected to depend on how the speakers produced emotive signals, especially through modulation of voice pitch and other emotion-related cues, which are likely to mediate the effect of complaining prosody on participant's evaluations. Finally, it was predicted that social-relational factors would influence complaint perception: participants were expected to discriminate complaints from neutral utterances better for speakers of their own cultural group, potentially because of underlying biases and/or specific display rules associated with complaining speech.

2.2. Methods

2.2.1. Participants

Power analyses for mixed models (Judd et al., 2016) were performed to determine the required number of participants. Large effects of prosody and verbal content were reported in previous studies with similar procedures (Caballero et al., 2018; Mauchand et al., 2020). Due to the large number of stimuli (n=320), less than 25 participants were required to attain power over 99% for these effects. The effect of culture, if present, would be smaller based on previous cross-cultural studies that have used recognition tasks (Elfenbein & Ambady, 2002; Jiang et al., 2018; Laukka et al., 2016; Liu, Rigoulot, Pell, et al., 2015). Based on an effect size of 0.3 with intercepts and slopes variances of 0.1, a minimum sample size of 57 participants would be required to achieve power of 90% for this variable.

In total, 31 French and 27 Québécois participants, aged 18-35, with no hearing or neurological impairment were recruited in the Montréal area. French participants were born in France, had lived in France until at least 18, and had arrived less than 3 years ago in Montréal (for study or work). Québécois participants were born and lived in Québec (a French-speaking province in Canada) until age 18 and had never lived in France or another francophone country. All participants spoke French as their mother tongue.

Data about participants' personality and cultural attitudes were collected through a number of tests and questionnaires (see Mauchand and Pell in review b for a full report on these measures). Accent-based implicit biases were measured through a modified Implicit Association Test (Greenwald et al., 1998) consisting of Pleasant and Unpleasant words presented together with French and Québécois neutral utterances (Mauchand and Pell in review b). Explicit attitudes towards French and Québécois populations were probed through a questionnaire based on the Stereotype Content Model (Fiske et al., 2002), composed of 20 questions about the perceived Warmth and Competence of each community. Finally, empathic abilities were assessed through the Perspective-Taking and Empathic Concern subscales of the French version of the Interpersonal Reactivity Index (Gilet et al., 2013).

2.2.2. Materials

Materials were created and validated in a previous study focusing on the acoustic dimensions of speech complaints (Mauchand and Pell in review). Stimuli were short spoken utterances describing a past event, constructed in the form of *token sets* (each composed of 4 unique utterances). A token set was built around a root sentence that was manipulated in two ways. First, we modified the verbal content by modifying the last word of the statement, to refer to a neutral event e.g. "Il a dit que j'étais sorti / He said I was outside" (*Control* condition) or a socially painful event for the speaker, e.g. "Il a dit que j'étais stupide / He said I was stupid" (*Pain* condition). The list of sentences, together with their English translation, can be found in Table A1 of the Appendix. For each type of statement, we then manipulated the form of prosodic expression: speakers uttered each sentence in a manner as if simply reporting the event (*Neutral* condition) or as if complaining to a friend (*Complaint* condition). One token set was thus composed of 4 utterances with different Statement/Prosody combinations: *Control/Neutral,* *Control/Complaint, Pain/Neutral, Pain/Complaint.* Forty-two token sets were thereby created.

Initially, 672 utterances were produced by 4 French and 4 Québécois speakers (2 males and 2 females in each group) in order to modulate accent/sociocultural features of the stimuli. Recordings were digitally captured in a sound-attenuated chamber with a high-quality head-mounted microphone onto a Tascam recorder (sampling rate of 44.1 kHz, 16-bit, mono, .wav format). They were then edited in Praat (Boersma & van Heuven, 2001) into short .wav audio files and normalized to a peak intensity of 70 dB.

A short validation study was conducted to ensure the quality of the recordings and to select a subset of the stimuli for the current study. Ten French (5 males, 5 females, age: M = 21.1, sd = 3.8) and 9 Québécois (3 males, 6 females, age: M = 23.00, sd = 2.78) participants listened to all utterances from their own group (n = 336) and evaluated: 1) whether an utterance was a complaint (yes/no); and 2) if it was a complaint, its intensity of expression on a 5-point scale. Results of the validation task are displayed in Table 2.1. Pain/Complaint utterances were almost unanimously considered complaints with high intensity ratings, while Control/Neutral utterances were very rarely considered complaints. Results for Pain/Neutral and Control/Pain utterances suggest that prosody had a larger impact than statement type on the perception of complaints.

For the present study, a subset of utterances was selected to minimize the repetition of sentences in the experiment, to remove potential outliers, and to ensure that stimuli were representative of the speakers' intentions (complaining vs. neutral) according to listeners from their own group. For each speaker, a token set was selected if there was enough consensus that the Control/Neutral utterance was NOT a complaint and that the

Pain/Complaint utterance was indeed a complaint with high intensity ratings. To avoid selection bias on the prosody/statement effects, results for "incongruent" utterances were not taken into account for the selection. Moreover, each speaker had a "mirror" speaker (of the same sex) in the other cultural group that uttered exactly the same token sets, such that each token set was present exactly once in each group. This selection process did not affect the overall perceptual quality of the stimulus set, as scores for selected and unselected items remained close. In total, there were 2 Accents x 4 Speakers x 10 Token Sets x 2 Prosodies x 2 Statements = 320 selected utterances.

Table 2.1. Results of the validation/selection task, by speaker group (Mean + standard deviation).

Utterance/prosody type	Unselected utterances (n = 352)		Selected utterances (n = 320)	
	Proportion of YES answers to "is the person complaining?"	Intensity rating[a] (1 to 5)	Proportion of YES answers to "is the person complaining?"	Intensity rating[a] (1 to 5)
Québécois				
Control/Neutral	.26 (.27)	1.80 (.87)	.21 (.20)	1.89 (.99)
Control/Complaint	.81 (.21)	2.94 (.91)	.81 (.19)	2.89 (.70)
Pain/Neutral	.60 (.21)	1.74 (.63)	.64 (.21)	1.69 (.63)
Pain/Complaint	.96 (.07)	3.15 (.84)	.98 (.05)	3.34 (.57)
French				
Control/Neutral	.23 (.16)	1.53 (.54)	.25 (.15)	1.43 (.45)
Control/Complaint	.86 (.13)	3.45 (.78)	.87 (.13)	3.37 (.62)
Pain/Neutral	.57 (.16)	1.64 (.38)	.53 (.18)	1.67 (.43)
Pain/Complaint	.95 (.06)	3.47 (.60)	.94 (.08)	3.46 (.52)

[a] Note that the rating is only made when answering YES to the previous question.

Acoustic measures for each of the 320 selected utterances were collected using the Geneva Minimalistic Acoustic Parameter Set/GeMAPS (Eyben et al., 2016) package from the publicly available openSMILE toolkit (Eyben et al., 2010). The GeMAPS constitutes a reliable standardized baseline set of affect-related acoustic measures (for more details on the computation and implementation of the measures, see Eyben et al., 2016). A full acoustic analysis of all 672 stimuli is presented in a previous study (Mauchand and Pell in review a). The present study focuses on measures of pitch, voice quality, and rhythm known to be perceptually relevant in complaint production (Acuña-Ferreira, 2002; Rao, 2013) and other related modes of emotional expression (Laukka et al., 2016; Raine et al., 2019). Note that since the volume of stimuli was normalized for perception, intensity-related acoustic measures could not be reliably extracted for consideration in the present study. The following acoustic measures were computed as a mean measure over the full duration of each utterance:

- F0, the fundamental frequency, indexing pitch on a logarithmic semitone scale. Considering the importance of pitch in complaints, both the mean (F0 M) and the rescaled standard deviation (F0SD) over the utterance were computed.
- Jitter, indexing aperiodicity (instability) of the F0 signal - voice "creakiness"
- Shimmer, the difference of the peak amplitudes of consecutive F0 periods, indexing voice roughness in dB
- Harmonics-to-Noise Ratio (HNR), indexing the relative amount of additive noise in the voice
- F1, first formant center frequency in Hertz
- Utterance duration and final word duration in seconds (computed on Praat).

These measures are summarized in Table 2.2.

Table 2.2. Summary of acoustic measures for the selected stimuli for each speaker group (Mean + standard deviation). F0 M = mean fundamental frequency; F0 SD = rescaled standard deviation of the fundamental frequency; HNR = Harmonics-to-Noise Ratio; F1 = first formant center frequency

	French		Québécois	
	Neutral	Complaint	Neutral	Complaint
F0 M	28.43 (4.43)	34.13 (3.57)	28.93 (5.23)	34.28 (6.14)
F0 SD	.14 (0.06)	.15 (0.08)	.17 (.09)	.20 (.08)
HNR	6.64 (2.4)	9.22 (1.66)	6.4 (2.59)	7.83 (2.94)
Jitter	.05 (.02)	.04 (.02)	.06 (.03)	.05 (.03)
Shimmer	1.31 (.42)	1.06 (.35)	1.35 (.44)	1.18 (.34)
F1	535.98 (87.65)	554.86 (74.77)	534.44 (61.28)	559.84 (60.59)
Duration	1.16 (.26)	1.3 (.3)	1.42 (.29)	1.46 (.39)
Final word duration	.38 (.12)	.45 (.14)	.47 (.15)	.56 (.17)

2.2.3. Procedure

Each participant was presented all 320 selected stimuli in a fully randomized order using Cedrus Superlab 5 software. The stimuli were divided in 8 blocks of 40 utterances, with a self-monitored break between each block. After presentation of an utterance, participants answered the question "À quel point cette personne est-elle en train de se plaindre?" (*How much is this person complaining?*) on a 7-point Likert scale ranging from *Pas du tout* (*Not at all*) to *Énormément* (*Very much*) by pressing a button on a response box. No time limit was set. Participants were not given any indication or strategy on how to form their answer and were told that there was no right or wrong answer. The whole experiment lasted a little more than one hour.

2.3. Results

2.3.1. Main Model

Participant's ratings were analyzed through a Linear Mixed Effect Model using the R package lme4 (Bates et al., 2015). T-tests and p-values were computed with Satterthwaite's approximation using lmerTest package (Kuznetsova et al., 2017). The model was built with the participant's Response (0-6) as the response variable, and Participant Culture (French/Québécois), Speaker Accent (French/Québécois), Statement (Control/Pain), and Prosody (Neutral/Complaint) as predictors. All 2- and 3-way interactions were also entered as predictor terms. Participant and Speaker/TokenSet were added as random intercepts: TokenSet was nested within Speaker, such that Speaker was one random intercept and the interaction between Speaker and TokenSet was another random intercept, thus accounting for the variability of speakers and the variability of token sets within each speaker. Additionally, Culture, Statement and Prosody were added as uncorrelated by-Speaker/TokenSet slopes, and Accent, Statement and Prosody were added as uncorrelated by-Participant slopes.

The model accounted for 70% of the variance in the data ($r^2 = .70$). The model revealed a significant effect of Content ($\beta = .91$, se = .13, $t(19.13) = 7.04$, $p <.001$), suggesting that when speakers provided linguistic evidence of a painful situation (Pain vs. Control statement), ratings increased by almost 1 point on the scale. A larger effect of Prosody was observed ($\beta = 2.38$, se = .21, $t(12.82) = 11.38$, $p <.001$); statements expressed in a complaining versus neutral tone tended to increase ratings by more than 2 points. Speaker accent was associated with a marginal, yet noticeable effect, as statements produced in the Québécois accent tended to be rated stronger exemplars of complaints than those produced in the French accent (β = .68, se = .30, t(6.20) = 2.27, p = .063). This trend was informed by another marginally significant pattern in the data, representing a 3-way interaction of Participant Culture, Speaker Accent and Prosody (β = .35, se = .18, t(13.71) = 1.98, p = .068). The effects of Prosody (Complaint > Neutral) on complaint perception tended to be greater when Québécois participants were listening to the Québécois accent. No other term showed a significant effect (ps > .1). Results are summarized in Table 2.3; Content and Prosody effects are detailed in Figure 2.1.

Table 2.3. Mean rating of "how much the speaker is complaining" by French and Québécois listeners, according to the speaker's accent, prosody, and the type of statement (0-6 scale)

			French participants	Québécois participants
Accent	Statement	Prosody	M (SD)	M (SD)
French	Control	Neutral	.92 (.66)	.89 (.63)
		Complaint	3.28 (.85)	3.27 (1.03)
	Pain	Neutral	1.94 (.95)	1.70 (1.10)
		Complaint	3.96 (.74)	3.91 (.79)
Québécois	Control	Neutral	1.32 (.72)	1.22 (.77)
		Complaint	3.88 (.85)	4.22 (1.07)
	Pain	Neutral	2.72 (.85)	2.37 (1.01)
		Complaint	4.76 (.62)	4.90 (.62)

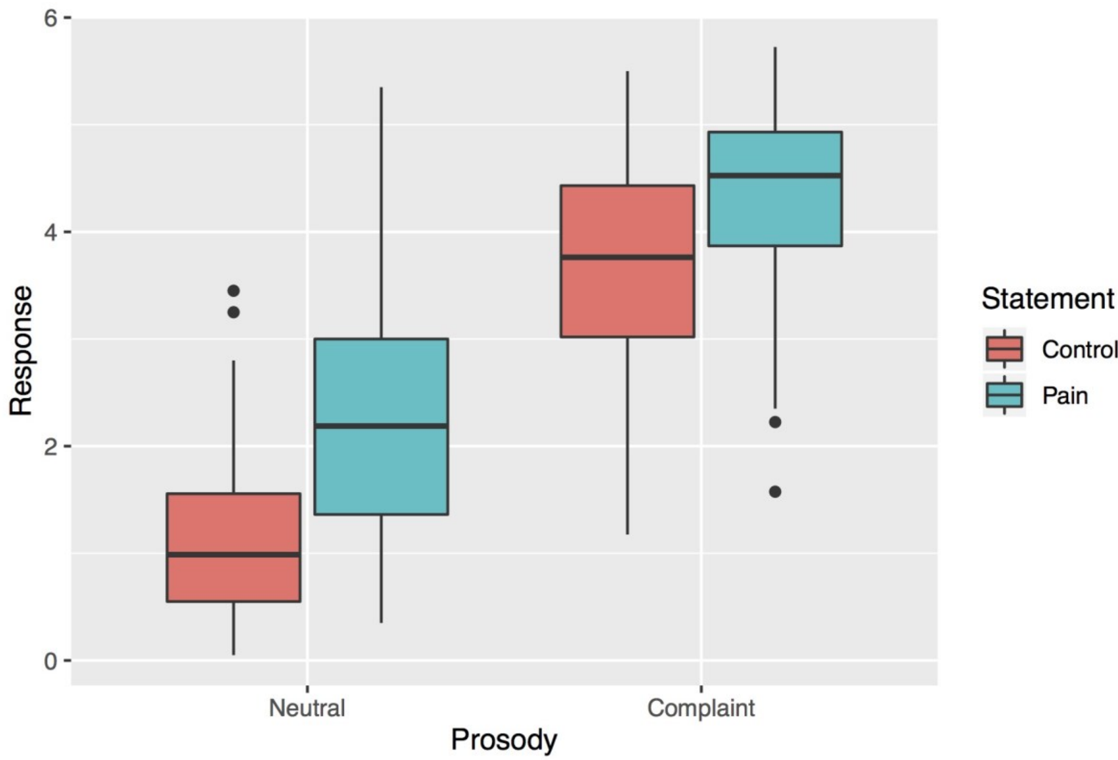

Figure 2.1. Box-plot summary of Prosody and Statement effects, averaged by participant.

Follow-up analyses were run to further investigate the relative effects of lexical and prosodic manipulations on the participant's responses. Looking at the model's random slopes reveals important variance in these two predictors (.82 for the slope of Prosody by Participant, .45 for the slope of Statement by Participant). A large negative correlation between the two slopes was found (r = -.52), indicating that participants with greater Prosody coefficients tended to have smaller Statement coefficients (see Figure 2). Note that a possible outlier showing extreme coefficients can be seen on Figure 2 but removing this participant from the analysis did not affect results. Correlations were then calculated between the predicted random effects of Prosody and Content and IRI scores, revealing a medium correlation between a participant's predicted Prosody effect and their score on the

Perspective Taking scale (r = .21), but not the Empathic Concern scale (r = .06). This pattern was mirrored in correlations with the predicted Statement effect, although to a much lesser extent (PT scale: r = -.13; EC scale: r = -.01). These results suggest that participants who were more sensitive to complaining prosody (especially those with greater perspective-taking skills) relied less on the actual statements.

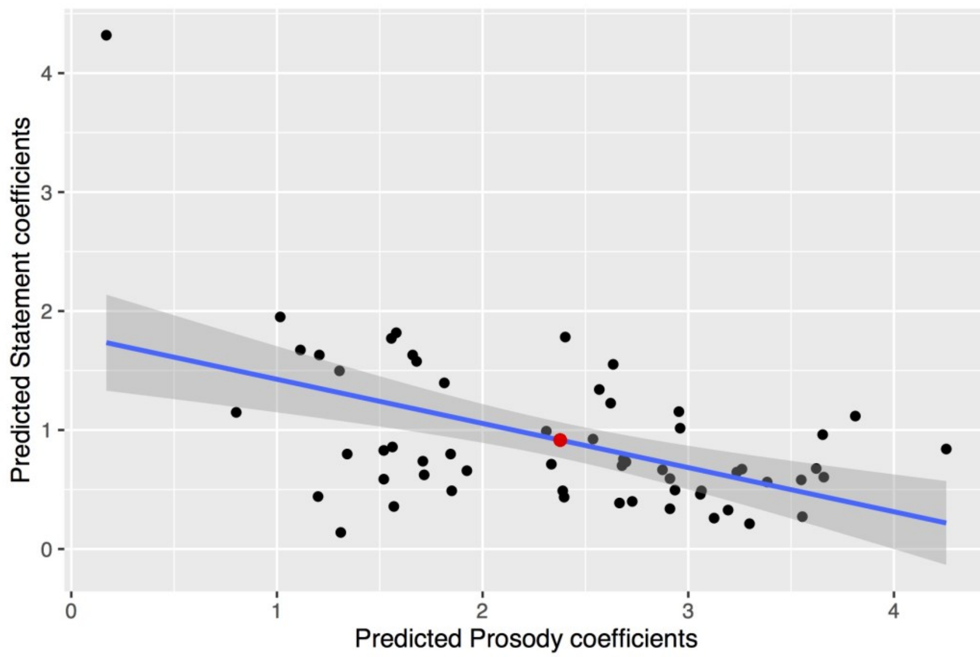

Figure 2.2. Relationship and linear regression slope between each participant's predicted coefficients for Statement and Prosody effects in the linear mixed-effects model. The red point indexes the actual coefficients from the whole model.

Analyses also probed the effect of speaker accent and assessed whether this effect could be driven by more specific social-relational factors such as cultural attitudes. A measure of implicit cultural bias was derived from a customized version of the IAT, designed to measure implicit attitudes held by French and Québécois towards speakers of each group (Greenwald, McGhee, and Schwartz 1998; Mauchand and Pell in review b) Based on the IAT D-score, the predicted random effects for each participant showed no particular relationship with implicit biases towards speakers of each cultural group (r = .04) nor with any of the Stereotype Content Model scores for either group (French Warmth: r = -.05; French Competence: r = .04 ; Québécois Warmth: r = .10; Québécois Competence: r = .07). This suggests that accent effects were not strongly driven by implicit or explicit cultural biases.

2.3.2. Mediation of Prosody Effects by Acoustic Parameters

To determine how the effect of prosody on complaint perception relates to specific acoustic properties of the voice, a regression-based mediation analysis with multiple mediators was run following Vanderweele and Vansteelandt (2014). This method accounts for potential relationships between mediators and prevents any effect overlap and redundancies of running several individual mediation analyses. Acoustic parameters described in the Methods section were selected as mediators (see Table 2.2). The measures from each utterance were standardized by subtracting the mean and dividing by the standard deviation of all utterances. The mediation analysis was thus performed with Prosody as the treatment variable, Response as the outcome variable, and the eight acoustic parameters as mediators.

First, to assess how the treatment variable Prosody affected the mediators, eight linear regressions were run, each with a mediator as the response variable and Prosody as the predictor. Then, to evaluate the effects of the treatment and mediators on the outcome, a multiple linear regression was run with Response as the response variable and the treatment (Prosody) and all eight mediators as predictors. The direct effect of Prosody is given by its coefficient in the latter regression model; the indirect effect of Prosody through a given mediator is given by the product of the effect of Prosody on this mediator and the effect of the mediator on the Response; the total indirect effect of prosody is given by the sum of all such mediated effects.

The speaker's mode of prosodic expression had significant effects on each mediator: compared to neutral statements, complaints showed increased F0M ($\beta = .49$, se $< .01$, $t = 76.79$, $p < .001$), increased F0SD ($\beta = .11$, se $< .01$, $t = 15.39$, $p < .001$), reduced shimmer ($\beta = -.26$, se $< .01$, $t = -37.16$, $p < .001$), reduced jitter ($\beta = -.06$, se $< .01$, $t = -8.39$, $p < .001$), longer utterance duration (($\beta = .09$, se $< .01$, $t = 17.91$, $p < .001$) and final word duration ($\beta = .25$, se $< .01$, $t = 34.56$, $p < .001$), increased HNR ($\beta = .38$, se $< .01$, $t = 55.22$, $p < .001$), and increased F1 ($\beta = .15$, se $< .01$, $t = 21.09$, $p < .001$). In turn, participant's Response/ratings were positively affected by F0M ($\beta = 1.62$, se $= .05$, $t = 29.52$, $p < .001$), Jitter ($\beta = .25$, se $= .03$, $t = 7.49$, $p < .001$), and utterance duration ($\beta = .20$, se $= .03$, $t = 6.51$, $p < .001$), and negatively affected by Shimmer ($\beta = -.16$, se $= .04$, $t = -4.22$, $p < .001$), HNR ($\beta = -.78$, se $= .06$, $t = -12.77$, $p < .001$), and F1 ($\beta = -.19$, se $= .03$, $t = -6.20$, $p < .001$. No effect of F0SD ($\beta < .06$, se $= .\ 03$, $t = 1.67$, $p = .094$) or final word duration ($\beta < -.02$, se $= .03$, $t = -.81$, $p = .420$) were found. As shown in Figure 3, F0M was by far the greatest mediator of Prosody on Response ($\beta = .79$), followed by shimmer ($\beta = .04$) and utterance duration ($\beta = .02$). Meanwhile, the mediations of HNR ($\beta = -.29$), F1 ($\beta = -.03$), and jitter ($\beta = -.02$) were negative. Most of the Prosody effect was not linearly mediated by acoustic measures, as the total indirect effect of Prosody ($\beta = .54$) accounted for much less of the total effect ($\beta = 2.38$). The mediation model is illustrated in Figure 2.3.

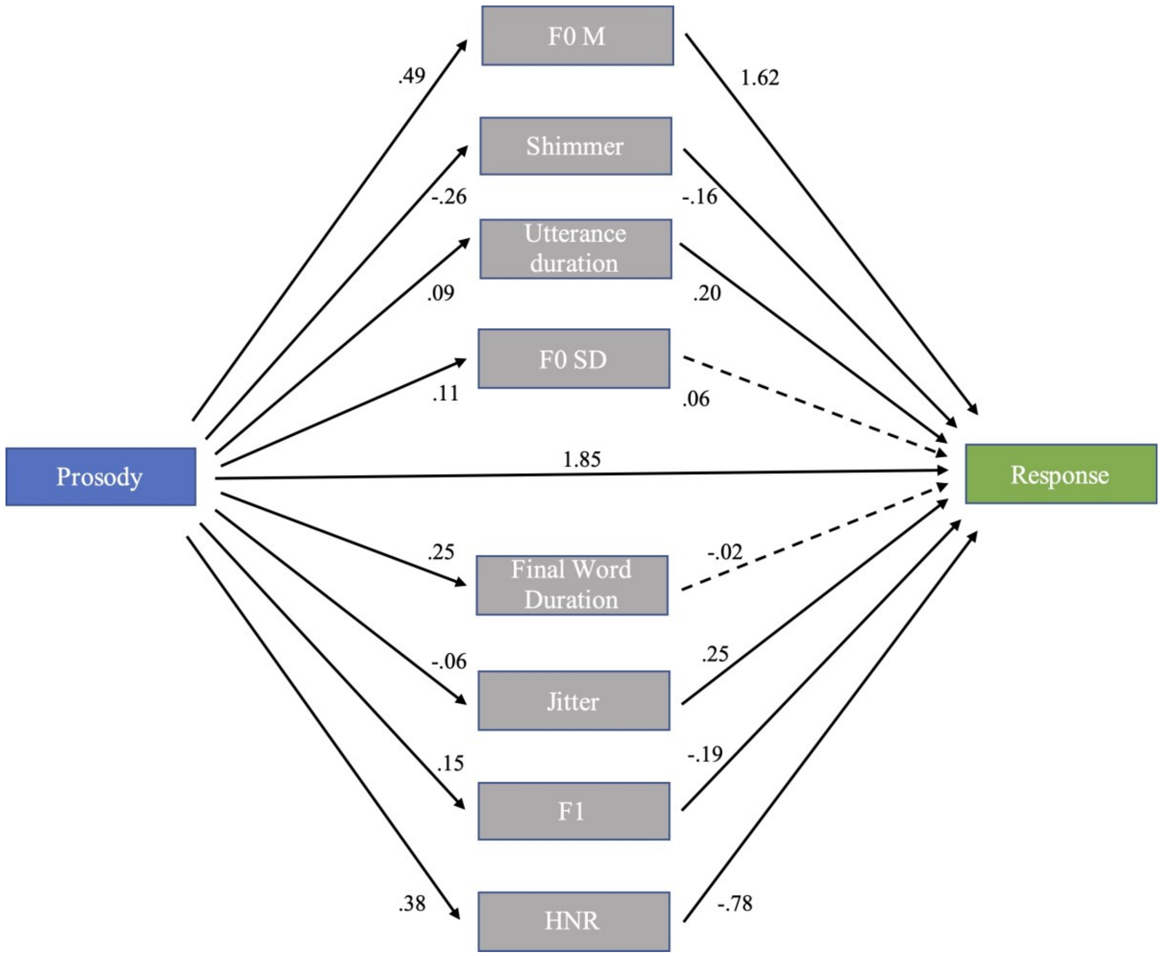

Figure 2.3. Model summary for the multiple mediation anlaysis. F0M = mean fundamental frequency; HNR = Harmonics-to-Noise Ratio; F0SD = standard deviation of the fundamental frequency

2.4. Discussion

Our results provide experimental evidence supporting the literature on complaints, emotive communication, and vocal affect. As elaborated below, they emphasize the important role of prosody in conveying emotive information in communication and its relationship to other message-level (e.g., lexical) and social-relational (e.g., cultural) dimensions of social interaction.

2.4.1. Affective Prosody, Effective Complaint

The core of the study measured how listeners evaluate the complaining nature of utterances in different situations combining several factors. The manipulation of the speaker's prosody was revealed to have the largest effect on listener's evaluations; everything else controlled for, switching from a "neutral" to a complaining tone of voice led to a marked increase in whether statements were judged to be a complaint. This finding parallels the ability to recognize basic emotions and evaluate speaker arousal from vocal expressions (Grandjean et al., 2006; Scherer, 2003), extending this ability to the general perception of a speaker’s emotivity in discourse. Through the speaker’s intention to foreground speaker affect (Arndt & Janney, 1991; Caffi & Janney, 1994), our results show that complaints can be discriminated from vocal signals without requiring complex attitudinal inferences from situational context (Wichmann, 2000). This exemplifies the use of emotional expressions as a social tool, providing listeners with affective information that allows them to make inferences and to (voluntarily) share the speaker’s emotive state (Scarantino, 2017; Van Kleef, 2009). Here, prosody appears to be the main device in the collaborative treatment of affectivity (Drew, 1998; Selting, 2010), constituting a relatively direct and effective way for listeners to assess a complainer's subjective state (Acuña-Ferreira, 2002; Edwards, 2005). It can be said that detecting the emotivity of the speaker is a crucial first step in complaining interactions; by allowing listeners to recognize complaints, prosody is likely to play a key role in facilitating the affiliative and empathic response of listeners (Boxer, 1993; Traverso, 2009).

Prosody was not the only way speakers could influence listener's evaluation of complaints. Utterances that described an explicitly painful situation were perceived as stronger exemplars of complaints than statements which did not. Affective words and sentences are known to affect a listener's perception of emotions in speech (Pell et al., 2011; Regenbogen, Schneider, Finkelmeyer, et al., 2012; Rigoulot et al., 2020). However, this effect did not interact with prosody and was small enough that control statements spoken in a complaining tone were perceived as more complaining than pain-related sentences in a neutral tone. This confirms an important characteristic of complaints: *how* we complain is more important than *what* we complain about, and one can virtually complain about anything (Alicke et al., 1992; Boxer, 1993). Still, the description of a past situation that would typically be associated with (social) pain can facilitate the perception of an utterance as a complaint; this factor is likely to play a role in how complaining interactions unfold in spontaneous interactions.

Interestingly, the perceptual weight given to the statement seemed to be greater when prosody was less efficient; listeners who were less sensitive to prosodic signals could presumably compensate by relying on the more tangible, explicit nature of verbal information (Zougkou et al., 2017). The relative weighting of prosodic and linguistic information can be partially explained by listener's empathic abilities; individuals with heightened perspective-taking skills (or *cognitive* empathy), relied more on prosody and less on the verbal statement. In contrast, participants with greater empathic concern (or *affective* empathy) did not show such associations. These results are congruent with the nature of the task, which required *understanding* the speaker's intention; in this context, the interpretation of the displayed affect would have been driven by inferential rather than affective processes (Van Kleef, 2009). Future research using other designs such as self-ratings or physiological measures (de Vignemont & Singer, 2006; Kanske et al., 2015;

Lang et al., 2011) could further distinguish affective from inferential processes in empathy and assess how listeners actually *share* a complainer's affective state from prosody.

2.4.2. From Acoustic Signals to Emotive Representations

The manipulation of prosody in our study allowed us to determine to what extent these cues are instrumental for listeners to recognize the speaker's intent to complain; however, it does not explain *which* acoustic cues drive these judgements and *how* they do it. Prosody researchers who have adopted a Brunswikian approach have stressed that while emotion encoding and decoding have been widely covered by the literature in a separate manner, investigations that *combine* both processes are lacking (Grandjean et al., 2006; Juslin & Laukka, 2003; Scherer, 2003). Acoustic analyses of the present stimuli had revealed a number of parameters that speakers seem to manipulate in order to convey their complaints (Mauchand and Pell in review a). In particular, increased mean F0 and F0 variability, decreased shimmer, increased Harmonics-to-Noise ratio, and lengthened final word were widely used acoustic strategies to communicate complaints. The multiple mediation analysis performed here assessed if and how these parameters were actually used by listeners in their evaluations.

Results of the mediation analysis suggest that mean F0 was by far the most important acoustic parameter in mediating the effect of Prosody; complainers increased their mean pitch, which was perceived as more complaining by listeners. Fundamental frequency is known to be the most directly accessible marker of affect for listeners, and is modulated in both a discrete and continuous manner to express basic emotions (Eyben et al., 2016; Frick, 1985b; Grandjean et al., 2006) and attitudes (Caballero et al., 2018; Jiang

& Pell, 2017; Mauchand et al., 2018; Truesdale & Pell, 2018). Increased F0 mean also marks non-aggressivity and is central to affiliative behaviors as described by the Frequency code (Gussenhoven, 2004; Ohala, 1984), which could explain its central importance in the production and perception of complaints.

Differences in voice quality also showed notable patterns in mediating the effect of prosody on complaint recognition. Compared to neutral speech, complaints displayed reduced shimmer, increased HNR, and to a lesser extent reduced jitter, indicating that speakers employed a less rough, less creaky and less noisy voice when they were complaining. Evidence of increased voice control (Latoszek et al., 2018) while complaining is also characteristic of simulated but not natural pain (Lautenbacher et al., 2017; Raine et al., 2019). Interestingly, HNR and Jitter negatively mediated the participant's response, suggesting that listeners may perceive that complaints are not genuine but reconstructed displays of affect (Selting, 2010). This impression may also explain why even complaints with pain-related statements were rarely evaluated using the highest points on the scale. In addition, reduced shimmer was associated with a slight increase in complaint ratings, possibly due to the importance of this acoustic marker in detecting sadness (Juslin & Laukka, 2003). Increased F0SD and Final World Duration, which were associated with complaining prosody, did not significantly affect listener's judgements in the current study. It should be borne in mind that complaints occur in complex interactions, and the role of prosodic features may not be limited to signaling an emotive intent. Dynamic variations in pitch and rhythm, which mark the emphatic structure of speech (among others), could instead help to coordinate the upcoming interaction and indicate how the collaborative treatment of affect should proceed (Selting, 1994; Szczepek

Reed, 2011). Also, the fact that effort-related parameters, such as higher F1 and larger F0 variation (Traunmüller & Eriksson, 2000), had little or even negative effects on the perception of complaints reaffirms that successful complaints are conveyed through affiliative signals (as per the Frequency code), rather than effort-derived meanings (as per the Effort code) (Gussenhoven, 2004; Ohala, 1984).

It is important to note that while a portion of the prosody effect on complaint perception was mediated by specific forms of acoustic change, a large part of the effect remains unexplained in the model. As our selected acoustic parameters cover many of the core acoustic features of utterances (except loudness), it is unlikely that entering more parameters as mediators would significantly increase the proportion of the mediated effect. Instead, it appears that the transformation of acoustic signals into an emotive representation is not a linear process that can be fully decomposed. In the context of our task, it is likely that the apparent contrast between neutral and complaining prosody allowed a discrete categorization of the two utterance types; the relative salience of certain parameters (such as pitch or vocal noise) could then further modulate the perception of utterances within each category.

2.4.3. Social-Relational Factors in Emotive Communication

While evaluations of complaints relied mainly on prosodic and lexical information, the cultural manipulation of this experiment had a marginal, but still noteworthy, impact on perceptual judgements. Overall, Québécois speakers were rated as producing stronger (i.e., more prototypical) complaints than French speakers, and there was a strong trend for

Québécois listeners to recognize complaining prosody better when produced by other Québécois speakers.

In a previous study (Mauchand & Pell, in review), differences between French and Québécois complaints were reported at both the acoustic and perceptual level, motivating our continued interest in how socio-cultural variables influence complaint perception. In that study, we found that Québécois speakers, when complaining, used greater pitch variability and distinct rhythmic patterns than French speakers and were perceived as angrier and more surprised (as opposed to sad for the French speakers, Mauchand & Pell, in review). Of key interest, Québécois speakers used a harsher voice quality than French speakers when producing complaints (reduced HNR). Here, the mediation analysis revealed that HNR reduced the intensity of the perceived complaints; the harsher vocal quality of Québécois speakers might thus have facilitated the detection of complaints by certain listeners. This facilitation was enhanced at the in-group level, as Québécois listeners seemed more attuned to prosodic contrasts produced by other Québécois speakers. This finding suggests the existence of cultural display rules and in-group advantages in emotive speech communication as is the case for the expression of emotions (Elfenbein & Ambady, 2002). However, the absence of a similar in-group advantage for the French group suggests this effect might depend on the interplay of individual, cultural and contextual factors. For example, the exposure of our French participants to the Québécois culture in this study could have reduced potential in-group advantages for that group. However, French participants were very recent immigrants in Québec, and most of them reported having very few Québécois people in their social and professional circles. On the other hand, Québécois participants reported having more French acquaintances, and are frequently exposed to French-accented speech from an early age (Kircher, 2012). Thus, the asymmetry in cultural effects may alternatively be due to a lack of sensitivity of French participants to the more expressive Québécois complaining style.

While the decoding of emotive cues in the voice may be enhanced for certain in-group interactions, this facility does not seem to originate from cultural bias or prejudice. No relationship was found between the effect of accent and either implicit or explicit biases towards either group, even though such biases exist between French and Québécois communities (Auger & Valdman, 1999; Kircher, 2012; Mauchand & Pell, 2022a). While stereotypes and prejudice do affect neural activity (Jiang et al., 2018; Quadflieg & Macrae, 2011) and affective empathy (Contreras-Huerta et al., 2014; Xu et al., 2009), they often don't impede speech comprehension and affect recognition (Gill, 1994; Lev-Ari & Keysar, 2010; Thierry et al., 2015). Thus, accent effects may instead arise from processing issues and/or differential use of prosodic signals. Even then, the potential impact of accent cues was minimal when compared to the efficacy of both speaker groups to convey a complaining intention through prosody. These results thus reveal a strong consistency of speakers in intentionally using emotions as social signals and of listeners to infer their intentions in the case of complaints. This inference process can be subtly modulated by social-relational factors, such as the culturally normative usage of certain prosodic cues (Elfenbein & Ambady, 2002; Scherer, 2003; Van Kleef, 2009). Other factors not taken into account here may also play an important role in natural complaint perception: here, the absence of context, visual cues, or a true indication of the social proximity between speaker and listener might explain why evaluations of complaints rarely reached the end of the scale. Sex/gender is also often mentioned as an important factor in complaining (Acuña-

Ferreira, 2002; Selting, 2010); anecdotally, speaker sex was tentatively added as a parameter in our model, but did not show any significant effect (although this could be due to the small number of male/female speakers in our experiment). Future studies should investigate how a wider range of these social factors influence inferential and affective processes underlying emotive speech communication.

2.5. Conclusion

As the first perceptual investigation of complaining speech, the present study reaffirms the central role of prosody as a social device to foreground the emotive state of the speaker. The effective production and appraisal of emotive features in the voice denote a tacit understanding between speaker and listener on how complaints are performed, which depends on the capacity of listeners to detect these signals and collaborate with the social goals of the speaker (i.e., to commiserate and co-complain). Listeners also use linguistic evidence describing the nature and/or antecedents of a complaint when evaluating these speech acts, although these cues may be less diagnostic than prosodic contrasts for determining when a speaker intends to complain (and seek social affiliation and support). As such, complaints can be qualified as acts of manipulation without deception, similar to other emotive acts like persuasion, motivation or charismatic speech: intentional displays of emotion that regulate the dispositional affect of listeners and promote social affiliation. This metapragmatic understanding of human affect, central to speaker/listener relationships, needs to be systematically considered in future investigations of speech, attitudes, and emotions (Pell & Kotz, 2021). Including social-relational factors, such as cultural relationships, is crucial to advance perspectives in this literature; future work should investigate how more distant cultures communicate complaints and other types of emotive meanings. Experimental approaches that include empathic assessments, neurophysiological measures, or which study group interactions would also produce valuable evidence to build on theoretical frameworks describing emotive communication, affect, and prosody.

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SECTION II: TIME COURSE OF NEURAL EMPATHIC RESPONSES TO COMPLAINTS

Preface to Chapter 3

The previous two chapters, while not featuring any neuroscientific data per se, provide critical context to better understand the subject of study and interpret the rest of the thesis. Together, these two initial chapters are the first quantitative and experimental investigations providing an end-to-end, speaker-to-listener description of complaints. Building on pragmatic models of speech communication and affect, they allow a simple understanding of what complaints are at a scale that is directly accessible and model critical prosodic, lexical, and social-relational factors into this understanding. And now that it is clear what a complaint *is*, we may proceed to investigate what a complaint *does.*

This section is composed of two reports from an EEG experiment, analyzing event-related potentials (ERPs) related to brain responses as complaining utterances unfold in time. The procedural design of this experiment is purposefully similar to the previous chapter, with only task demands changing from "How much is this speaker complaining?" to "How hurt does the speaker feel?". This simple change aimed to switch the attention of the listeners from the complaint itself to the affective state of the speaker and probe their empathic reactions. Indeed, it was not clear, after the first two experiments, whether what qualifies as a "good" complaint effectively conveys a true feeling of pain, and how listeners appraise this feeling. The following chapter addresses these questions and provides the first insight into how the brain responds empathically to this feeling of pain.

The development of this experiment was troubled by unexpected alterations of research activities during the COVID-19 pandemic. Due to the numerous restrictions on testing procedures, it was decided to restrict the population of interest to French participants. This decision was taken based on three factors: I had already started testing French participants before restrictions were set; restrictions prevented hiring and training a Québécois research assistant to test Québécois participants (to avoid examinator-related biases as was done in the previous chapter); and previous experiments revealed that French participants were easier to recruit through targeted outreach strategies (e.g., in social media groups of "French living in Montreal"). Hence, the following chapters will focus on French listeners; stimuli were thus re-labelled as "Ingroup" for French utterances and "Outgroup" for Québécois utterances.

Chapter 3. Listen to my feelings! How prosody and accent drive the empathic relevance of complaints

3.1. Introduction

Much of our daily social interactions go beyond a simple exchange of verbal information. When speaking, we often appeal, voluntarily or not, to the emotional nature of others by making them feel *and* understand how we feel. This phenomenon, often defined as empathy, is operationalized by certain speech acts such as complaining. Complaints are verbal descriptions of a distressing, annoying, or painful event (Boxer, 1993; Drew, 1998). When addressed indirectly to a third party - as opposed to direct complaints addressed to the source of the distress (see Laforest, 2002) - complaints do not seek to resolve an issue, but rather, to foster the listener's affiliation to their suffering (Alicke et al., 1992; Drew & Walker, 2009). In order to negotiate this affiliation, speakers aim to trigger mechanisms of mood contagion and shared affect (Kowalski, 2002; Selting, 2010), as well as mentalizing processes for their listener to infer their subjective state (Edwards, 2005). Complaining thus becomes an *emotive* speech act (Caffi & Janney, 1994; Selting, 2010) in which emotions are used as social information to elicit affective responses in others (Scarantino, 2017; Van Kleef, 2009).

To convey emotivity, speakers often provide vocal paralinguistic signals, i.e., they modulate acoustic features of their speech prosody such as pitch, loudness, voice quality, or rhythm. While many emotional signals can be attributed to biological effects of a speaker's emotional state (Grandjean et al., 2006; Scherer & Bänziger, 2004), emotive vocal expressions can also be strategically used to communicate intentions and to influence others (Pell & Kotz, 2021). In the case of complaints, speakers use prosody to reconstruct an impression of their affective state during the recalled event. This allows them to create an emotive involvement between them and their listener despite the temporal and contextual distance of the complaining topic (Selting, 1994). Acoustically, complaining speech is often marked by a higher pitch and wider pitch range (Ogden, 2010; Rao, 2013), emphatic elongations of words or syllables (Acuña-Ferreira, 2002; Selting, 1994), and changes in voice quality (Mauchand & Pell, n.d.). Beyond showing enhanced "expressivity", these acoustic markers mimic vocal expressions of high arousal and negative emotions such as anger, sadness, and surprise (Acuña-Ferreira, 2002; Mauchand & Pell, n.d.; Selting, 2010), and share a number of qualities with the vocal expression of pain (Lerner et al., 2016; Raine et al., 2019). These emotive signals are graded and can be exaggerated for communicative purposes: displaying more and/or stronger affective cues allows complainers to increase the involvement and empathic response of their listener (Mauchand & Pell, 2021; Selting, 2010). The goal of this study was to assess how this empathic response is manifested, and how it may relate to current views and theories on empathy in the brain.

3.1.1. Neural substrates of empathy

Despite the rapidly growing literature on empathy, this construct remains poorly defined (Cuff et al., 2016) and its operation is rarely studied in the context of speech communication from a neurocognitive standpoint. While empathy can be broadly defined as a shared affective state elicited by the observation of another person (Preston & de Waal, 2002), the nature of mechanisms involved in the empathic response is disputed. Some refer to empathy as an automatic affective reaction congruent to the feeling of the observed person which should be distinguished from mentalizing processes, i.e., conscious inferences about the other's feelings (de Vignemont & Singer, 2006). Many include mentalizing as part of the empathic process, describing both automatic (affective empathy) and controlled (cognitive empathy) mechanisms, although their distinctness and independence varies across the literature (Fan & Han, 2008; Kanske et al., 2015; Preis et al., 2015; Sessa, Meconi, & Han, 2014). Some definitions even include broader notions such as compassion, sympathy, and/or emotional contagion (Carré et al., 2013; Preston & de Waal, 2002). Given its complexity, some researchers advise against using the umbrella term "empathy" and to focus on individual underlying mechanisms (for a review, see Hall & Schwartz, 2018). Beyond these conceptual debates of empathy, it is nonetheless apparent in affective perception research that observing another person experiencing a given feeling (e.g., pain) elicits at least two types of processes: early, automatic responses linked to physiological arousal and emotional mirroring (Baird et al., 2011; Prochazkova & Kret, 2018); and late, controlled appraisals related to affective cognition and mentalizing (Ong et al., 2018; Spunt & Adolphs, 2017).

Neurocognitive processes underlying empathy and their temporal signature have, for the most part, been brought to light by the study of event-related potentials (ERPs) in response to visual depictions of pain. In an early study, Fan & Han (2008) found that viewing images of hands in a painful situation elicited an early positive shift 140ms after image onset followed by an increase in the P3 component; these components were modulated by the reality of the image (picture vs. cartoon) and by participant attention (pain evaluation vs. finger count), respectively. These results highlighted the affective-cognitive dissociation of empathic responses to other's pain, with an early automatic component preceding a later controlled appraisal.

A similar sequence of empathy-related neural responses, with some variability in what components were modulated, has been reported by several other visual studies of pain. For the early response, many showed modulations of the N2 component (J. Chen et al., 2020; Galang et al., 2021; Meng et al., 2012; Sessa, Meconi, & Han, 2014; Sessa, Meconi, Castelli, et al., 2014), but some also found earlier responses in the P2 (Sessa, Meconi, & Han, 2014; Sheng & Han, 2012) and even N1 components (Decety et al., 2010; Meng et al., 2012). For the late response, most studies report P3 increases for pain, though later positivities in the 500-700ms latency range are also reported (Cheng et al., 2014). In some work, P3 modulations to painful stimuli have been observed in the absence of earlier ERP components (Lyu et al., 2014; Sessa & Meconi, 2015). There is also evidence that individual differences in certain empathy-related traits, usually measured by the Interpersonal Reactivity Index subscales (Gilet et al., 2013; Mauss & Robinson, 2009) affect these responses. Trait empathic concern (Cheng et al., 2014; Sessa, Meconi, Castelli, et al., 2014; Sheng & Han, 2012) and perspective-taking skills (J. Chen et al., 2020; Galang et al., 2021; Lyu et al., 2014) are related to the early vs. late ERP responses, respectively, providing further support for a dissociation of (early) affective and (later) cognitive processes in the perception of pain, at least when visual depictions are processed.

To perceive pain in speech, whether these expressions are genuine or socially motivated, requires the continuous uptake of acoustic features which are likely to affect how and *when* empathic processes occur. Speech prosody is known to be an efficient channel for communicating affect (Mauchand et al., 2020; Regenbogen, Schneider, Finkelmeyer, et al., 2012; Rigoulot et al., 2020; Truesdale & Pell, 2018) and to mobilize empathic abilities (Esteve-Gibert et al., 2020). Recently, Meconi et al. (2018) revealed that priming affective prosody affected both early and late empathic responses to emotional facial expressions. There has been no ERP investigation of complaints to date, but several studies have shown insight on the processing of vocal affect and emotions. The detection of affective prosody can occur as early as 100ms after voice onset (Nordström & Laukka, 2019; Pell et al., 2015); in ERPs, the P200 component has been suggested to index emotional and motivational salience perception (Paulmann et al., 2011; Steber et al., 2020). It is often followed by late positivities (Mauchand et al., 2021; Paulmann et al., 2013; Zougkou et al., 2017), analogous to the dissociation of affective and cognitive components of empathy. Depending on context and task demands, other early and late components of affective prosody perception have also been reported, such as mismatch negativity (Carminati et al., 2018; Thönnessen et al., 2010), early posterior negativity (Jaspers-Fayer et al., 2012; Mittermeier et al., 2011), or P3a (Carminati et al., 2018; Wambacq & Jerger, 2004).

3.1.2. Empathy as a socio-cultural process

A major aspect of empathy is its social and cultural dimension; indeed, sharing and understanding other's emotions is often facilitated by socio-cultural proximity (Cheon et al., 2010). Social interactions are usually affected by implicit biases governed by associative processes (e.g., ingroup/outgroup perception), and explicit biases in propositional evaluation based on beliefs (Gawronski & Bodenhausen, 2006). For instance, cultural biases have been found to modulate the affective processing of others' pain:

perception of other-race faces in pain often reduce early, but not late, ERP responses compared to own-race faces (Contreras-Huerta et al., 2014; Sessa, Meconi, Castelli, et al., 2014; Sheng & Han, 2012). On the other hand, social evaluations such as trustworthiness (Sessa & Meconi, 2015) or social power (Galang et al., 2021) have been found to affect later responses to visual pain. In the communication of complaints, the role of culture may also be critical and potentially complex: group differences can be evident through the speaker's accent and also by potential differences in the cultural form of expression of complaints (Mauchand & Pell, n.d.; Rao, 2013). A speaker's accent, beyond showing their linguistic/cultural identity, also marks social differences, with standard accents being often perceived as higher in status than regional accents (Kristianse, 2001; Pantos & Perkins, 2012). In French, which was the focus of this study, the Québécois (French-Canadian) accent is phonetically distinct from the standard French accent (Ménard et al., 1999). To listeners who speak standard French, the Québécois accent is subject to implicit group biases and may be perceived as lower in prestige (Kircher, 2012; Mauchand & Pell, 2022a). In a speech act promoting affiliation and empathy such as complaints, these characteristics are likely to affect the listeners responses early on and throughout the whole utterance.

ERP evidence suggests that speaker accent is detected rapidly with reductions of N100 and P200 components for outgroup accents (Foucart & Hartsuiker, 2021; Jiang et al., 2020; Romero-Rivas et al., 2015). Other studies argue that early processing of outgroup accents is actually indexed by an increased Phonological Mapping Negativity (Goslin et al., 2012; Porretta et al., 2017), occurring in a similar time-window. At later processing stages, outgroup accents are also found to affect task-based N400 responses by reducing N400 responses during truth evaluation (Foucart et al., 2019; Foucart & Hartsuiker, 2021), but increasing them during phonetic or semantic anomaly processing (Romero-Rivas et al., 2015; Voeten & Levelt, 2019), suggesting that outgroup accents can elicit either shallower or deeper processing of speech-related cues depending on task focus and/or contextual constraints. This effect also appear to be sensitive to perspective-taking, revealing increased effort in processing conflicting spoken content and speaker identity (van den Brink et al., 2012), status-based accent perception (Pélissier & Ferragne, 2021), or out-group believability (Foucart & Hartsuiker, 2021; Jiang et al., 2020). As such, it can be hypothesized that outgroup accent cues may affect both early and late stages of neurocognitive processing for emotive speech in social communication tasks (Jiang et al., 2020).

3.1.3. Objectives

The present study aims to assess the neural processes at play during the empathic perception of complaining speech. More specifically, our goals are to determine the role of prosody in eliciting affective and cognitive mechanisms of vocal pain perception by comparing ERP responses to spoken complaints and neutral speech. To investigate how accent-based cultural differences might affect these mechanisms, European French participants listened to utterances produced by both in-group French speakers and out-group Québécois (French Canadian) speakers. Based on the fundamental goal of complaints to elicit empathy, combined with an empathy-inducing task of pain evaluation, we expected affective and cognitive responses analogous to previous empathy literature. The affective salience of an emotive (versus neutral) voice was expected to be registered early and indexed by increased P200 responses, especially for in-group complaints, related to an affective component of empathy. Complaining voices were also predicted to enhance later components compared to neutral speech, indicating effort in consciously (re)appraising speaker suffering. While cognitive empathy is not often modulated by cultural cues in the visual literature, the complexity of emotive speech and accent processing could also affect late components by increasing or delaying appraisal efforts for outgroup complaints, especially if early affective responses are reduced.

3.2. Methods

3.2.1. Participants

A power analysis was run using G*power to determine a minimum sample size for the experiment (Faul et al., 2007). Expecting large effects of prosody, but conservatively assuming medium effect sizes regarding accent effects on the ERP components of interest in this experimental setting (Jiang & Pell, 2015; Mauchand et al., 2021), a minimum of 24 participants was determined to achieve a power over 80%.

Twenty-eight French participants were recruited in the region of Montreal. Since two participants did not complete the experiment due to technical issues on site, 26 subjects (16F, 10M; Age: M = 26.08, SD = 4.09; years of education: M = 16.23, SD = 2.55) were analyzed in total. All participants were born in France and had lived in France until they were at least 18; to limit common habituation to the regional Québécois accent (Sumner & Samuel, 2009), they were selected based on having lived less than two years in Québec. All participants were right-handed and reported no history of major psychiatric or neurological illness or speech/hearing problems. Participants voluntarily consented to take part in the study that was ethically approved by the Faculty of Medicine Institutional Review Board (McGill University, Montreal, Canada).

3.2.2. Stimuli

Stimuli were 320 short French utterances created, validated, and selected in two previous studies focusing on the acoustic and perceptual aspects of complaining speech (Mauchand & Pell, n.d., 2021). Utterances were statements describing an action performed by a third party (e.g., "Il a dit que j'étais stupide/He said I was stupid"). They first varied in terms of prosody: each statement was produced twice, first in a neutral, fact-stating manner, and then with a complaining tone of voice. Utterances were produced by 4 French (Ingroup) and 4 Québécois (Outgroup) speakers to modulate the accent of the utterances. Multiple speakers were used to introduce natural variability in the stimuli and provide a more global impression of each accent; each group of speakers contained two men and two women with acting experience, matched for age and education. A third, semantic manipulation was created by constructing sentences as pairs differing in their final word to express a pain-related vs. neutral statement (e.g., "Il a dit que j'étais stupide/sorti" - *He said I was stupid/outside*); a full list of the sentences used as stimuli is provided Table A1 of the Appendix. As the present paper focuses on ERPs from utterance onset that index processes *prior* to the onset of the semantic manipulation, this distinction was not relevant to the current analysis and all utterances were analyzed together (regardless of Statement type). Recordings were digitally captured in a sound-attenuated chamber with a high-quality head-mounted microphone onto a Tascam recorder (sampling rate of 44.1 kHz, 16-bit, mono, .wav format). They were then edited in Praat (Boersma & van Heuven, 2001) into short .wav audio files and normalized to a peak intensity of 70 dB. There were 672 utterances were generated during the initial recording sessions.

In a validation study, ten French (5M, 5F, age: M = 21.1, sd = 3.8) and 9 Québécois (3M, 6F, age: M = 23.00, sd = 2.78) participants listened to all utterances from their own group (n = 336) and evaluated: (1) whether an utterance was a complaint (yes/no); and (2) if it was a complaint, its intensity of expression on a 5-point scale. 20 utterance pairs (complaint and neutral) were selected for each speaker based on these ratings and such that each utterance pair was present only once in both accents (see Mauchand & Pell, 2021 for more details). In summary, there were a total of 2 Accents x 4 Speakers x 20 Statements x 2 Prosodies = 320 utterances. A summary of the acoustic and perceptual properties of the stimuli is provided in Tables 2.1 and 2.2.

3.2.3. Procedure

During the EEG task, participants were seated comfortably in an electrically shielded, sound-attenuating booth. Stimuli were presented through earphones in a pseudo-randomized order that prevented the direct repetition of utterances from the same speaker or token set. In each trial, an utterance was presented after a jittered fixation point (500 to 1500ms) followed by a question prompting them to evaluate "how hurt the speaker feels" ("À quel point cette personne se sent-elle blessée?"). This judgement requires listeners to evaluate the socioaffective state of the speaker without drawing explicit attention to any particular speech cues. The question prompt appeared 1000ms after auditory stimulus offset and responses were recorded through a 5-button response box ranging from "Not at all" ("Pas du tout") on the leftmost button to "Very much" ("Énormément") on the rightmost button. The trial ended after a response from the participant or 5 seconds after the question, and the next trial started after a 1500ms blank screen. An example trial is summarized in Figure 3.1. The experiment started with 8 practice trials to familiarize participants with the procedure and was then divided into 8 blocks of 40 trials, with a self-paced pause between each block to allow participants to rest.

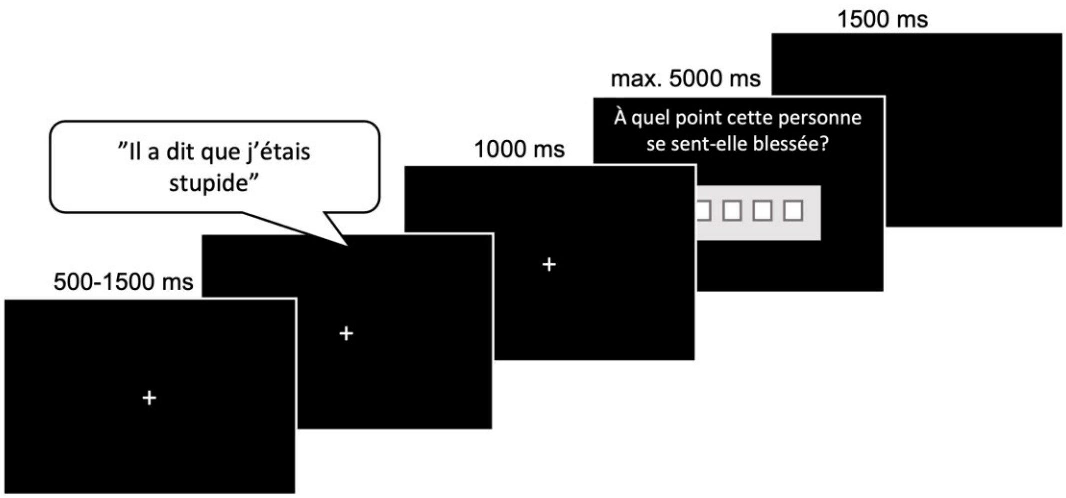

Figure 3.1. Experimental paradigm for one trial.

While performing the task, the electroencephalograms (EEGs) were recorded continuously from 64 Ag/ACl electrodes using the ActiCap System (Brain Products, Germany). The vertical electrooculograms (VEOG) were recorded from above and below the right eye and the horizontal electrooculograms (HEOG) were recorded from the outer canthus of both eyes. The recordings were online referenced to FCz and re-referenced offline to the bilateral mastoids. EEGs were digitized at 500 Hz and filtered with a band-pass from 0.016 Hz to 100 Hz. The EEG task lasted approximately 30 to 40 minutes.

After the main experiment, participants completed a series of tasks and questionnaires to investigate individual cultural and personality differences. Accent-based implicit biases were measured through a modified Implicit Association Test (Greenwald et al., 1998) consisting of Pleasant and Unpleasant words presented together with ingroup French and outgroup Québécois neutral utterances (Mauchand & Pell, 2022a). Explicit attitudes toward French and Québécois populations were probed through a questionnaire based on the Stereotype Content Model (Fiske et al., 2002), composed of 20 questions about the perceived Warmth and Competence of each community. Finally, empathy-related abilities were assessed through the Perspective-Taking and Empathic Concern subscales of the French version of the Interpersonal Reactivity Index (Gilet et al., 2013).

As the experiment was run partly during the COVID-19 pandemic, the experimenter and participants followed a strict protocol involving surface and hand disinfection, health checks, and personal protective equipment (masks and gloves). Social distancing was maintained at all times except during the electrode set-up phase, for which the experimenter wore a protective visor. The whole session lasted approximately 2.5 hours, including EEG preparation and completion of the post-tests. Participants were compensated a nominal amount at the end of the study for their involvement.

3.2.4. ERP Analysis

EEG recordings were pre-processed using EEGLAB (Delorme & Makeig, 2004) and ERPLAB (Lopez-Calderon & Luck, 2014). The continuous EEGs were filtered using a 40-Hz low-pass and a 0.1-Hz high-pass Butterworth of the fourth order, and were manually inspected to remove excessive movement artifact, alpha activity, or amplifier saturation. The subsequent EEGs were then decomposed with Independent Component Analysis (Makeig et al., 1996) to remove ocular artifacts. Data were then epoched into 1200ms segments time-locked to the acoustic onset of the utterance, with a 200ms prestimulus baseline correction, to examine neural effects due to the processing of prosody and speaker accent (results were not analysed for individual speakers). Segments with signal peak-to-peak voltage exceeding 100 mV within a 200-ms sliding window in steps of 100ms were automatically rejected. None of the subjects showed enough trial rejection to justify a complete exclusion from further analysis (remaining trials per condition per participant: M = 70.94, sd = 9.62).

As trial-to-trial latency jitter creates single-trial variability that reduces component discrimination, attenuates component amplitudes, and may erroneously yield significant effects, a Residue Iteration Decomposition (RIDe) procedure was performed on the ERP data before analysis (Ouyang et al., 2016). RIDe uses the latency variability and time markers to separate ERP components into predicted component clusters with a stimulus-locked cluster and one or more central clusters with unknown latency. The stimulus-locked cluster was set to a time window of 0-400ms, and the central cluster was set to a time window of 200-1200ms, with the latency first estimated by Woody's method within this time window. Then, ERPs were subjected to RIDe into the component clusters associated with the latency sets; these two steps were iterated until convergence. After resynchronization of the subcomponent clusters to their own latency across single trials, ERPs were reconstructed accounting for variability of latency across trials (Ouyang et al., 2015).

Considering the disparities in the empathy literature regarding components of interest, and the potential for temporal overlap of several speech-related components (e.g., P200, PMN, N400), the present data were analyzed with temporal-spatial Principal Component Analysis (PCA) to limit bias and assumptions in component labelling (ERP

PCA toolkit, see Dien, 2010). Subject-level ERP amplitudes of all channels in the entire epoch (-200 to 1200ms) were decomposed based on their correlational structure to identify underlying components that are temporally and spatially distinct. The PCA was performed in two steps. First, a temporal Infomax decomposition was performed to identify temporal factors of interest; the factors to retain were determined by a Parallel Scree Test (Horn, 1965). Second, a spatial Promax rotation was performed on each surviving temporal factor to identify independent spatial component within their time window (Dien, 2012).

Temporal-spatial factors that accounted for more than .5% of unique variance were subsequently analyzed. Factor loadings were rescaled to microvolts by converting them into covariance loadings. For each factor, the loadings from the peak channel at the peak time point were entered into a Linear Mixed-Effect Model as responses, with Accent (Ingroup/Outgroup) and Prosody (Neutral/Complaint) as fixed factors, and Participants as a random intercept, using lme4 (Bates et al., 2015) and lmerTest (Kuznetsova et al., 2017) packages in R software (R Core Team, 2018). The models were built with Ingroup Neutral utterances as the intercept.

3.3. Results

3.3.1. Behavioral Results

A linear mixed-effect model was built with participant's evaluations as a response, Accent and Prosody as interacting fixed factors, Participant and Item as random intercepts, and Accent and Prosody as by-Participant random slopes. The model showed no effect of Accent ($\beta = .22$, se = .39, $t(12.07) = .55$, $p = .592$), a significant effect of Prosody ($\beta = 1.26$, se = .40, $t(13.90) = 3.11$, $p = .008$), and no interaction ($\beta = .09$, se = .54, $t(12.05) =$

.18, p = .864). Overall, participants evaluated speakers who used a complaining prosody (M = 3.49, sd = .55) as being more hurt than when they spoke in a neutral tone (M = 2.23, sd = .56), irrespective of their accent. Behavioral results are displayed in Figure 3.2.

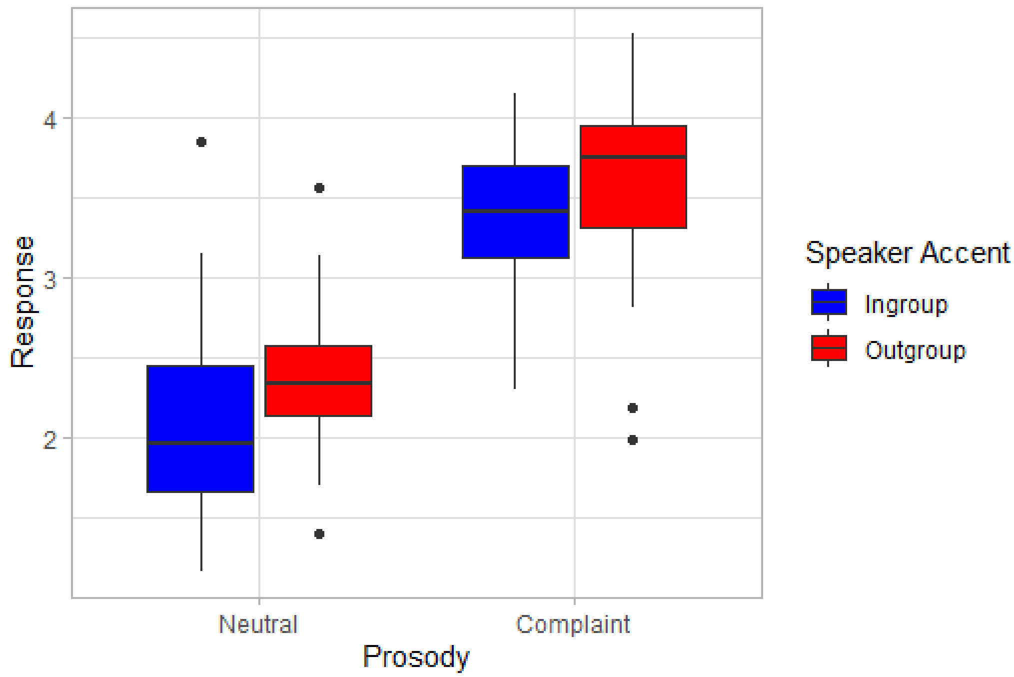

Figure 3.2. Effects of Prosody and Accent on evaluations of "how much the speaker is feeling hurt".

3.3.2. ERP Results

The PCA revealed seven temporal factors (87% of variance) and two spatial factors (73% of variance). Twelve temporal-spatial components that accounted for more than .5% of variance were then analyzed (see Table 3.2). Condition effects appeared in three temporal factors, as shown in Figure 3.3. and further described below.

Table 3.2. Summary of PCA temporal-spatial factors accounting for over .5% of total variance. Bolded rows indicate factors that showed significant condition effects.

Factor	Peak latency (ms)	Negative peak channel	Positive peak channel	Variance explained
TF1SF1	1026	Cz	-	15.4%
TF1SF2	1026	P2	F7	2.6%
TF2SF1	**240**	**-**	**Cz**	**14.4%**
TF2SF2	**240**	**POz**	**AF7**	**2.5%**
TF3SF1	624	-	Fz	11.3%
TF3SF2	624	POz	Fp1	1.6%
TF4SF1	498	Fz	-	10.9%
TF4SF2	**498**	**P2**	**AF8**	**1.0%**
TF5SF1	**818**	**Cz**	**-**	**6.1%**
TF5SF2	818	P2	F7	1.7%
TF6SF1	152	Cz	-	2.8%
TF7SF1	914	-	Fz	2.6%

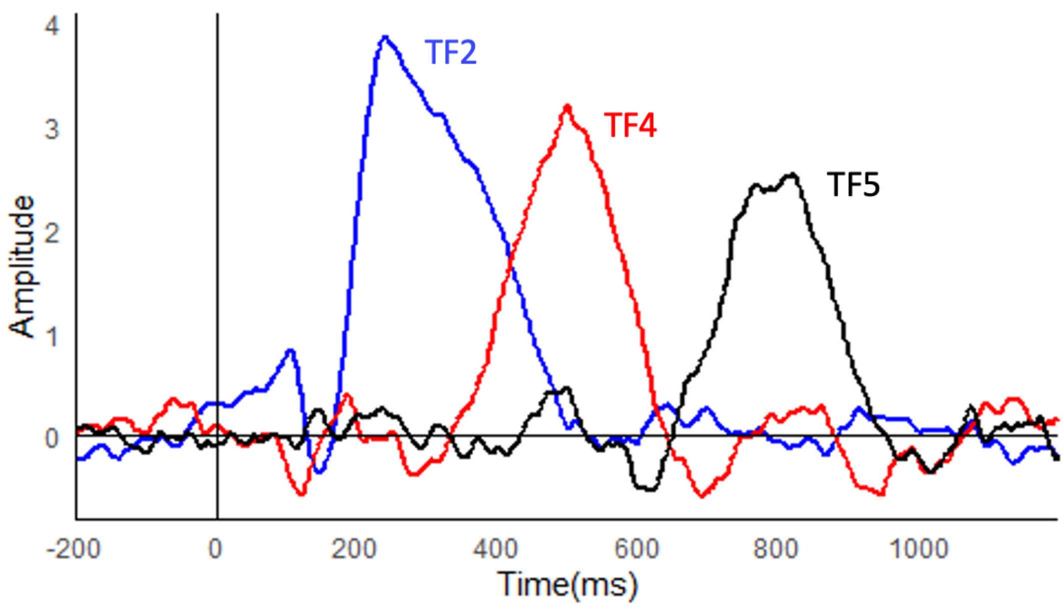

Figure 3.3. Temporal factors in which significant condition effects were found during temporal spatial PCA of latency-corrected ERP data.

3.3.2.1. P200 and EPN. The earliest temporal factor showed a large, early response from 175ms to 450ms and peaking 240ms after onset. This factor was spatially divided into two components. The first component, accounting for 14.3% of total variance, was characterized by a frontal-central positive deflection peaking at Cz, suggesting a P200 component (Figure 3.4a). The linear mixed-effect model for this component at Cz showed a main effect of Prosody, revealing that the P200 response was significantly greater for Complaints compared to Neutral utterances ($\beta = 1.17$, se = .46, $t(75) = 2.55$, $p = .013$), but an Accent x Prosody interaction showed that this effect was absent for Outgroup utterances ($\beta = -1.51$, se = .66, $t(75) = -2.33$, $p = .022$). This effect was significant at a broad array of central-anterior electrodes (AF3, AF4, Fz, F1, F2, F3, F4, FC1, FC2, FC3, FC4, Cz, C1, C2, C3, C4, CPz, CP1, CP2, P2, P4).

The second t-s component, accounting for 2.5% of total variance, appeared to originate from a negative deflection at parietal-occipital electrodes in the same time window, peaking at POz; this component displayed temporal and spatial characteristics of an Early Posterior Negativity (EPN) (Figure 3.4b). Analysis at POz revealed a significant interaction coefficient in the absence of main effects, suggesting that this negative wave increased for Complaints compared to Neutral only in the Outgroup condition ($\beta = -.73$, se = .28, $t(75) = -2.64$, $p = .010$). This effect was significant at electrodes POz, P2, P3, P4, and PO3.

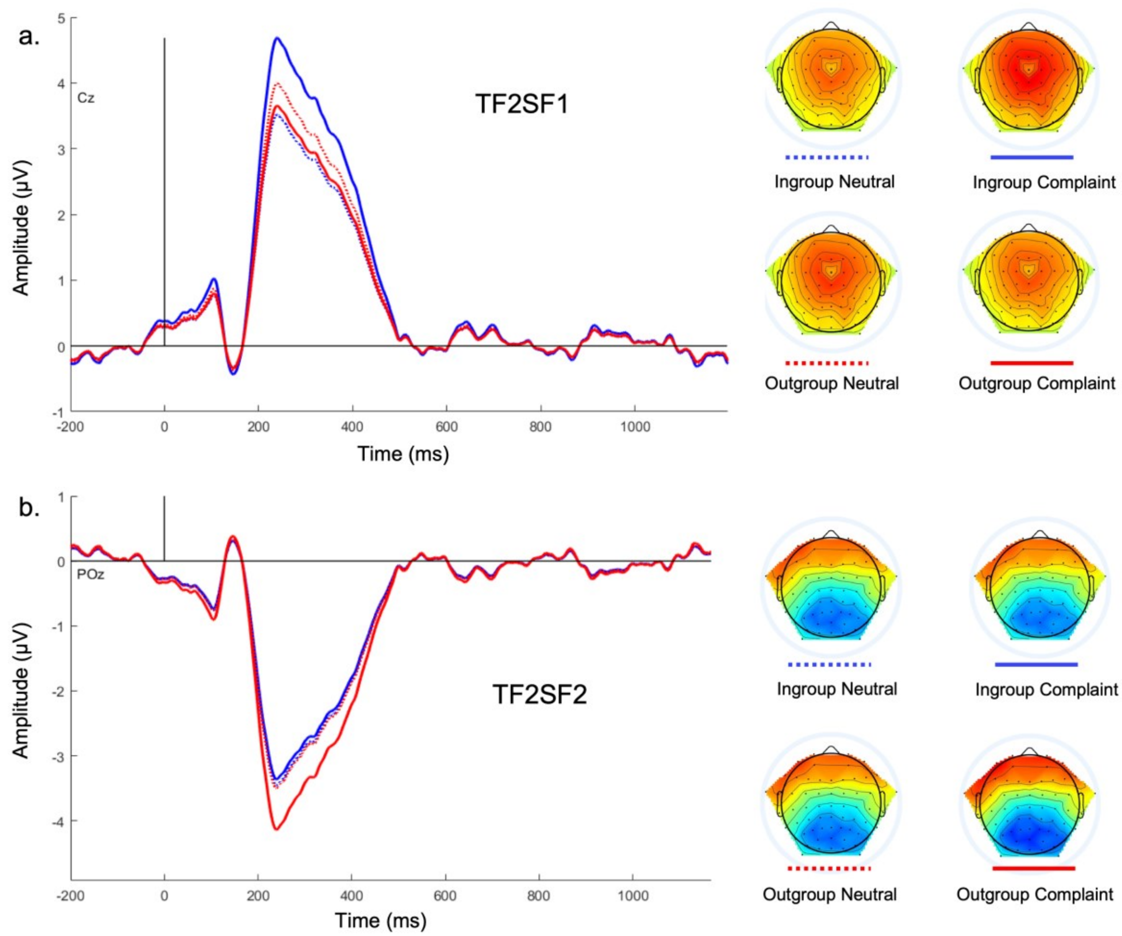

Figure 3.4. Effects of Prosody and Accent on the early components. a. Factor TF2SF1 (P200 response). Left: Form of the P200 amplitude at channel Cz. Right: Topo- graphic scalp maps of channel amplitudes at the peak of the factor (240 ms), for each condition. b. TF2SF2 (EPN response). Left: Form of the EPN amplitude at channel POz. Right: Topographic scalp maps of channel amplitudes at the peak of the factor (240 ms), for each condition.

3.3.2.2. N400. A second temporal factor revealed a negative deflection at parietal electrodes within the traditional N400 time-window (400-600ms), peaking at P2 at 498ms (1.0% of variance - Figure 3.5). The significant interaction coefficient from the model at P2, in the absence of main effects, suggested that the N400 component was more negative for complaining compared to neutral prosody produced by Outgroup speakers, but no differences were observed for Ingroup speakers ($\beta = -.90$, se = .35, $t(75) = -2.56$, $p = .012$). This effect was significant at a large number of central-posterior electrodes: CPz, CP1, CP2, CP3, CP4, Pz, P1, P2, P3, P4, P6, P8, P6, POz, PO3, PO4, PO8, PO10, Oz, O1, and O2.

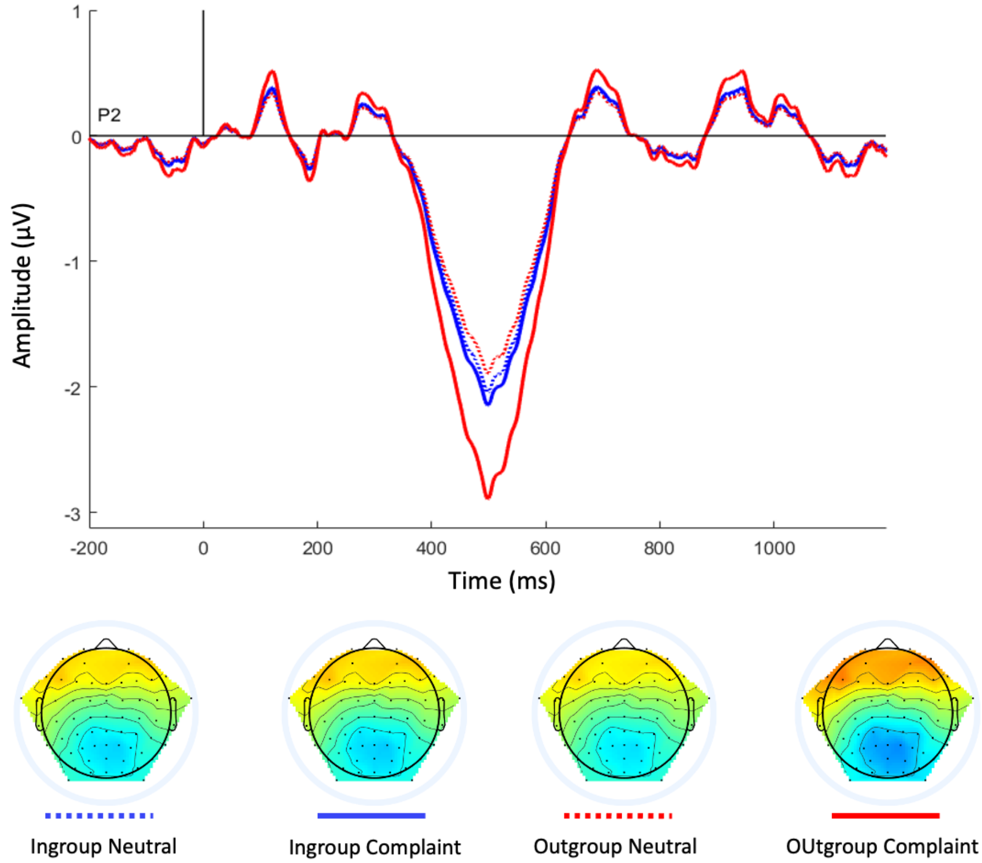

Figure 3.5. Effect of Prosody and Accent on factor TF4SF1 (N400 response). Top: Form of the N400 amplitude at channel P2. Bottom: Topographic scalp maps of channel amplitudes at the peak of the factor (498 ms), for each condition.

3.3.2.3. Late negativity. The last temporal factor showed a late negativity over central electrodes between 650-900ms, peaking at Cz at 818ms (6.1% of variance), as shown in Figure 3.6. The model at Cz showed a significant positive effect of Accent (β = 1.61, se = .58, t(75) = 2.77, p = .007), a positive effect of Prosody (β = 1.55, se = .58, t(75) = 2.67, p = .009), but a negative interaction coefficient (β = -1.94, se = .82, t(75) = -3.36, p = .021). The late negativity selectively increased for Ingroup utterances produced in a

Neutral tone in this time window. This effect was significant at AF3, AF4, AF7, AF8, Fp1, Fp2, Fz, F1, F2, F3, F4, F5, F6, FC1, FC2, FC3, FC4, FC6, Cz, C1, C2, C3, C4, CPz, CP1, CP2, CP3, CP4, Pz, P1, P2, and P4.

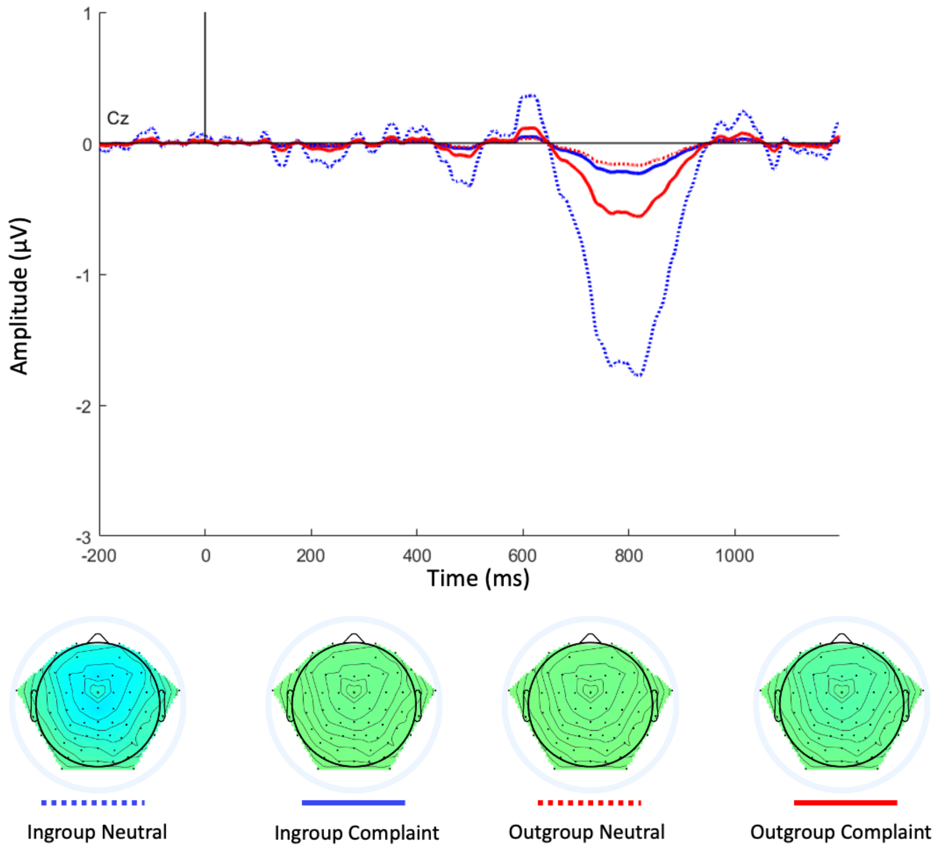

Figure 3.6. Effect of Prosody and Accent on factor TF5SF1 (late negativity). Top: Form of the late negativity amplitude at channel Cz. Bottom: Topographic scalp maps of channel amplitudes at the peak of the factor (818 ms), for each condition.

3.3.3. Relationship between PCA components and individual differences

To further explore how neurocognitive processing effects of complaining speech related to individual personalities, biases, and behavior, Pearson correlations were run between the loadings of each PCA component and participant scores on the different tests and questionnaires (IRI, SCM, and IAT), as well as the mean behavioral ratings for each condition within the main experiment. To account for multiple comparisons, p-values were adjusted with Holm correction.

3.3.3.1. P200. No significant correlation was found.

3.3.3.2. EPN. For the EPN temporal-spatial factor, a moderate negative correlation was found between participant's D-scores from the IAT and the loadings for Ingroup Complaints ($r = -.40$, $p = .04$), suggesting that implicit preference for the in-group accent increased the EPN response for in-group complaints.

3.3.3.3. N400. For the N400 temporal-spatial factor, a large positive correlation was found between the loadings of Ingroup Complaints and the Perspective-Taking scale ($r = .65$, $p < .01$), suggesting that greater perspective-taking abilities reduced the N400 response for these utterances, whereas lower perspective-taking abilities increased it. In addition, correlations with behavior were found; the N400 amplitude for Outgroup Complaints correlated with ratings of perceived pain for Outgroup Complaints ($r = -.44$, $p = .03$), but also with those of Ingroup Complaints ($r = -.48$, $p < .01$). Participants who displayed larger N400 responses to Outgroup Complaints rated both Ingroup and Outgroup Complaints as more suffering. Interestingly, N400 loadings for Ingroup Complaints significantly correlated with the ratings for Outgroup Complaints ($r = -.40$, $p = .04$), suggesting that participants showing a greater N400 for Ingroup Complaints rated Outgroup Complaints as more suffering.

3.3.3.4. Late negativity. No significant correlation was found.

3.4. Discussion

How the brain registers vocal cues to interpret the communicative intentions of a speaker is being actively explored in reference to various types of speech acts (Jiang & Pell, 2015; Mauchand et al., 2021; Rigoulot et al., 2020; Vergis et al., 2020; Zougkou et al., 2017) and in the context of different indexical cues derived about a speaker (Foucart & Hartsuiker, 2021; Jiang et al., 2020). The present study is the first to provide ERP evidence demonstrating the time course for deriving meaning from third-party complaints, which serve primarily an *expressive* function during speech communication. As such, our work extends the empathy literature by highlighting specific affective and cognitive responses to emotive utterances expressing pain, meant to promote affective sharing and affiliation with the listener, as they unfold during speech processing. Findings highlight the impact of social-relational factors (ingroup status of the speaker) on on-line processes that mark the motivation relevance of speech cues and for inferring the affective state of the speaker, consistent with the idea that emotion and affect are used as social information during interpersonal communication (van Berkum, 2019; Van Kleef, 2009).

3.4.1. Early responses: is it relevant, or simply salient?

As predicted, vocal emotive cues elicited early responses within the first 300 milliseconds after utterance onset. In general, statements produced with a complaining tone of voice significantly increased the neural response in this time window when compared to identical statements produced in a neutral prosody. Because of its early temporal signature, the P200 is often categorized as a perceptual component, but appears to index more than just sound discrimination (Pell & Kotz, 2021; Schirmer & Kotz, 2006). The fronto-central

P200 is known to be sensitive to the emotional salience of prosodic signals, especially if they are congruent with task demands (Mauchand et al., 2021; Paulmann et al., 2013; Pell & Kotz, 2021). As such, it has been argued that P200 differences are an early index of the motivational significance of speech sounds, allocating attention to signals that are socially relevant to the listener (Jiang et al., 2020; Mauchand et al., 2021; Paulmann et al., 2011; Pell et al., 2015; Vergis et al., 2020). Here, the observation that more expressive, complaining voices increased neural activity at early stages of salience detection is consistent with our task demands to attend to the level of the speaker's *suffering*; differences in speakers' vocal expressive patterns would explain why listeners directed more attentional resources to complaining speech cues compared to neutral utterances with the same linguistic structure. These early responses constitute a first insight into affective empathy in vocal communication.

Importantly, while early ERP responses seemed to prioritize attention to complaining speech patterns, the speaker's accent evoked spatially independent neural responses to ingroup and outgroup complaints within this time-window. When listeners heard ingroup speakers, complaints elicited a larger anterior P200 response compared to neutral utterances; in contrast, outgroup complaints increased a posterior negative deflection over ingroup complaints in this time window (this latter component was interpreted as an Early Posterior Negativity, see below). Thus, unique to this experiment, our data suggest that the motivational relevance of prosodic information was (partly) driven by operations sensitive to the speaker's identity (ingroup/outgroup status), producing qualitatively distinct and spatially independent neural responses to ingroup vs. outgroup complaints at the salience detection stage. Since the anterior P200 component was only modulated by vocal expressions produced by ingroup speakers, our data suggest that the motivational or *empathic* relevance of vocal expression information can be influenced by information about the speaker's identity and cultural affiliation at early processing stages (Cheon et al., 2010; Sessa, Meconi, Castelli, et al., 2014).

Several studies have reported P200 reductions for out-group accents in other speech processing contexts (Foucart & Hartsuiker, 2021; Jiang et al., 2020; Romero-Rivas et al., 2015), suggesting that the early processing of relevant speech information can be altered by less familiar, outgroup signals. Our data extend these observations to the perception of emotive speech cues, re-affirming the importance of "social-relational factors" in affective reactions and early attentional encoding of emotional signals (Kemper, 2006; Van Kleef, 2009). The effect of accent on the P200 supplies new evidence that speech cues revealing a speaker's identity contribute to what is considered "motivationally significant" to the listener when making affective evaluations. This early preferential processing of ingroup emotive signals is also in line with associative processes of social evaluation (Gawronski & Bodenhausen, 2006), as participants may have been more responsive to speakers who were culturally (and thus emotionally) closer to them (Jiang et al., 2020). The perception of outgroup utterances would not capture attention to the same extent because of the less motivating social information (e.g., status, power) they carry (Kemper, 2006), which could explain neural differences we observed in the early response to complaints. As complaining is a cultural ritual (Edwards, 2005; Katriel, 2013; Traverso, 2009; Winchatz, 2016) associated with somewhat distinct acoustic forms of expression for French and Québécois speakers (Mauchand & Pell, i*n review*, 2021a), familiarity with ingroup "display rules" for vocally expressing complaints could also have increased their motivational significance to participants at this early stage.

While shifts in the anterior P200 imply greater motivated attention to complaints expressed by ingroup speakers, an independent posterior negative component was enhanced by outgroup complaints in tandem with the P200 response. While accent has been shown to elicit PMN responses in this time window for certain studies (Goslin et al., 2012; Porretta et al., 2017), the absence of an Accent main effect, together with the spatial signature of this component, instead suggest an early posterior negativity (EPN-like component), driven by attention towards affective stimuli. Although the EPN was initially found for visual emotional stimuli (Hajcak et al., 2011; Schindler & Bublatzky, 2020; Schupp et al., 2006), this component has been reported in response to lexical (Herbert et al., 2008; Kissler et al., 2009; G. G. Scott et al., 2009) and prosodic (Jaspers-Fayer et al., 2012; Mittermeier et al., 2011) stimuli of an emotional nature. In contrast to the P200, the EPN appears to be mostly task-irrelevant and driven by stimulus arousal (Hajcak et al., 2011; Schindler & Bublatzky, 2020). It appears to index a shift of attention towards emotionally, but not necessarily motivationally, salient stimuli in the processing environment; for example, a recent study by Farkas et al. (2020) showed increased EPN responses to both erotic and nude, non-erotic images compared to neutral pictures, suggesting that the EPN is sensitive to arousal- and affect-related *properties* of a stimulus, rather than to the affective stimulus itself.

Our results extend the EPN literature by suggesting a culture-dependent modulation of this component within our experiment. The fact that outgroup complaints selectively increased the EPN amplitude, but not the anterior P200, suggests that despite not being motivationally drawn towards outgroup complaints, participants still registered affect-related cues produced by outgroup speakers at an early stage (albeit in a qualitatively different manner). Despite certain cultural differences in vocal expression, Québécois complaints possess a clear set of acoustic cues associated with high arousal, such as heightened pitch and greater pitch variability, which distinguish them from neutral statements and share central tendencies with French complaints (Mauchand & Pell, n.d., 2021). The P200/EPN dissociation shows that these components are not simple perceptual responses to basic acoustic parameters but reflect fundamental differences in how speakers empathically appraise complaints. Our data suggest that, for outgroup complaints, listeners reliably "tag" these less familiar affective signals to initiate deeper processing at a later stage, although using different mechanisms or processing routines than those applied to ingroup complaints. Our data thus diverge from traditional models of cultural empathy which usually describe outgroup pain perception in terms of an *absence* of early responses, which are compensated by later cognitive processing (Cheon et al., 2010). Curiously, post-EEG measures obtained from our participants using a modified Implicit Association Task revealed that individuals with stronger ingroup bias (i.e., implicit preference for their own accent) displayed an increased EPN for ingroup complaints. This effect, while only suggestive at this stage, could represent a more generalized, enhanced attention towards ingroup affective signals supported by both P200 and EPN processing mechanisms in participants who had strong preferences for speakers from their own group.

3.4.2. Initial stages of meaning resolution: N400

As spoken complaints continued to be processed, the early P200/EPN responses were followed by cognitive (semantic) processing in the form of an N400 component. While many studies in the empathy literature involving pain-related visual stimuli describe late components as insensitive to cultural biases (Sessa, Meconi, Castelli, et al., 2014; Xu et al., 2009), the present results show increased N400 amplitudes in response to complaints vs. neutral utterances produced only by the outgroup speakers (peaking around 500ms post-onset of the utterance). As a component indexing efforts of meaning retrieval, the N400 is known to be sensitive to context and previously processed cues (Delogu et al., 2019), including indexical characteristics of the speaker (Jiang et al., 2020). Outgroup accents have been found to affect the N400 in credibility evaluations (Foucart & Hartsuiker, 2021), social inferences (Pélissier & Ferragne, 2021), and status perception (Foucart et al., 2019). Here, the fact that the N400 was only modulated by statements produced by outgroup members (complaints > neutral) suggests that more cognitive effort was needed to evaluate the affective state of outgroup speakers from complaints at stages traditionally associated with meaning elaboration. For ingroup speakers, rather, these representational details appeared to be registered at the P200 stage and did not require ongoing analysis (Jiang et al. 2020). While slightly differing from the usual cultural modulations of empathy , these results do suggest a cultural identity empathic bias, with ingroup processing occurring early on while most of the outgroup processing is carried out through additional cognitive steps (Cheon et al., 2010; Sessa, Meconi, Castelli, et al., 2014).

Thus, while the P200 (and, to a certain extent, the EPN) could reflect mechanisms associated with an initial empathic *reaction* to a speaker's social pain, the N400 could reflect ongoing attempts to cognitively evaluate expressions produced by outgroup members, leading to increases in what may be called empathic *effort* in our study. Less effort would be required when no ostensive affective cues are present (i.e., neutral statements) or when pain-related vocal cues are successfully processed at an earlier stage (i.e., ingroup statements). Assuming that outgroup (Québécois) complaints were merely tagged as emotionally salient (highly aroused) by EPN-related mechanisms, additional cognitive resources would need to be mobilized to assess the emotive meaning of outgroup complaints at the N400 processing stage (Jiang et al., 2020). While there is evidence that the EPN-N400 components are sometimes confused in the emotion perception literature (Aldunate et al., 2018), our results argue that these components reflect two distinct, consecutive neural operations necessary to interpret emotive speech cues when outgroup members are encountered.

The link between N400 responses and the degree of cognitive effort required during emotive speech processing is further suggested by correlations between N400 amplitudes, individual perspective-taking scores, and behavioral ratings of speaker suffering. Previous research has showcased the sensitivity of the N400 component to trait empathy (van den Brink et al., 2012). Here, participants with lower perspective-taking skills showed increased N400 amplitudes for in-group complaints; this pattern suggests that individuals who had difficulties in mentalizing were more likely to engage in ongoing, effortful analysis of complaining speech, even for ingroup speakers, thus "cancelling out" any ingroup processing advantage for these participants. In addition, enhanced N400 responses to outgroup complaints were associated with higher ratings of speaker suffering for both outgroup and ingroup complaints. The relationship between the N400 and offline judgements of speaker suffering, may imply that neurophysiological activity in the N400 time window reflects the extent of cognitive empathy effort as listeners evaluated information that was used by participants to make decisions about the speaker's socio-affective state in our study. These correlations remain however low-powered and should be interpreted with caution.

3.4.3. Late effects and inferential processing

Results show that initial stages of processing tended to enhance neural responses to complaining (vs. neutral) voices under particular conditions to mark the relevance and salience of these cues (P200/EPN) and to elaborate their affective significance (N400) when judging speaker pain. Later, though, neutral speech elicited an enhanced, widespread negative deflection in the 650-900ms latency range (peaking at ~800ms), but only for ingroup statements produced in a neutral tone (compared to all other stimulus conditions). Interestingly, Jiang & Pell (2015) reported an increased late positivity beginning ~1000ms post-onset of neutral-sounding (vs. overtly confident or unconfident) utterances when listeners evaluated the speaker's confidence level based on their vocal expression. Such late components usually reflect a continuous monitoring of speech signals (Schirmer & Kotz, 2006; Zougkou et al., 2017) and are likely to index operations for inferring social and communicative intentions of the speaker (Baggio et al., 2008; Jiang & Pell, 2016; Lattner & Friederici, 2003; Vergis et al., 2020). In particular, the late negativity has been linked to a second-pass, combinatory analysis of stimulus features when integration is difficult and meaning representations must be rebuilt (Bostanov & Kotchoubey, 2004; Jiang et al., 2013; Wu & Coulson, 2007, see Jiang et al., 2020 for a discussion).

In our study, the late central negativity may indicate a re-analysis stage where inferences are made about utterances that did not trigger an affective reaction at earlier timepoints (i.e., neutral statements), necessitating a second-pass analysis to infer the communicative intentions of the speaker. Without ostensive vocal cues conveying pain or any other contextual information, our task is likely to require listeners to re-orient and draw demanding inferences about speaker suffering from utterances expressed in a neutral tone of voice (van Berkum, 2019). Of central interest here, these late inferential processes were selectively enhanced and motivated by *ingroup* statements and were thus dependent on the group membership (accent) of the speaker and their perceived linguistic-cultural background. These patterns supply evidence that social categorization bias has lasting effects on speaker evaluation and speech comprehension processes over a protracted time period (Jiang et al., 2020). These results could also reflect our listeners' tendency to engage in shallower processing of the semantic and pragmatic meanings conveyed by accented speakers when they failed to provide salient emotional cues to guide speaker impressions (see Foucart & Hartsuiker, 2021 for recent data and a discussion).

Looking strictly at the behavioral responses (i.e., perceptual impressions of speaker suffering) points to two major findings. First, as expected, prosody appears to be an efficient emotive device to communicate speaker suffering (Selting, 2010), as complaining utterances were clearly perceived as showing more pain than neutral-intended ones. Second, speaker accent did not influence the final evaluative decision of listeners, despite eliciting diverging processing routes in the brain during online perception. A previous perceptual study using the same stimuli showed that accent led to slight differences in ratings when participants evaluated "how much the speaker was complaining" (ingroup >

outgroup, Mauchand & Pell, 2021b) in contrast to how much the speaker is suffering (ingroup = outgroup). Possibly, when focusing more narrowly on a speaker's feelings (to express pain) rather than the social intentions of their speech act (to complain), regional differences in accent are not a significant barrier for listeners (Elfenbein & Ambady, 2002; Laukka & Elfenbein, 2020). This interpretation is somewhat limited by the low sensitivity of the behavioral scale which may not be able to pick up more subtle effects of group. Nonetheless, group differences have been found for other affective constructs using similar scales (Jiang et al., 2018, 2020); considering the large number and variability of the stimuli used, the present results appear to indicate a relatively consistent cross-cultural behavioral response.

3.4.4. Empathy beyond visual pain

The present experiment is in line with a growing body of literature that aims to capture emotions and affect as social information in interpersonal contexts (Pell & Kotz, 2021; Scarantino, 2017; van Berkum, 2019; Van Kleef, 2009). Incorporating these concepts to empathy, this study includes a shift of focus from the raw perception of others' pain to a broader view of the daily communication of each other's feelings. In particular, it posits that empathic processes are driven not just by the salience, but also by the social *relevance* of affective and emotive signals. Most neuroscientific experiments on empathy use visual stimuli, where salient cues are available immediately to the subjects (Avenanti et al., 2010; Fan & Han, 2008; Sessa, Meconi, & Han, 2014; Sessa & Meconi, 2015; Xu et al., 2009). This allows a rapid and homogeneous assessment of affective and cognitive empathic processes, indexed by the presence or absence of early and late components. Still, the relevance of visual pain can be affected by manipulating stimulus reality (Fan & Han, 2008; Sessa & Meconi, 2015), participant attention (Fan & Han, 2008; Sheng & Han, 2012), group biases (Cheon et al., 2010; Sessa, Meconi, Castelli, et al., 2014), or individual attributes (Decety et al., 2010; Yamada & Decety, 2009). This is exacerbated when listening to speech, as processing the relevance of spoken signals require the continuous uptake and integration of information (Nordström & Laukka, 2019; Paulmann et al., 2011; Pell et al., 2011), which dynamically influence empathic responses.

As a result, the neural time course of empathic responses to complaints reveals different neural routes depending on the motivational processing of accent and prosodic signals: while emotive prosody is quickly detected, other cues such as speaker identity can affect when and where empathic reactions and mentalizing efforts will occur (Jiang et al., 2020; Liu, Rigoulot, & Pell, 2015). Neuroimaging evidence provides leads on the nature of these processing routes: a number of studies reveal dissociations between a fronto-temporal network (Anterior Insula, ACC, IFG) related to affective empathy, and the Theory of Mind network (TPJ, pSTS, pMTG, MPFC) when perceiving visual (Masten et al., 2010; Mathur et al., 2010; Vö et al., 2005), auditory (Lang et al., 2011), and audio-visual pain (Kanske et al., 2015; Regenbogen, Schneider, Gur, et al., 2012). In parallel, many of the ERP components identified here have been linked to analogous networks: P200 elicited from affective prosody appears to originate from similar fronto-temporal regions (Jiang et al., 2020; Steber et al., 2020), while EPN and N400 components have been sourced to posterior temporal and parietal cortices (Jaspers-Fayer et al., 2012; Khateb et al., 2010; Lau et al., 2008). More generally, prosody processing involves widespread brain networks centered around and communicating with the Superior Temporal Cortex through interconnected pathways underlying related perceptual, affective, and cognitive functions (Grandjean, 2020). Further investigation would be required on how these pathways relate specifically to the empathic processing of spoken complaints and other expressive speech acts.

3.5. Conclusion

The presented results reveal how vocal emotive signals from complaints are processed in the brain in several successive stages depending on accent group perception. Ingroup complaints are preferentially processed at an early stage, and do not appear to require much additional processing if the listener has sufficient mentalizing abilities. Meanwhile, early responses towards out-group complaints appear to be a shallower detection of affect-related cues requiring additional cognitive efforts, which will be crucial in the listener's final evaluation of speaker suffering. Later, inferential processes of in-group neutral suggest a re-analysis of potentially missed emotive signals from culturally relevant speakers. While somewhat diverging from the traditional two-step models of empathy, the present results reveal that emotive speech elicits different affective reactions and cognitive inferences based on relevant prosodic information, as intended by speakers. These processes are bound by social-relational factors between speaker and listener which can elicit different processing routes depending on display rules, familiarity, cultural biases, and empathic abilities. These results, however, are limited by the group of interest, i.e., European French who recently immigrated to Québec. Future investigations on Québécois participants, as well as non-expatriated French participants would provide additional insights into these phenomena. Still, the present results emphasize the growing complexity of processes hidden under the umbrella term of empathy, extending it to a more "mundane" type of pain expression, complaints. In a broader sense, it highlights how the brain apprehends competing signals of socially relevant speech acts, universal affect, and speaker identity to form representations of another's feelings.

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Preface to Chapter 4

As the first neurocognitive investigation of complaining speech perception, Chapter 3 was conceived as the cornerstone of this thesis. Within the project, it assumed the role of transitioning the focus from "complaint as object" to "complaint as agent", marking the first concrete insights into the role of emotive speech in empathic processes. In a broader fashion, it connected two research perspectives, integrating experimental pragmatics into the neuroscientific literature on empathy. It revealed that the empathic appraisal of complaints follows a complex time-course; while suggesting interesting parallels with previous empathy research, it is anchored in mechanisms specific to pragmatic speech processing. Of note, this chapter has emphasized the role of speaker accent which, despite showing more marginal effects at the acoustic and behavioral levels described in Chapters 1 and 2, was shown to be a critical factor in how emotive prosody was processed in the brain.

But speech processing integrates more than accent and prosody. As explained earlier, semantic information about the topic of complaints was introduced in the form of a critical, final word. The following chapter focuses on how this information was processed and integrated with aspects of the vocal signal which, as we have seen, are perceived from utterance onset. In particular, Chapter 4 will develop an answer to a question that began being formulated in Chapter 2: can we complain about anything? In answering this question, I take a step aside of "traditional" models of empathy to focus specifically on the semantic and pragmatic processing of complaints, extending the meaning of these processes to the context of empathy in a more general manner.

Chapter 4. Complain like you mean it! How prosody conveys suffering even about innocuous events.

4.1. Introduction

In our everyday use of language, the very act of conversing is often more important than the actual topic of conversation. In such cases, the verbal information conveyed is merely a pretext to carry out a social act and promote interpersonal affiliation (Scarantino, 2017; Tomasello, 2008).

One of the most remarkable examples of such non-instrumental speech acts is third-party complaining. A third-party complaint is a verbal report of a distressing, painful, or annoying event suffered by the speaker, which is communicated to a listener with no agency in that event (Mauchand & Pell, 2021; Ogden, 2007). Importantly, complaints are usually not focused on the event itself, but rather on the subjective state of the speaker; what the complaint is about, and what can be done about it, are less important than how the speaker *feels* (Drew & Walker, 2009; Edwards, 2005). Complaining exchanges often drift away from their initial topic, but always remain centered on their purpose of affect sharing between the complainer and the complainee. In fact, many complaints do not relate "true" suffering but describe harmless or innocuous events (Alicke et al., 1992; Boxer, 1993). While eliciting empathy and affiliation by describing low-suffering situations may seem counter-intuitive, this communicative strategy appears to effectively facilitate the empathic involvement of listeners in certain types of social relationships, from routine rituals with intimates to ice-breaker conversations with strangers (Boxer, 1993; Kowalski, 2002).

Given that the events described in complaints are not always so painful, complaining often functions as an emotive act: a social performance in which affect is not directly experienced but reconstructed (Caffi & Janney, 1994; Selting, 1994, 2010). In order for discourse to efficiently convey emotivity without salient verbal cues, speakers often modulate their vocal expression (*prosody*) to signal their affective disposition (Acuña-Ferreira, 2002; Ogden, 2010). Prosody is a powerful medium to convey emotions and can act as a negotiating resource in social interactions (Pell & Kotz, 2021; Szczepek Reed, 2011; Truesdale & Pell, 2018). As a listener, it can facilitate third-person appraisal: reasoning forward about how an event may affect the subjective state of the speaker (Ong et al., 2018). As such, prosody can increase listener motivation, persuasion, and involvement even in low-involvement contexts (Gelinas-Chebat & Chebat, 1992; Van Zant & Berger, 2020; Zougkou et al., 2017).

In complaints, prosody serves as the main emotive device to elicit empathy in the listener through acoustic markers of affect and expressivity, such as heightened pitch, greater pitch variability, and rhythmic emphasis (Acuña-Ferreira, 2002; Ogden, 2007; Rao, 2013). Recent acoustic and perceptual analyses suggest that complaints exhibit changes in voice quality and high-frequency energy similar to pain vocalizations (Mauchand & Pell, in review; Raine et al., 2019). Complaining prosody is easily discriminated from neutral speech, and perceptually associated with negative, high-arousal emotions such as anger, sadness, and surprise (Mauchand & Pell, 2021, in review). The characteristic "sound of complaints" serves a dual social function to both implicitly increase affect sharing and explicitly signal the emotive, complaining nature of the current discourse. In so doing, the speaker ensures the empathic involvement of the listener (Selting, 2010); even when they describe seemingly innocuous events, prosody may thus point the listener towards a painful, suffering interpretation of their utterance and promote empathic affiliation.

How, then, does a speaker's prosody affect how listeners process complaining statements which do not always describe emotionally painful events? While the meaning of spoken utterances unfolds progressively, there is evidence that listeners use currently available cues and knowledge sources interactively to make predictions about upcoming words in a goal-directed fashion as an utterance representation is formed (Kuperberg & Jaeger, 2016; Kutas & Federmeier, 2011). Neurophysiological tools such as electroencephalography (EEG) and event-related potentials (ERPs) provide insight as to how predictions derived from vocal speech cues facilitate, or fail to facilitate, the semantic processing of linguistic cues as an utterance unfolds (Van Berkum et al., 2008). In particular, N400 and P600 components, often modulated by semantic and pragmatic manipulation, are thought to index efforts in word meaning retrieval and in-utterance word integration, respectively (Aurnhammer et al., 2021; Brouwer et al., 2017; Delogu et al., 2019; Van Petten & Luka, 2012).

While most early evidence for N400 and P600 responses results from sentences manipulated to contain anomalous, mismatching, or unexpected words (Kutas & Federmeier, 2011; Lau et al., 2008), recent research reports modulation of these semantic components as listeners process more natural types of discourse, including irony (Caillies et al., 2019; Cornejo et al., 2007), world knowledge and (dis)trust (Foucart & Hartsuiker, 2021; Jiang et al., 2020), impositional requests (Vergis et al., 2020), or innuendo (Rigoulot et al., 2020). In these cases, increased amplitudes in the N400 (and sometimes P600) were evoked by mismatches between the current word and contextual cues (e.g., irony, truth value), task demands (e.g., assess confidence, friendliness), or general conversational rules (politeness, appropriateness). While in these diverse and complex social-pragmatic tasks the roles attributed to the N400 and P600 vary, N400 responses usually pertain to the relationship between the current word and other lexical, vocal, or task constraints (Molinaro et al., 2009; Paulmann & Kotz, 2008b; van den Brink et al., 2012), while P600 effects indicate pragmatic (re)-interpretation efforts of the whole utterance within its context (Regel et al., 2011; Rigoulot et al., 2014).

The sensitivity of word and utterance meaning retrieval to such a wide variety of factors is revealing of the multitude of signals that can simultaneously constrain speech processing. To account for the integration of all this information, parallel constraint-satisfaction models suggest that listeners process social and stereotyping signals immediately as they are available to form impressions about speakers and to constrain the interpretation of discourse (Kunda & Thagard, 1996; Pexman, 2008). New signals that do not satisfy these impressions will have increased surprisal and require greater effort to retrieve their meaning, whereas words whose meaning has been pre-activated will be processed more easily (Caffarra et al., 2019; Levy, 2008). In the present context of complaint evaluation, it is likely that the goal of assessing speaker suffering would constrain listener's attention to expect pain-related verbal cues; in this case, statements describing innocuous events would have a high surprisal potential and increase processing demands over statements which describe explicit situations involving (social) pain.

However, the speaker's prosody is also a potential constraint which could modulate the surprisal of words in spoken complaints, altering how speaker intentions are inferred (Hellbernd & Sammler, 2016; Wichmann, 2002, 2000). A recent study by Mauchand et al.

(2021) revealed that statements (e.g., *You are such a great cook*) produced with an obviously ironic tone of voice elicited smaller N400 and P600 responses at the critical word than when spoken in a literal tone; this finding suggests that the prosodic signature of irony/sarcasm registered from the onset of the utterance allowed listeners to better predict the ironic intention of upcoming words than a less marked literal voice. Zhang et al. (2021) also reported that prosodic accentuation (e.g., higher pitch) was associated with N400 reductions in high-surprisal words within discourse. These results are important in light of recent work on complaint perception, which showed that utterances produced in an expressive, complaining prosody are motivationally more salient and neurally differentiated from neutral prosody as early as 200ms after utterance onset (Mauchand et al., 2022). It can be hypothesized that early and continuous appraisal of the speaker's emotive prosody would guide the listener's interpretation towards an impression of suffering even in the absence of pain-related verbal information.

Another contextual variable which could impact on how listeners process complaining utterances is the speaker's *identity* based on their speech characteristics (e.g., accent). A speaker's perceived linguistic-cultural background is rapidly inferred from their accent, which can induce biases that alter social interactions (Fiske et al., 2016). Out-group perception is known to activate implicit negative biases that affect downstream semantic processing (Gawronski & Bodenhausen, 2006; Mauchand & Pell, 2022a; Pantos & Perkins, 2012). Important to the processing of complaints, which are designed to promote affect sharing, empathy is highly sensitive to outgroup biases, with out-group perception being associated with altered, often diminished empathic responses (Bestelmeyer et al., 2015; Cheon et al., 2010; Sessa, Meconi, Castelli, et al., 2014; Xu et al., 2009). In language processing, accented speech has been found to elicit greater N400 responses than ingroup accent overall (Goslin et al., 2012; Romero-Rivas et al., 2015), but can also modulate N400 effect in more complex contexts such as credibility evaluations (Foucart & Hartsuiker, 2021; Jiang et al., 2020) or accent-based stereotype violation (Pélissier & Ferragne, 2021).

Specific to this study, recent data point to important differences in the neurocognitive processing of ingroup vs. outgroup complaints at utterance onset, with out-group complaints being marked as less salient and demanding greater empathic (cognitive) effort to evaluate than in-group complaints (Mauchand & Pell, 2022). However, it is unclear whether early differences in how listeners appraise ingroup vs. out-group emotive signals based on the speaker's prosody and accent-related cues would impact on late interpretation stages at the sentence-final word, for example, by promoting shallower pragmatic processing of outgroup complaints with effects on the word-final N400 (Foucart et al., 2019; Foucart & Hartsuiker, 2021). Exploring this hypothesis was a secondary aim of our study.

The present study investigated how vocal-speech cues (prosody, accent) influence and hypothetically *constrain* how listeners appraise speaker suffering during online processing of verbal complaints. Given our participants' instruction to focus on how the complainer was feeling (extent of suffering), we expected that utterances that describe innocuous events would be associated with greater lexical retrieval (increased N400) and pragmatic interpretation (increased P600) efforts on the final word than utterances describing task-relevant, socially painful events. However, given evidence that the neurocognitive system differentiates emotionally expressive and neutral prosody almost immediately following utterance onset (Mauchand & Pell, 2022), we predicted that lexical-semantic processing of the final word would be strongly constrained/facilitated by the complaining, emotive tone of voice, which would mark the utterance as an attempt to induce empathy in the listener even when the subject of the complaint was seemingly innocuous (reducing differences in the N400/P600 following complaining prosody). Given evidence that speaker accents tend to promote a more effortful set of procedures to infer the pragmatic meaning of a speaker (Jiang et al., 2020; Mauchand & Pell, 2022), we speculated that the ingroup/outgroup status of the speaker would additionally affect how prosodic information is integrated at the final word, albeit in a less clear manner.

4.2. Methods

4.2.1. Participants

A power analysis was run using G*power to determine a minimum sample size for the experiment (Faul et al., 2007). Expecting large effects of prosody, but conservatively assuming medium effect sizes regarding accent effects on the ERP components of interest (Jiang & Pell, 2015; Mauchand et al., 2021), a minimum of 24 participants was determined to achieve a power over 80%. Twenty-eight French participants were recruited in the region of Montreal, Canada. Two participants could not complete the experiment due to technical issues, leaving 26 subjects (16F, 10M; Age: M = 26.08, SD = 4.09; years of education: M = 16.23, SD = 2.55) for the analyses. All participants were born in France, had lived in France until they were at least 18, and were living in Montreal to pursue studies or work. To limit effects of long-term habituation to the regional Québécois accent (Sumner & Samuel, 2009), participants were selected based on having lived less than two years in the province of Québec. All participants were right-handed and reported no history of major psychiatric or neurological illness or speech/hearing problems. Participants voluntarily consented to take part in the study which was ethically approved by the Faculty of Medicine Institutional Review Board (McGill University, Montreal, Canada). Participants were remunerated for their involvement ($40CAD).

4.2.2. Stimuli

Stimuli were 320 short French utterances created, validated, and selected in two previous studies focusing on the acoustic and perceptual aspects of complaining speech (Mauchand & Pell, in review, 2021b) and also used in a previous ERP study focusing on the neurocognitive effects of complaining prosody (Mauchand & Pell, 2022). Stimuli were constructed in the form of token sets composed of 4 utterances. Each token set was built from a root sentence describing an action performed by a third party and then distinguished in terms of verbal content and prosody. The verbal content was manipulated by changing only the last word of the statement to describe either a socially harmful event (e.g., “Il a dit que j’étais stupide/He said I was stupid”) or an innocuous event (e.g., “Il a dit que j’étais sorti/He said I was outside")[4]. Prosody was then manipulated by having the speakers utter each sentence in a complaining and in a neutral tone of voice. One token set thus comprised four combinations of the manipulations: *Neutral/Pain, Neutral/Innocuous, Complaint/Pain, Complaint/ Innocuous.*

Utterances were produced by 4 French and 4 Québécois speakers to modulate the accent of the utterances. Note that from the perspective of our participants, the French

[4] For a complete list of the materials, see Mauchand & Pell, 2022.

accent would lead to an “ingroup” categorization, whereas the Québécois accent would promote an “outgroup” categorization (Mauchand & Pell, 2022a). Recordings were digitally captured in a sound-attenuated chamber with a high-quality head-mounted microphone onto a Tascam recorder (sampling rate of 44.1 kHz, 16-bit, mono, .wav format). They were then edited in Praat (Boersma & van Heuven, 2001) into short .wav audio files and normalized to a peak intensity of 70 dB. There were 672 utterances produced in the initial recording; following a validation study, 10 token sets were selected for each speaker such that each token set was present only once in both accents (Mauchand & Pell, 2021). In summary, there was a total of 2 Accents x 4 Speakers x 10 Token sets x 2 Statements x 2 Prosodies = 320 utterances.

4.2.3. Procedure

During the EEG task, participants were seated comfortably in an electrically shielded, sound-attenuating booth. Stimuli were presented through earphones in a pseudo-randomized order that prevented the direct repetition of utterances from the same speaker or token set. In each trial, an utterance was presented after a jittered fixation point (500 to 1500ms) followed by a question prompting them to evaluate "how hurt the speaker feels" ("À quel point cette personne se sent-elle blessée?"). This task required listeners to expect pain-related cues without drawing attention to a specific source of information in the speech signal. The response prompt appeared 1000ms after stimulus offset, and responses were recorded through a 5-button Cedrus response box ranging from "Not at all" ("Pas du tout") on the leftmost button to "Very much" ("Énormément") on the rightmost button. The trial ended after a response from the participant or 5 seconds after the question appeared, triggering the next trial after a 1500ms blank screen. The experiment started with 8 practice trials to familiarize participants with the procedure and was then divided into 8 blocks of 40 trials, with a self-paced pause between each block to allow participants time to rest.

While performing the task, the electroencephalograms (EEGs) were recorded continuously from 64 Ag/ACl electrodes using the ActiCap System (Brain Products, Germany). The vertical electrooculograms (VEOG) were recorded from above and below the right eye and the horizontal electrooculograms (HEOG) were recorded from the outer canthus of both eyes. The recordings were online referenced to FCz and re-referenced offline to the bilateral mastoids. The EEGs were digitized at 500 Hz and filtered with a band-pass from 0.016 Hz to 100 Hz. The EEG task lasted approximately 30 to 40 minutes. After the task, participants completed a series of questionnaires including the Empathic Concern and Perspective-Taking subscales of the Interpersonal Reactivity Index (IRI), as well as an Accent-based Implicit Association Test, and a Stereotype Content Model questionnaire assessing implicit and explicit biases towards each cultural group (Mauchand & Pell, 2022a).

4.2.4. ERP Analysis

EEG recordings were pre-processed using EEGLAB (Delorme & Makeig, 2004) and ERPLAB (Lopez-Calderon & Luck, 2014). The continuous EEGs were filtered using a 40-Hz low-pass and a 0.1-Hz high-pass Butterworth of the fourth order, and were manually inspected to remove excessive movement artifact, alpha activity, or amplifier saturation. The subsequent EEGs were then decomposed with Independent Component Analysis (Makeig et al., 1996) to remove ocular artifacts. Data were then segmented into

1200ms epochs time-locked to the onset of the final word to explore how verbal-semantic information about the speaker's pain was processed depending on the nature of preceding prosodic and accent information available to listeners. Epochs were baseline corrected based on the mean EEG activity during the 200ms preceding target word onset. Segments with signal peak-to-peak voltage exceeding 100 mV within a 200-ms sliding window in steps of 100ms were automatically rejected. None of the subjects showed enough trial rejection (i.e., more than 40% of trials) to justify exclusion from further analysis.

As trial-to-trial latency jitter creates single-trial variability that reduces component discrimination, attenuates component amplitudes, and may yield erroneously significant effects, a Residue Iteration Decomposition (RIDe) procedure was performed on the ERP data before analysis (Ouyang et al., 2016). RIDe uses the latency variability and time markers to separate ERP components into predicted component clusters with a stimulus-locked cluster and one or more central clusters with unknown latency. The stimulus-locked cluster was set to a time window of 0-400ms, and the central cluster was set to a time window of 200-1200 ms, with the latency first estimated by Woody's method within this time window. Then, ERPs were subjected to RIDe into the component clusters associated with the latency sets; these two steps were iterated until convergence. After resynchronization of the subcomponent clusters to their own latency across single trials, ERPs were reconstructed accounting for variability of latency across trials (Ouyang et al., 2015).

To isolate the latent structures of critical components from ERP waveforms in an objective manner (Brouwer & Crocker, 2017), data were first analyzed with temporal-spatial Principal Component Analysis (PCA) (ERP PCA toolkit, see Dien, 2010). Subject-level ERP amplitudes of all channels in the entire epoch (-200 to 1200ms) were decomposed based on their correlational structure to identify temporally and spatially distinct underlying components. The PCA was performed in two steps. First, a temporal Infomax decomposition was performed to identify temporal factors of interest; the factors to retain were determined by a Parallel Scree Test (Horn, 1965). Second, a spatial Promax rotation was performed on each surviving temporal factor to identify independent spatial component within their time window (Dien, 2012). Factors accounting for more than 0.5% of total variance were analyzed; two temporal factors, TF4 and TF5, showed significant condition effects, each across two spatial factors (Table 4.1 and Figure 4.1). The loadings from peak channel at peak latency of each factor were rescaled to microvolts and entered into a Linear Mixed-Effect Model as responses, with Accent (Ingroup/Outgroup), Prosody (Neutral/Complaining), and Statement (Painful/Innocuous) as fixed factors, and Participants as a random intercept. The model was built using lme4 (Bates et al., 2015) and lmerTest (Kuznetsova et al., 2017) packages in R software (R Core Team, 2018) with Ingroup Neutral Painful utterances as the intercept.

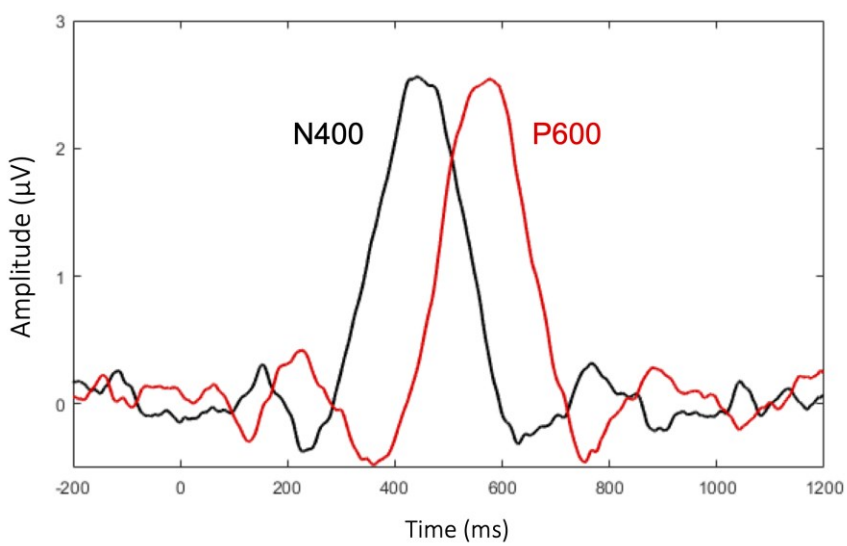

Figure 4.1. Temporal factor loadings for the N400 and P600 factors.

Table 4.1. Summary of PCA temporal-spatial factors accounting for over 0.5% of total variance. Bolded rows indicate factors that showed significant condition effects.

Factor	peak latency (ms)	negative peak	positive peak	variance explained
TF1SF1	1036	EOG2	-	12.70%
TF1SF2	1036	EOG2	EOG1	6.10%
TF1SF3	1036	EOG2	POz	3.30%
TF1SF4	1036	F7	EOG2	1.80%
TF2SF1	814	-	Fz	8.50%
TF2SF2	814	EOG2	EOG1	1.10%
TF2SF3	814	Fp1	P2	0.50%
TF3SF1	690	Fz	-	8.10%
TF3SF2	690	Fp1	POz	0.80%
TF4SF1	**576**		**Cz**	**8.80%**
TF4SF2	**576**	**Fp1**	**POz**	**0.80%**
TF5SF1	**442**	**Fz**	**-**	**7.20%**
TF5SF2	**442**	**PO4**	**Fp1**	**1.20%**
TF5SF3	442	EOG2	FT10	0.70%
TF6SF1	238	-	Cz	4.70%
TF6SF2	238	P2	F8	0.70%
TF7SF1	936	-	Fz	1.60%
TF8SF1	144	Fz	-	0.90%

4.3. Results

4.3.1. Behavioral results

A linear mixed-effect model was built with participant's evaluations as a response, Accent, Prosody and Statement as interacting fixed factors, Participant and Item as random intercepts, and Accent, Prosody and Statement as by-Participant random slopes. The model showed no effect of Accent ($\beta = .23$, se = .16, $t(9.28) = 1.40$, $p = .193$), a significant effect of Prosody ($\beta = 1.28$, se = .20, $t(17.23) = 6.52$, $p < .001$) a significant, but smaller effect of Statement ($\beta = .82$, se = .18, $t(13.05) = 4.59$, $p < .001$), with no interactions. Overall, speakers were rated as feeling more hurt when they produced utterances in a complaining prosody (M = 3.49, sd = .78) compared to neutral prosody (M = 2.23, sd = .81), and separately, when their utterances described painful (M = 3.27, sd = .93) versus innocuous (M = 2.46, sd = .92) events. Behavioral results are summarized in Figure 4.2.

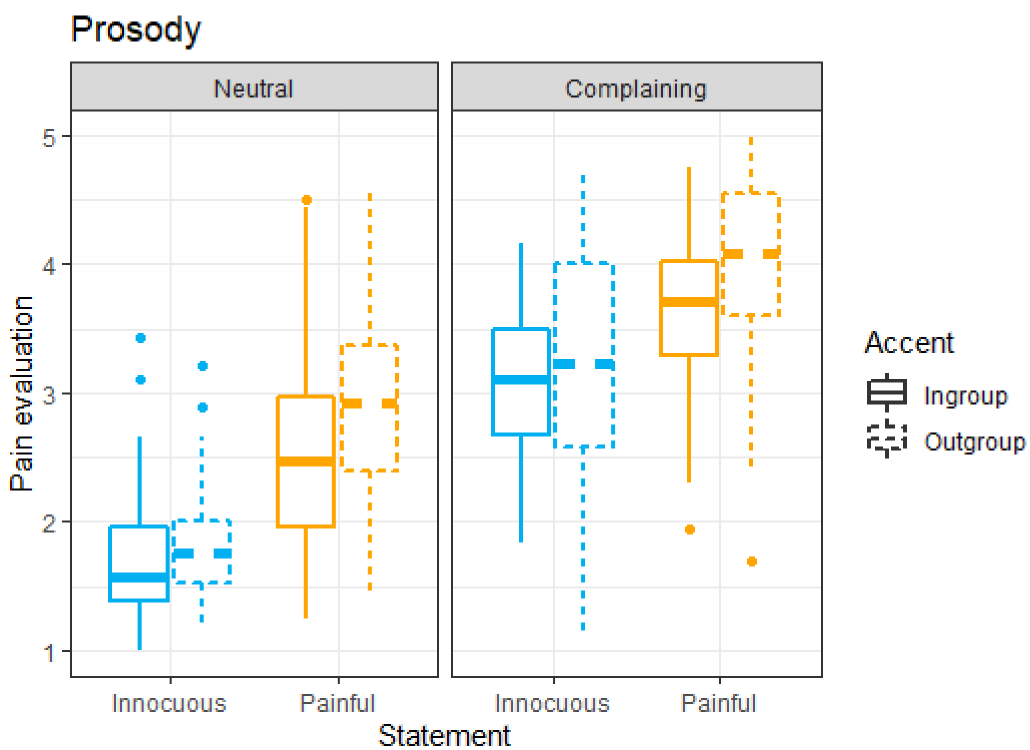

Figure 4.2. Behavioral ratings of "how hurt the speaker feels" based on Prosody, Statement, and Accent.

4.3.2. ERP results

4.3.2.1. N400. Factor TF5SF1 accounted for 7.2% of total variance in the PCA and was characterized by a large negative-going wave over the whole scalp, peaking at 442ms at Fz, as seen in Figure 4.3. The model revealed a significant effect of Statement (β = -2.62, se = .60, t(175) = -4.41, p < .001) combined with an interaction between Prosody and Statement (β = 1.67, se = .84, t(175) = -1.98, p = .049). Post-hoc pairwise comparisons revealed that when utterances were produced in a neutral prosody, innocuous statements yielded a significantly more negative N400 response than pain-related statements (β = -2.08, se = .42, t(175) = -4.94, p < .001). On the other hand, when produced with a complaining prosody, innocuous and painful statements did not elicit different N400 amplitudes (β = -.57, se = .42, t(175) = -1.35, p = .178). The interaction effect was significant at electrodes AF3, AF4, AF7, AF8, Fp1, Fp2, Fz, F1, F2, F3, F4, F5, F6, F7, F8, FCz, FC1, FC2, FC3, FC4, FC5, FC6, FT7, FT8, Cz, C1, C2, C3, C4, C5, C6, T7, T8, CPz, CP1, CP2, CP3, CP4, CP5, CP6, TP8, Pz, P1, P2, P3, P4, P5, P6, P8, POz, PO3, PO4, PO7, PO8, Oz, O1, and O2. The speaker's Accent also showed a significant main effect (β = -1.62, se = .60, t(175) = -2.72, p = .007) such that utterances spoken in an Outgroup Accent elicited a more negative response in the N400 time window.

A second spatial component in the same temporal window (TF5SF2) was observed at right posterior electrodes, peaking at PO4 and accounting for 1.2% of total variance (see Appendix Figure A). Analysis for this factor revealed a significant effect of Statement similar to the first N400 factor (i.e., increased negativity for innocuous vs. painful statements), but without any interaction (β = -.56, se = .24, t(175) = -2.28 p = .024). This effect was significant over electrodes C2, CPz, CP1, CP2, CP3, CP4, CP6, P1, P2, P3, P4, P5, P6, P7, P8, POz, PO1, PO2, PO3, PO4, PO7, PO8, PO9, PO10, Oz, O1, and O2.

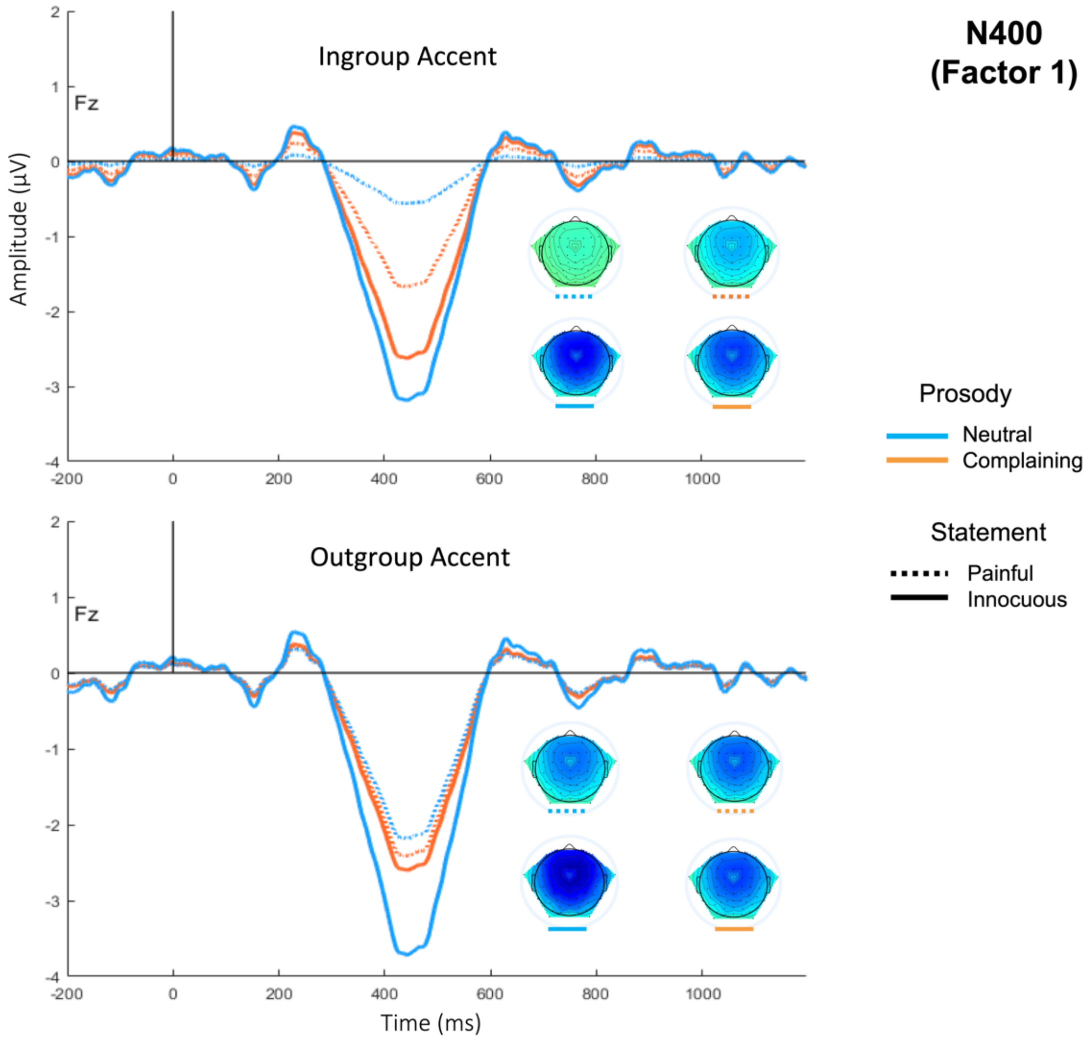

Figure 4.3. ERP-PCA waves and topographic maps showing the effects of Accent, Prosody, and Statement on factor TF5SF1 (N400). Top: Prosody and Statement effects for utterances produced by Ingroup speakers. Bottom: Prosody and Statement effects for utterances produced by Outgroup speakers.

4.3.2.2. P600. Factor TF4SF1 accounted for 8.8% of total variance in the PCA and was characterized by a positive-going wave over fronto-central electrodes, peaking at 576ms at Cz, as seen in Figure 4.4. The model revealed a significant interaction between Statement and Prosody (β = -2.09, se = 1.45, t(175) = -2.04, p = .043). Innocuous Statements elicited a more positive response than Painful Statements when produced in a Neutral prosody (β = -1.06, se = .51, t(175) = -2.06, p = .041), but a more negative-going response when produced in a Complaining prosody ($\beta = 1.30$, se = .51, $t(175) = -2.53$, $p = .012$). This interaction was significant at electrodes Fz, F1, F2, F3, F4, FC1, FC2, FC4, Cz, C1, C2,C4, CPz, CP1, CP2, and Pz.

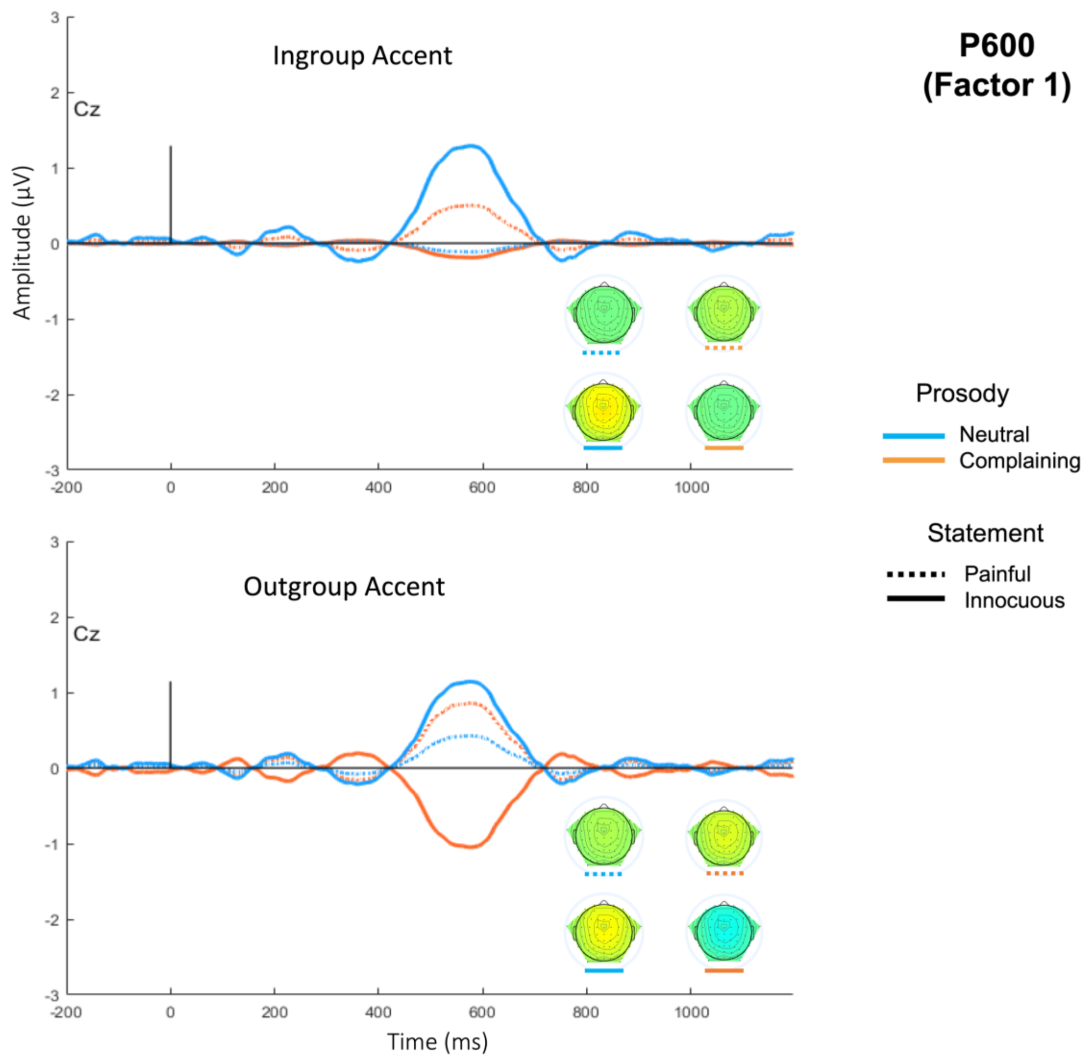

Figure 4.4. ERP-PCA waves and topographic maps showing the effects of Accent, Prosody, and Statement on factor TF4SF1 (P600). Top: Prosody and Statement effects for utterances produced by Ingroup speakers. Bottom: Prosody and Statement effects for utterances produced by Outgroup speakers.

A second spatial component in the P600 temporal window (TF4SF2) was more posteriorly distributed, peaking at POz and accounting for 0.8% of total variance (see Appendix Figure B). Analysis of this factor revealed that it was sensitive to the type of

Statement speakers made; Painful statements tended to produce a more positive response than Innocuous Statements ($\beta = -.72$, $se = .20$, $t(175) = -3.56$, $p < .001$) at posterior electrodes (CPz, CP1, CP2, CP3, CP4, CP6, Pz, P1, P2, P3, P4, P5, P6, P7, P8, POz, PO1, PO2, PO3, PO4, PO7, PO8, PO9, PO10, Oz, O1, and O2).

4.4. Discussion

4.4.1. Effects of context on lexical retrieval

As predicted, critical words that marked seemingly harmless, "innocuous" statements about past events elicited a stronger N400 response than words that described obviously painful events when listeners focused on "how hurt the speaker feels". This result highlights the contextual sensitivity of lexical retrieval, especially regarding goal-directed speech processing (Kutas & Federmeier, 2011; Molinaro et al., 2009). In the present experiment, participants were tasked with evaluating the suffering of the speaker, thus directing their attention towards cues relevant to any form of *pain*. The utterances they heard described an action performed by a third party, with only the last word determining whether that action was harmful to the speaker or not based on the linguistic message (She said I was ... / He took my ...). This sentence construction, combined with their task-induced motivated goal, would thus allow the prediction that the meaning of upcoming words would be associated with speaker suffering. Based on our findings, it appears that words that clearly satisfied this prediction (She said I was *stupid* / He took my *spot*) were retrieved with less difficulty based on evidence in the N400 processing window, while words that described relatively innocuous events (She said I was *outside* / He took my *hand*) were associated with increased difficulties at the access stage.

These findings are in line with current language processing theories regarding lexical retrieval at the N400 (Brouwer et al., 2017). In particular, they highlight the dependence of the N400 on expectation (here, from task demands) and association (here, the preceding verbal information), with words that are expected and easily associated requiring less retrieval efforts (Aurnhammer et al., 2021; Delogu et al., 2019). Importantly, they extend these theoretical frameworks into a novel, socially relevant setting and provide another real-life example of how listeners can make on-line predictions about upcoming words in interpersonal discourse.

4.4.2. Prosodic constraints on semantic processing

While the listener's socio-evaluative goal prompted them to expect certain semantic information related to pain, a key result of this experiment is that the speaker's prosody strongly constrained this expectation at semantic processing stages. When complaints were spoken in a neutral voice, innocuous key words elicited significant increases in the N400 and P600 components when compared to painful words. However, when utterances were expressed in an affective, complaining voice, there were no differences in the N400 amplitude at the critical word and the effect of the key word was reversed in the P600 window. In other words, complaining prosody, which was processed and distinguished early on from utterance onset (Mauchand & Pell, 2022), reduced retrieval efforts for words that are underspecified in a context of pain evaluation, and altered subsequent pragmatic interpretation processes. As elaborated below, these effects underline the critical role of prosody during speech processing: first, as a support for a parallel constraint-satisfaction model of affective speech perception (Caffarra et al., 2019; Levy, 2008); second, as an emotive device superseding semantic content in complaining interactions.

At the onset of the final word, listeners were aware of at least three critical aspects of the presented utterance: that it described an action performed by a third-party; that they had to evaluate how hurt the speaker felt; and that it was produced (or not) in a complaining prosody. Parallel constraint-satisfaction models posit that these pieces of information are processed in a parallel and connected manner to form impressions that will compete or converge to guide discourse interpretation (Kunda & Thagard, 1996; Levy, 2008; Pexman, 2008). Figure 5 summarizes a model specific to complaint perception in this experiment. By knowing from preceding verbal content that the event described as a third-party action, the final word can yield two different outcomes: either the action had a harmful effect on the speaker, or it did not. As described earlier, the experimental context constrained listener's interpretation to expect a more or less harmful outcome, making words that satisfied this expectation easier to retrieve than words that did not. Prosody, on the other hand, appeared to constrain this retrieval in a different manner. Rather than narrowing listener's predictions of the upcoming word, it allowed them direct access to the speaker's affective state (Ong et al., 2018; Pell et al., 2018), thus already satisfying the task-induced prediction of suffering regardless of the outcome of the sentence. A complaining tone of voice thus facilitated the retrieval of otherwise unexpected words, effectively reducing the N400 effect between painful and innocuous utterances.

The constraining effect of prosody continued throughout later interpretation efforts, albeit in a less straightforward manner, by "reversing" the P600 effect of innocuous over painful words. The P600 window often reflect pragmatic integration and updating of the meaning of utterances (Brouwer et al., 2012; Delogu et al., 2019). Negative effects have been reported in this time-window in innuendo statements, when prosody was used as a cue to interpret otherwise ambiguous statements (Rigoulot et al., 2020), suggesting a prosody-based pragmatic resolution of such ambiguity. Alternatively, the resulting increased P600 for Neutral/Innocuous and Complaint/Painful statement may reflect fine-grained, in-depth interpretation of speaker intentions in unambiguous speech (i.e., matched valence of prosody and statement) (Jiang et al., 2013; Jiang & Pell, 2015). In any case, these results further suggests that prosody can act as a high-constraint signal that influence N400 and P600 effects (Mauchand et al., 2021; Molinaro et al., 2009; Zhang et al., 2021), effectively superseding other contextual and verbal cues in appraising other's discourse.

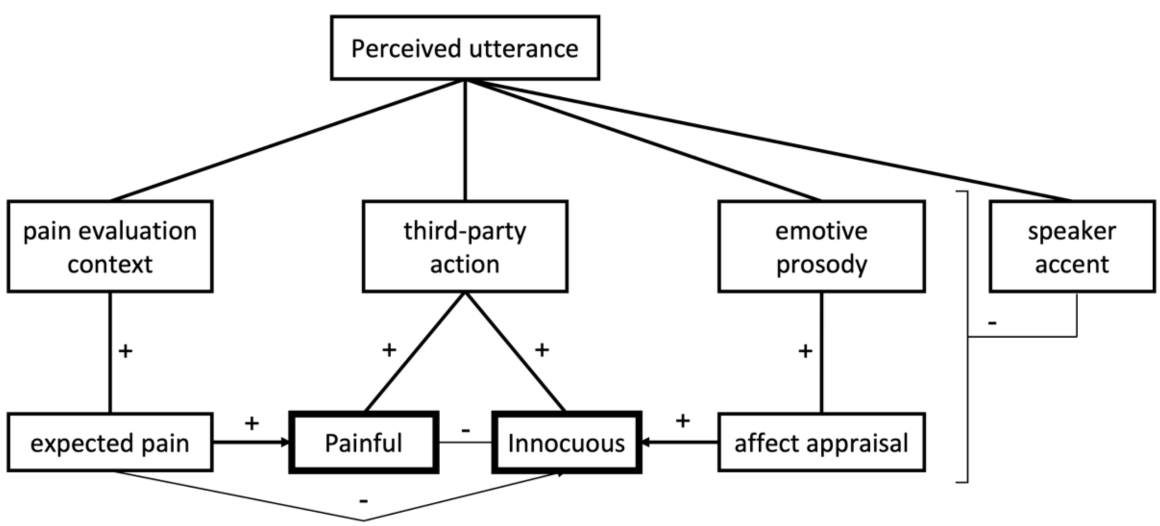

Figure 4.5. Parallel constraint-satisfaction model for complaint processing.

This facilitation of innocuous complaints confirms their non-instrumental nature: one can virtually complain about anything (Alicke et al., 1992; Boxer, 1993), as long as they can efficiently reconstruct and convey their affective state (Caffi & Janney, 1994; Selting, 2010). Prosody appears as the emotive device of choice in that regard, with a clear acoustic signature (Mauchand & Pell, in review) that is perceptually identifiable (Mauchand & Pell, 2021) and processed from utterance onset (Mauchand & Pell, 2022b). The present study is the first to provide neurophysiological evidence of this primacy of emotive prosody over semantic information in complaining speech, complementing a sparse but growing literature across pragmatics (Drew & Walker, 2009; Edwards, 2005; Selting, 2010), acoustics (Acuña-Ferreira, 2002; Ogden, 2007; Rao, 2013), and experimental psychology (Mauchand & Pell, 2021) fields. Behavioral results, however, suggest that this primacy is not absolute: while prosody largely drives perceived speaker pain, listeners still somewhat hierarchize complaining topics even when spoken with an emotive voice (Alicke et al., 1992).

Put into a broader perspective, these results underlie the importance of the voice as an everyday tool for coordinating meaningful social interactions (Pell & Kotz, 2021; Szczepek Reed, 2011). Beyond being a simple "readout" of one's emotions, prosody can be used to provide social information that can guide a listener's processing and direct their social behavior (Scarantino, 2017; Van Kleef, 2009). By reducing processing demands on incongruously benign statements, affective prosody facilitates interpersonal affiliation even in low-involvement contexts (Boxer, 1993; Van Zant & Berger, 2020). This also highlights the social significance of "small talk", which is an often-underplayed yet critical aspect of our social life (Coupland, 2010). In these extraordinarily mundane interactions, prosody acts as a transverse and reliable affective signal with major implications in their social outcome (Mauchand et al., 2021; Meconi et al., 2018; Vergis et al., 2020; Zougkou et al., 2017).

4.4.3. Cross-cultural constraints

In addition to contextual, semantic, and prosodic information, listeners also had early access to the speaker's cultural identity through their accent. Here, accent modulated demands in the N400 processing interval, with outgroup speech eliciting larger N400 amplitudes that ingroup utterances, although these effects were independent of the speaker's prosodic expression. The accent effect shows that speaker identity information can influence processes underlying lexical access and retrieval (e.g., Foucart & Hartsuiker, 2021); however, since the speaker's accent did not interact with the prosody manipulation, our findings demonstrate that the speaker's form of vocal expression remains a robust signal in conveying social-emotional information across cultures.

In parallel-constraint satisfaction models, categorical information such as cultural identity is a critical constraint on how impressions are formed about others (Kunda & Thagard, 1996). The perception of an out-group accent is known to affect subsequent speech processing based on intelligibility and familiarity (Derwing & Munro, 1997; Floccia et al., 2009; Jiang et al., 2020; Voeten & Levelt, 2019). Related to familiarity, accented speech is often subject to biases that can alter social impressions and constrain pragmatic processing (Heblich et al., 2015; Jiang et al., 2020; Pélissier & Ferragne, 2021). Specific to the present stimuli, for French speakers the Québécois accent is associated with implicit and explicit biases affecting its perceived status and prestige (Auger, 2005; Kircher, 2012; Mauchand & Pell, 2022a). The increase in N400 retrieval effort for outgroup utterances may thus be a consequence of such unfamiliarity and/or biases, which caused greater uncertainty about the meaning of the upcoming critical word. Previous analyses of ERP responses to complaints at utterance onset indeed revealed that outgroup vocal expressions were less motivationally relevant and required slower encoding efforts (Mauchand & Pell, 2022b). This may suggest that listeners are less attuned to cues about how outgroup speaker feel, leading to more effortful semantic processing of the outgroup speaker message. Still, the absence of interactions with prosody effects shows that emotivity expression in complaints shows central tendencies between cultural groups (Laukka & Elfenbein, 2020; Liu, Rigoulot, & Pell, 2015; Thompson & Balkwill, 2006). Prosody thus appears to elicit social impressions that are consistent across regional cultures and constrain empathic speech processing in the same way. As shown in Figure 5, accent constrains how the speaker's discourse is appraised in general, regardless of other vocal information.

4.5. Conclusion

The present study and results provide neurophysiological evidence for a parallel constraint-satisfaction model of affective speech processing. Extending neurolinguistic literature on the N400 and P600 to the social speech act of complaining, it suggests that expectation- and association-based retrieval efforts can be mitigated by parallel information from relevant para-linguistic signals such as speech prosody and accent. In the case of complaints, these results confirm that a speaker can virtually complain about anything, to anyone, as long as they convey proper emotive cues. More generally, they emphasize the role of prosody in facilitating empathic and affiliative mechanisms in social interactions, suggesting that that the "how" (and the "who") often supersedes the "what" in emotive speech.

4.6. Acknowledgements

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SECTION III: BRAIN NETWORKS IN EMPATHIC RESPONSES TO COMPLAINTS

Preface to Chapter 5

The previous section has provided a detailed and unique look at the processing of spoken complaints across time. While ERP experiments studying empathic processes and their timing are far from rare, these two chapters shed new light on the temporal organization of perceptual, affective, and cognitive mechanisms when attending to emotive voices. They show that the empathic appraisal of speech relies on the continuous uptake and integration of competing information as the utterance unfolds. Importantly, they reveal how different speech channels and social-relational factors can constrain and influence the processing of other parallel or upcoming signals, highlighting the many forms that empathy can take in different contexts.

In order to provide a complete picture of empathic processes in the brain, the next chapter approaches the perception of complaints from a spatial perspective. Using fMRI, this experiment aimed to identify brain regions involved in the perceptual, affective, and cognitive appraisal of emotive voices across cultures. Like Chapter 3, it aims to be a bridge between neuroimaging literatures on empathy, speech processing, affect perception, and cultural cognition, and show how these various perspectives can meet through common neural networks. To simplify the design of this fMRI experiment, the "statement" factor was simplified by only keeping utterances that explicitly described a pain-related topic (the "Painful" statement condition). Hence, the following chapter focuses on how emotive prosody, as produced by in- or outgroup speakers, is empathically processed across the brain.

Chapter 5. The vocal side of empathy: neural correlates of pain perception in spoken complaints

5.1. Introduction

Since its coining by philosopher Theodor Lipps in the early 20th century, empathy ("einfühlung") has been a concept which, despite being intuitively grasped by most individuals, has evaded a clear, consensual scientific definition (Cuff et al., 2016; Hall & Schwartz, 2018). Loosely described as the state resulting from the observation of another's feeling, most often pain (Preston & de Waal, 2002), it has been the subject of extensive neuroimaging research which highlighted, more or less effectively, a number of brain networks and processes associated with the perception of suffering in others (de Vignemont & Singer, 2006; Jauniaux et al., 2019). The present study aims to disentangle how these networks (and others) affect empathy in everyday social communication, by examining neural responses to spoken third-party complaints about painful events.

Most of the empathy literature involves presenting images of body parts experiencing pain (e.g. a hand caught in a door; Fan & Han, 2008), faces expressing pain, or humans in painful situations (Mathur et al., 2010); other designs involve film excerpts (Borja Jimenez et al., 2020) or dynamic settings such as the social exclusion cyberball game (Eisenberger, 2012). Usually, participants are then asked to evaluate the pain of the person they see. Across this vast literature, many studies report that the perception of suffering in others elicits activity in two critical regions of the salience network: the dorsal anterior cingulate (dACC) and anterior insula (AI) (Masten et al., 2011; Mathur et al., 2010; Preis et al., 2015). This network is sometimes also referred to as the "pain matrix" and "core empathy network" because of its involvement in perceiving pain both in the self and in other (Fan et al., 2011; Jackson et al., 2006; Lamm et al., 2011). More generally, dACC and AI are usually mobilized during the perception of salient and emotionally relevant stimuli that engage the attention of the subject (Legrain et al., 2011; Perini et al., 2018). In addition, a number of empathy experiments highlight the role of areas involved in Theory of Mind (ToM) such as the temporo-parietal junction (TPJ), superior temporal cortex (STC), together with the medial prefrontal cortex (mPFC) and posterior cingulate (PCC) from the default mode network (Cheon et al., 2011; Kim et al., 2017; Li et al., 2014). While some consider ToM as a process separate from empathy per se (Kanske et al., 2015; Vö et al., 2005), many define empathy as a dual stream composed of distinct, but interrelated affective (dACC/AI) and cognitive (ToM) components (Cuff et al., 2016; Sessa, Meconi, & Han, 2014). Less commonly, some studies describe a somatomotor component of empathy involving the mirror neuron system, somatosensory, motor and pre-motor areas, potentially indicating a more reactive "resonance" of the observer with the pain of the observed (Baird et al., 2011; Borja Jimenez et al., 2020).

From early on, research on empathy has been tightly linked to concepts of affiliation, social proximity, and group belonging (Cheon et al., 2010; Hollan, 2012). It is usually argued that since empathy involves the appraisal of other's feelings within the self, it is thus facilitated when the other is more familiar or more similar to the self. As such, an important part of the literature approaches empathy from a cultural perspective, although with mixed results. Reports include increased affective responses to in-group pain together with group-independent ToM processing (Fourie et al., 2017; Xu et al., 2009), in-group biases in ToM (Cheon et al., 2011; Mathur et al., 2010), or even culture-dependent empathic networks (Mathur et al., 2012). In addition, the relative roles of cultural similarity, familiarity, and other contextual constraints have been the subject of diverging, sometimes contradictory data (Avenanti et al., 2005; Contreras-Huerta et al., 2014; Sheng et al., 2014).

The diversity of results and perspectives in empathy research is attributable to two key aspects. First, the term "empathy" is an abstraction that captures a large variety of affective and cognitive processes (Hall & Schwartz, 2018), such that no neural correlate is consensually necessary or sufficient to form a unique "empathy network". Second, empathy is a state that can be experienced in a wide range of situations, leading to an important variability in experimental designs and context-dependent results (Schurz et al., 2021; Xiang et al., 2018). Interestingly, however, most of the literature appears to focus on first-hand perception of pain in others (i.e., directly witnessing a painful event), leaving out an important part of empathy which pertains to more mundane, daily empathic interactions of *reported* pain or suffering. Complaining, in particular, is a frequent social act whose purpose is to elicit empathy in the listener in order to obtain affiliation from them and strengthen social bonds (Acuña-Ferreira, 2002; Drew, 1998; Edwards, 2005).

Beyond verbally describing painful events, complaints communicate suffering through prosody: by modulating acoustic features of their voice such as pitch, voice quality, and rhythm, speakers can effectively create salient affective signals that reconstruct their emotive state to share it with others (Mauchand & Pell, 2021; Rao, 2013; Selting, 2010). In the brain, the processing of affective prosody mobilizes several cortico-subcortical networks centered around the Emotional Voice Areas (EVA), composed mainly of the STC and primary auditory cortex (Mauchand & Zhang, 2022; Schirmer, 2018), which interact with the amygdala during attentional capture of emotionally relevant sounds as well as orbitofrontal cortex for in-depth analysis of the affective meaning of vocal signals (Frühholz et al., 2016; Grandjean, 2021). In addition, the anterior insula appears to be involved specifically when subjects actively empathize with emotional or painful voices, while ACC activity remains unclear (Kanel et al., 2019; Lang et al., 2011). Although no fMRI experiment has yet been conducted using spoken complaints, prosody is thought to play a critical role in empathy (Aziz-Zadeh et al., 2010; Meconi et al., 2018; Regenbogen, Schneider, Finkelmeyer, et al., 2012), and recent neurophysiological evidence suggests that a complaining voice does trigger a variety of empathic processes in listeners (Mauchand & Pell, 2022b).

Consistent with the cultural significance of empathy, complaining is a social and cultural ritual influenced by social proximity and identity (Boxer, 1993; Katriel, 2013). In the voice, one way that identity is communicated through is a speaker's accent, from which listeners can rapidly infer cultural information that influences speech processing (Adank et al., 2015; Hernández et al., 2019; Van Berkum et al., 2008). How accent affects the perception of affective voices likely involves a complex interplay of factors such as accent familiarity, intelligibility, and associated biases; however, there is clear evidence that perceived differences in group membership can affect how affective signals are appraised (Laukka et al., 2016; Laukka & Elfenbein, 2020), especially in more complex speech acts (Jiang et al., 2018). Related to the present study, recent perceptual-acoustic evidence points towards central tendencies in complaining behavior from French and Québécois (French Canadian) groups, although subtle differences were noted both in production and perception of complaining prosody (Mauchand & Pell, n.d., 2021). ERP data obtained from the same stimuli revealed that complaining prosody elicited specific affective and cognitive empathic responses, but their time-course was determined by the perception of speaker accent (Mauchand & Pell, 2022b).

The present study aimed to assess the various neural systems at play during the empathic processing of spoken complaints, and how their operation may depend on vocal cues that communicate emotivity and/or which reveal the speaker's identity. Our primary objective was to determine how emotive prosody which simulates the speaker's pain elicits empathic processes in the listener by comparing responses to utterances produced in a complaining vs. neutral tone, and how this brain activity relates to explicit evaluation of speaker suffering. To investigate the cultural aspect of empathy as a secondary objective, French participants listened to complaining/neutral utterances expressed by both ingroup (French) and regional outgroup (Québécois, also known as French-Canadian) speakers. It was predicted that complaining prosody would increase activation of the Emotional Voice Areas when compared to neutral, as well as induce both affective and cognitive empathic responses in the salience and ToM networks. Accent-based cultural categorization was expected to alter activity across these patterns, albeit in a less clear manner: accent processing demands may increase activity in voice-sensitive areas (Adank et al., 2015; Jiang et al., 2018), while ingroup biases may enhance affective (and potentially cognitive) responses to ingroup pain or elicit distinct processing pathways in the empathic appraisal of vocal signals (Cheon et al., 2011; Mathur et al., 2010).

5.2. Methods

5.2.1. Participants

Twenty-four French-speaking adults were recruited in the region of Montréal, Canada (13F, 11M, age: M = 26.04, sd = 3.99). All participants were born and had lived in France until they were at least 18 years of age; to limit habituation to the regional Québécois accent (Sumner & Samuel, 2009), participants were selected based on having lived less than two years in the province of Québec. All participants were right-handed and reported no history of major psychiatric or neurological illness or speech/hearing problems. Participants voluntarily consented to take part in the study that was ethically approved by the Faculty of Medicine Institutional Review Board (McGill University).

5.2.2. Stimuli

Stimuli were 160 short (M = 1.29s, sd = .29s) French utterances from a corpus created and validated in two previous studies (Mauchand & Pell, n.d., 2021). The utterances were statements describing a situation in which a third-party agent caused the suffering of the speaker (e.g., "Il a dit que j'étais stupide/He said I was stupid"). Statements were then manipulated to vary across two orthogonal, binary factors of Prosody and Accent. For the Prosody manipulation, each statement was produced twice, first in a neutral, fact-stating manner (Neutral condition), and then with a complaining tone of voice (Complaint condition). For the Accent manipulation, utterances were produced by 4 French (Ingroup condition) and 4 Québécois (Outgroup condition) speakers such that each statement was produced (in both prosodies) by exactly one speaker of each group. Each group of speakers was composed of two men and two women with acting experience, matched for age and education. Recordings were digitally captured in a sound-attenuated chamber with a high-quality head-mounted microphone onto a Tascam recorder (sampling rate of 44.1 kHz, 16-bit, mono, .wav format). They were then edited in Praat (Boersma & van Heuven, 2001) into short .wav audio files and normalized to a peak intensity of 70 dB.

The stimuli used in the present study were selected from an original set of 672 utterances based on a perceptual validation study (see Mauchand et al., 2021b for details). Utterance sets that were most representative of complaints or neutral productions according to listeners from each cultural group were selected. In total, 160 utterances were presented in the fMRI study (2 Accents x 4 Speakers x 10 Statements x 2 Prosodies).

5.2.3. fMRI scanning parameters

The fMRI scanning was performed at the Montreal Neurological Institute on a 3-T Siemens Imager with a 64-channel head coil. Functional images were acquired across four runs of 6:26 minutes using a multi-band accelerated pulse with a factor of 6. Four functional multi-band echo-planar runs were acquired for each participant. Each functional run continuously acquired 405 volumes (72 slices per volume, interleaved acquisition; FOV = 208 x 208 mm^2, matrix = 104 x 104, voxel size = 2 x 2 x 2 mm^3; TR = 927ms; TE = 30ms). The first 5 scans of the run were discarded due to T1 saturation. After the first two runs, a high-resolution T1-weighted image was acquired (voxel size 0.9mm^3, 208 slices, TR = 2300ms, TE = 2.32ms) for anatomical co-registration and normalization.

5.2.4. fMRI task procedure

In each run, 40 stimuli (10 Ingroup/Neutral, 10 Ingroup/Complaint, 10 Outgroup/ Neutral, 10 Outgroup/Complaint) together with 10 blank events were presented in a pseudo-random, fully balanced order (equal number of first-order transitions between each of the 5 event types), and such that the same speaker would not be heard more than two utterances in a row to avoid potential carry-over effects. Each stimulus was presented only once to each participant. Stimuli were presented binaurally via fMRI-adapted, sound-attenuating earbuds covered by foam pads to minimize scanner noise. Sound levels were tested and adjusted for participant comfort during a practice run presenting 4 utterances (not included in the main task). During the presentation of each stimulus, participants viewed a fixation cross on the screen. Immediately after utterance presentation, participants were prompted via an image to evaluate "How hurt the speaker felt" ("À quel point cette personne se sent-elle blessée?") using a 4-point response box attached to their right hand, ranging from "Not at all" ("Pas du tout") on the leftmost button to "Very much" ("Énormément") on the right. Participants were required to answer within a 3.5s window (RT: M = 1.47s, sd = .72s); jitter was naturally introduced between trials by leaving a black screen during the time remaining after the response, with an added fixed ISI of 2.5s. During Blank events, participants viewed a fixation cross during 3-seconds with no auditory stimulus or instruction presented. An example trial is summarized in Figure 5.1.

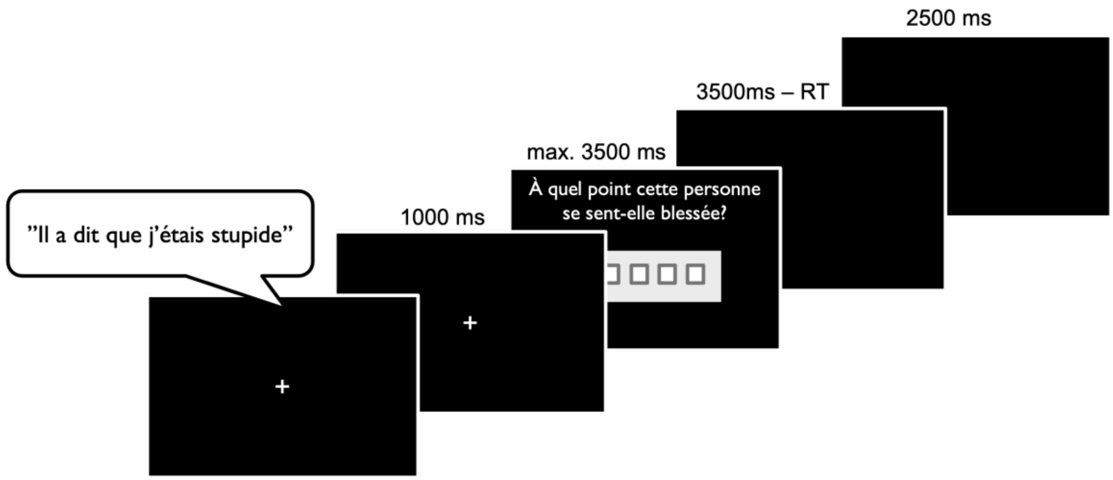

Figure 5.1. Example trial of the fMRI procedure.

5.2.5. fMRI pre-processing and analysis

fMRI volumes were pre-processed and analyzed using SPM12 (www.fil.ion.ucl.ac.uk/spm/). Functional images were spatially realigned to the first volume of the third run, which immediately followed the anatomical scan, and normalized to the Montreal Neurological Institute (MNI) 152 template. Images were then smoothed using a 5mm FWHM kernel.

A whole-brain, full-factorial univariate general linear model (GLM) was applied voxel-wise to the blood-oxygen-level-dependent (BOLD) signal. Single-subject data were analyzed at the first level by modeling each trial a box-car with the onset and duration of the stimulus convolved with the canonical hemodynamic response function, with Accent and Prosody as interacting two-level factors. The perceptual rating was included as a parametric modulator, modeled as an zero-duration event at the onset of the stimuli, to assess activity directly related to participant behavior. To account for potential excess head movement between volumes, motion parameters obtained during realignment were entered as regressors in the model. Mixed-effect analyses were obtained at a second level by performing t-tests on each contrast acquired during the 1st-level analysis of all subjects. Significance levels of resulting images were thresholded at $p < .001$ voxel-wise and FWE-corrected at $p < .05$ cluster-wise.

5.3. Results

5.3.1. Behavioral results

Behavioral responses (i.e., ratings of speaker suffering) were fitted into a linear mixed-effect model using lme4 (Bates et al., 2015) and lmerTest (Kuznetsova et al., 2017) packages in R software (R Core Team, 2018). Accent (ingroup/outgroup) and Prosody (neutral/complaining) were entered as interacting fixed factors, Participant and Statement were added as random factors, and Prosody-by-Participant, Accent-by-Statement, and Prosody-by-Statement were added as random slopes. Ingroup Neutral utterances were chosen as the intercept in the model. The analysis revealed a significant effect of Prosody ($\beta = .97$, se = .14, $t(15.87) = 6.98$, $p < .001$), showing that speakers were judged to be suffering more when producing complaining utterances than neutral ones. There was also a marginal effect of Accent ($\beta = .40$, se = .18, $t(6.77) = 2.27$, $p = .059$), suggesting a strong trend for participants to rate Outgroup speakers as suffering more than Ingroup speakers overall. These results are displayed in Figure 5.2.

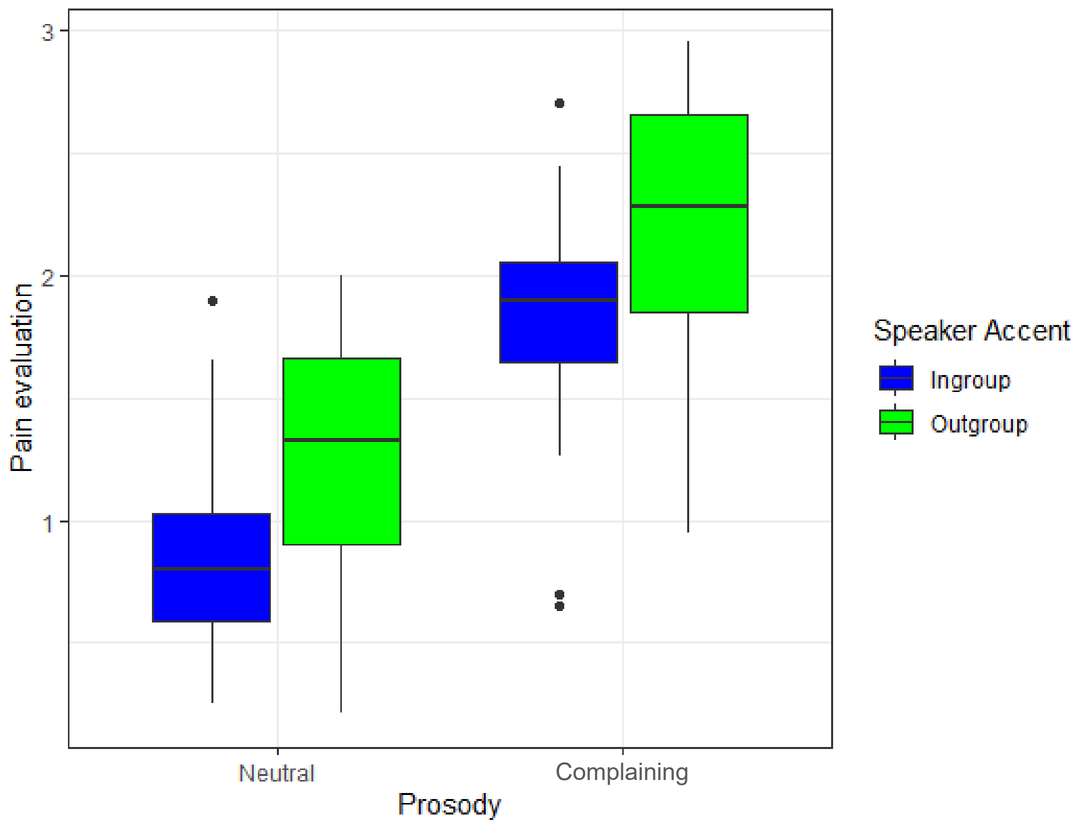

Figure 5.2. Behavioral evaluation of speaker pain according to their prosody and accent.

5.3.2. fMRI results

5.3.2.1. Prosody effects. The main contrast Complaining > Neutral revealed large bilateral activation clusters across the STC, extending posteriorly into auditory cortices and anteriorly into the anterior insulae. The contrast also showed significant bilateral activation of the amygdala, orbitofrontal cortex, mPFC, and vACC, as well as the left TPJ and left precuneus. These results are summarized in Table 1 and Figure 3.

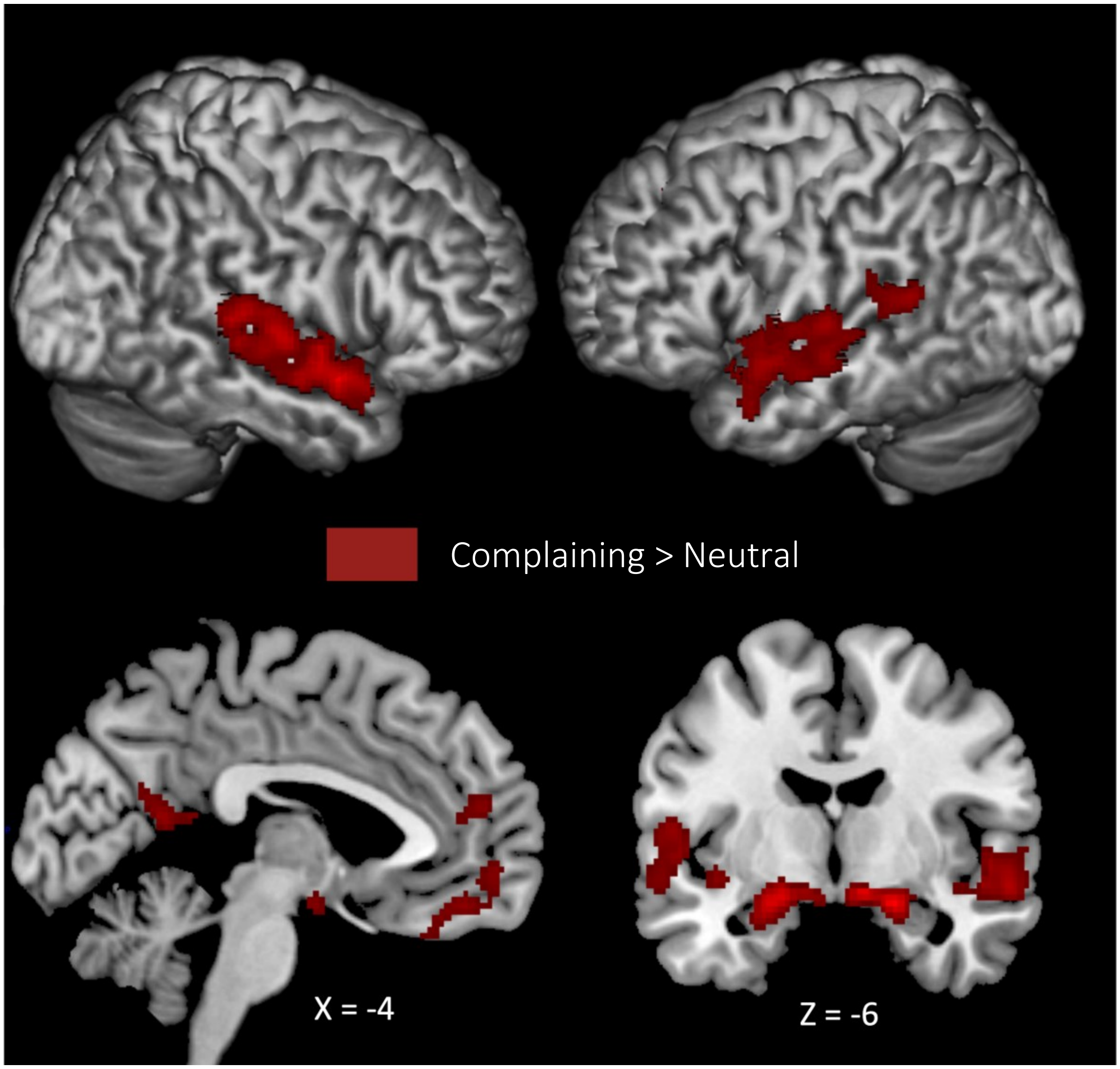

Figure 5. 3. Activation clusters for the prosody contrast

Table 5.1. Activation clusters for the Prosody contrast

Cluster			Peak			MNI coordinates		
Label	p_{FWE}	k	T	Z	p_{unc}	X	Y	Z
Complaining > Neutral								
R STC	<.001	1960	8.90	5.80	<.001	54	6	-10
			7.05	5.09	<.001	58	0	-2
			6.98	5.07	<.001	56	-32	14
R Amygdala	<.001	404	8.90	5.80	<.001	20	-6	-16
			7.80	5.40	<.001	8	-4	-12
			4.85	3.98	<.001	30	-24	-12
L Amygdala	<.001	605	7.53	5.29	<.001	-18	-6	-14
			6.76	4.97	<.001	-30	-20	-12
			5.79	4.50	<.001	-22	-22	-14
L STC	<.001	1007	5.59	4.40	<.001	-58	-20	-4
			5.59	4.40	<.001	-58	4	-6
			5.49	4.34	<.001	-60	-18	8
L Precuneus	.006	170	5.52	4.36	<.001	-6	-56	14
			4.30	3.65	<.001	-12	-56	8
			4.27	3.63	<.001	-16	-48	8
L TPJ	.001	227	5.30	4.24	<.001	-60	-46	18
			4.97	4.05	<.001	-56	-40	14
			3.85	3.35	<.001	-52	-30	26
L+ R OFC	<.001	353	5.23	4.20	<.001	-8	36	-20
			4.98	4.06	<.001	6	40	-18
			4.84	3.98	<.001	-4	46	-16
L+R ACC	.010	156	5.21	4.19	<.001	-8	50	16
			4.13	3.53	<.001	-16	48	10
			3.93	3.40	<.001	4	54	20
L+R MPFC	.009	157	5.05	4.10	<.001	-18	32	38
			4.35	3.68	<.001	-18	22	52
			3.61	3.18	<.001	-24	26	40

5.3.2.2. Accent effects. When assessing effects of accent irrespective of the speaker's manner of prosodic expression, the contrast Ingroup > Outgroup showed bilateral dorsal activation of pre-and post-central gyri covering somatomotor regions (SI/MI, association cortex), supplementary motor areas, as well as a large bilateral cluster in the lingual gyri and extrastriate cortices. The opposite contrast Outgroup > Ingroup instead showed greater activation in the default mode network (PCC, mPFC), bilateral auditory cortex (AC), anterior superior temporal sulcus (STS), bilateral amygdala, and right TPJ. Accent effects are summarized in Table 2 and Figure 4.

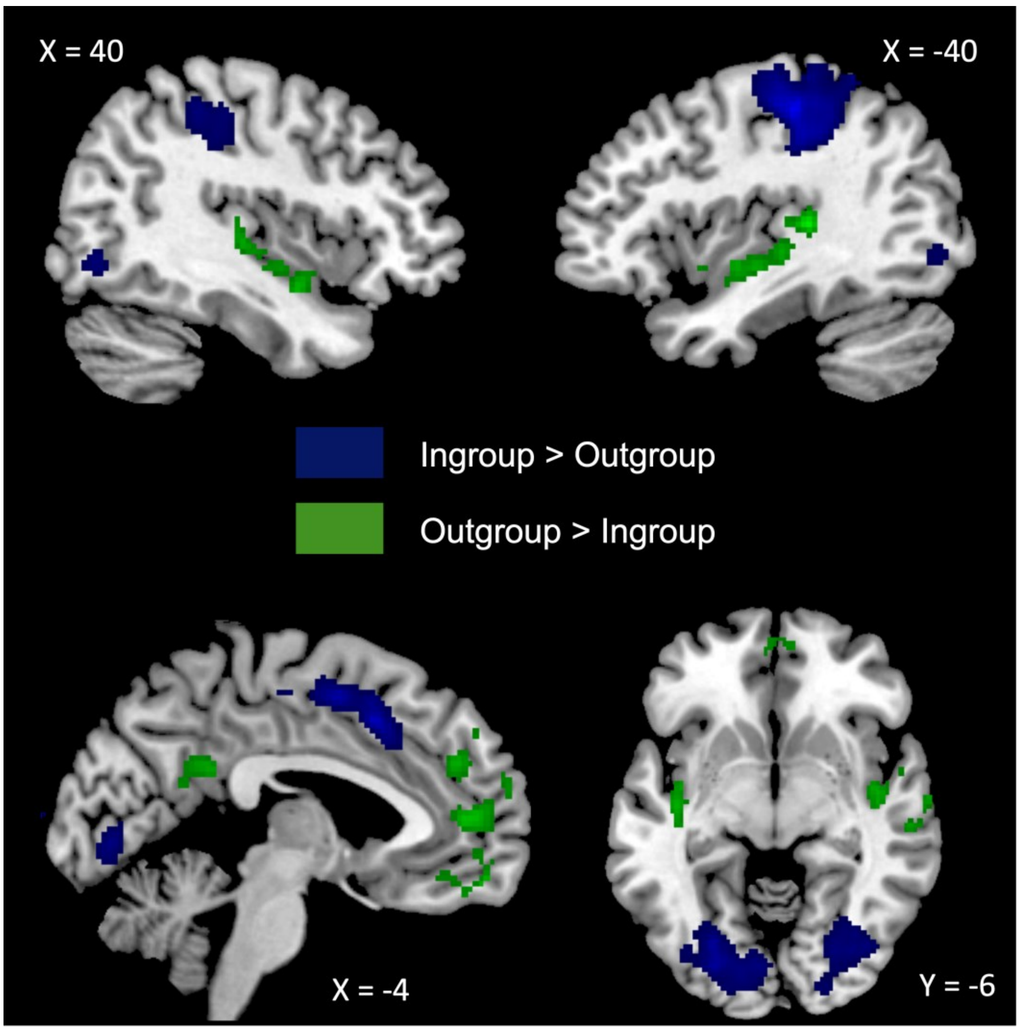

Figure 5.4. Activation clusters for the Accent contrasts

Table 5.2. Activation clusters for the Accent contrasts

Cluster			Peak			MNI coordinates		
Label	p_{FWE}	k	T	Z	p_{unc}	X	Y	Z
			Ingroup > Outgroup					
L SI + MI	<.001	3007	10.84	6.39	<.001	-38	-28	50
			8.76	5.75	<.001	-46	-34	48
			7.50	5.28	<.001	-48	-22	52
R MI	<.001	308	8.11	5.52	<.001	32	-2	48
			3.80	3.31	<.001	30	8	60
L+R SMA	<.001	742	7.75	5.38	<.001	-4	14	44
			7.33	5.21	<.001	-8	2	54
			5.78	4.50	<.001	10	4	50
L+R Lingual gyrus	<.001	2119	7.18	5.15	<.001	-26	-72	-4
			6.43	4.82	<.001	-26	-82	-6
			5.99	4.61	<.001	-8	-80	-2
R SI	<.001	1147	6.77	4.97	<.001	46	-26	46
			6.03	4.62	<.001	12	-62	60
			6.01	4.61	<.001	30	-46	44
			Outgroup > Ingroup					
R AC + amygdala	<.001	621	7.22	5.17	<.001	56	-2	6
			6.17	4.69	<.001	50	-4	-2
			5.03	4.09	<.001	20	-4	-16
R STS	<.001	328	6.95	5.05	<.001	58	-22	8
			6.95	5.05	<.001	48	-30	10
			4.86	3.99	<.001	64	-18	2
L STS	<.001	239	6.56	4.88	<.001	-40	-32	8
			5.01	4.08	<.001	-42	-12	-8
			4.71	3.90	<.001	-40	-22	-2
L+R MPFC	<.001	1055	5.58	4.39	<.001	-16	58	20
			5.49	4.34	<.001	-2	48	8
			5.27	4.23	<.001	4	64	14
R TPJ	.008	149	5.47	4.33	<.001	66	-42	26
			4.09	3.51	<.001	58	-52	26
			3.91	3.39	<.001	54	-44	28
L amygdala	.020	124	5.27	4.22	<.001	-24	-10	-12
			5.15	4.16	<.001	-20	-20	-14
			4.54	3.80	<.001	-18	0	-18

L+R PCC	.025	118	4.72	3.91	<.001	0	-42	20
			4.56	3.81	<.001	-4	-46	26
			3.83	3.33	<.001	4	-32	22
Ingroup(Complaining>Neutral) > Outgroup(Complaining>Neutral)								
No significant cluster								
Outgroup(Complaining>Neutral) > Ingroup(Complaining>Neutral)								
R STC	0.008	116	5.61	4.41	<.001	52	-4	-8
			4.11	3.52	<.001	64	-4	-12
			4	3.45	<.001	62	-2	-2

5.3.2.3. Interaction. The interaction contrast Ingroup [Complaining>Neutral] > Outgroup [Complaining>Neutral] did not reveal any significant activation. Meanwhile, the contrast Outgroup[Complaining>Neutral] > Ingroup[Complaining>Neutral] displayed enhanced activation in the right STS (Figure 5).

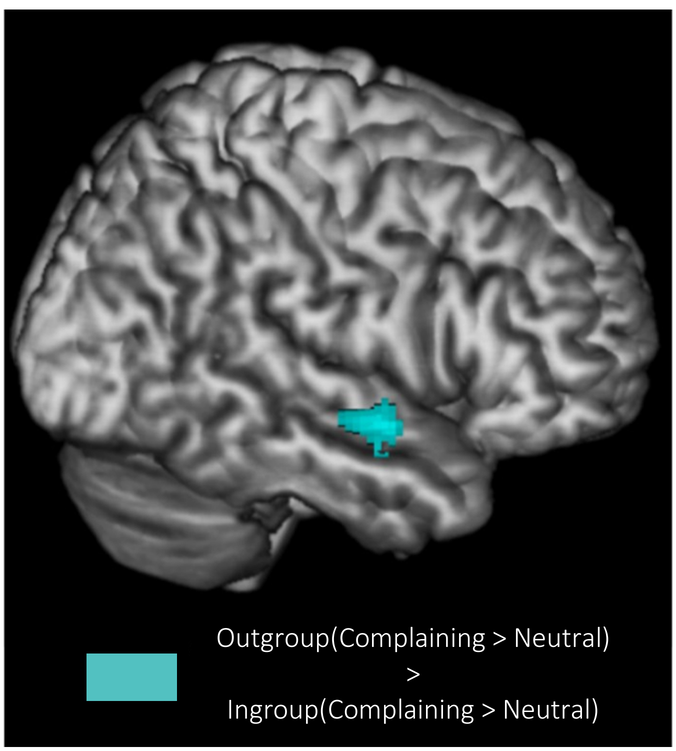

Figure 5.5. Activation clusters for the Accent X Prosody interaction

5.3.2.4. Behavioral effects. The parametric modulation of perceptual ratings revealed that evaluating an utterance as more suffering was associated with increased activation of the salience network (AI, dACC), bilateral TPJ, bilateral orbitofrontal cortices, left amygdala, bilateral lingual gyri and left precuneus (Figure 5.6).

Considering the large overlap between prosody-related and behavior-related activity, the thresholded activation map from the behavioral results was used as an inclusive mask over the Complaint > Neutral contrast. This revealed significant activation of the left TPJ, as well as marginal activation of the left amygdala and left anterior insula. No significant clusters survived when using Accent contrasts as masks. Results for the parametric modulations are summarized in Table 5.3.

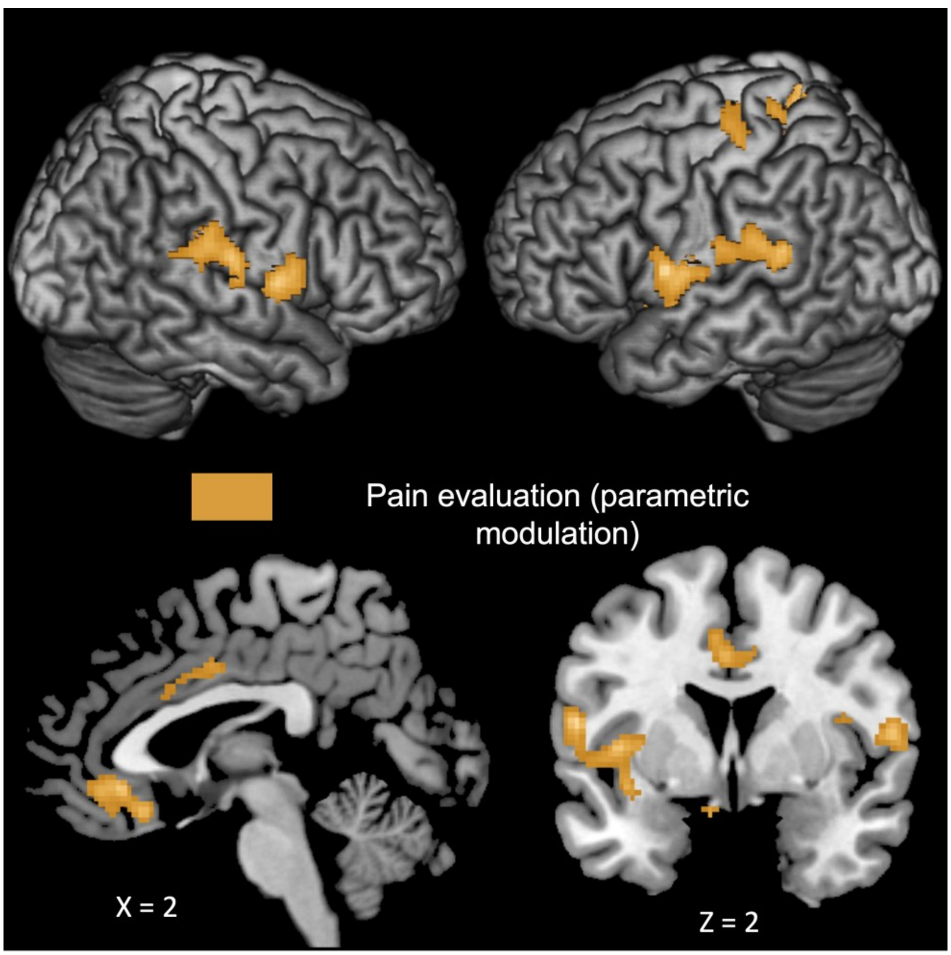

Figure 5.6. Activation clusters for the behavioral parametric modulation

Table 5.3. Activation clusters for the behavioral parametric modulation

Cluster			Peak			MNI coordinates		
Label	pFWE	k	T	Z	punc	X	Y	Z
L precuneus	<.001	559	6.79	4.98	<.001	-12	-44	-6
			6.32	4.76	<.001	-20	-50	6
			5.04	4.10	<.001	-8	-56	28
L TPJ	<.001	428	5.99	4.60	<.001	-50	-42	18
			4.63	3.85	<.001	-46	-48	26
			4.62	3.84	<.001	-60	-32	26
L AI	<.001	527	5.80	4.51	<.001	-56	2	14
			5.32	4.25	<.001	-40	2	4
			5.20	4.19	<.001	-40	6	-8
L Amygdala	.004	199	5.75	4.48	<.001	-6	-4	-18
			5.19	4.18	<.001	-20	-6	-20
			4.10	3.52	<.001	-24	-8	-10
R AI	<.001	507	5.73	4.47	<.001	40	-12	-6
			5.49	4.35	<.001	56	0	8
			4.97	4.05	<.001	36	-12	8
R + L OFC	<.001	434	5.64	4.42	<.001	-6	28	-24
			5.63	4.42	<.001	4	34	-8
			5.14	4.15	<.001	0	24	-16
L precuneus	<.001	309	5.34	4.26	<.001	-8	-48	66
			4.96	4.05	<.001	-6	-48	58
			4.22	3.60	<.001	-24	-40	70
R TPJ	<.001	426	5.29	4.24	<.001	64	-18	20
			4.73	3.91	<.001	66	-28	26
			4.66	3.87	<.001	50	-14	18
R+L dACC	.017	150	4.96	4.05	<.001	-2	0	38
			3.85	3.35	<.001	0	18	24
			3.56	3.15	<.001	10	4	40
R Lingual	.007	179	4.79	3.95	<.001	10	-62	-4
			4.35	3.68	<.001	8	-70	-4
			3.86	3.35	<.001	16	-52	-6
Precentral gyrus	.008	174	4.39	3.70	<.001	-36	-26	60
			4.12	3.53	<.001	-22	-30	54
			3.63	3.19	<.001	-22	-26	70
With Complaint > Neutral mask								
L TPJ	.047	119	5.99	4.60	<.001	-50	-42	18
			4.62	3.84	<.001	-60	-32	26
			4.57	3.82	<.001	-50	-32	26
L amygdala	.080	103	5.19	4.18	<.001	-20	-6	-20
			4.10	3.52	<.001	-24	-8	-10
L AI	.061	111	5.09	4.12	<.001	-54	-2	8

5.4. Discussion

The present results reveal distributed patterns of brain activity underlying the processing of speaker suffering from spoken complaints. Beyond extending knowledge of how empathy-related brain areas respond to emotive speech acts, results highlight that vocal signals reliably evoke processes of affect sharing and mentalizing driven mainly by speech prosody, but also dependent on categorization of a speaker's accent, as described below.

5.4.1. Prosody-driven empathic responses

Complaining prosody, as an ostensive emotive auditory signal, activated the Emotional Voice Areas bilaterally: the greater acoustic expressivity of complaints compared to neutral utterances increased activation in primary auditory cortices, as well as secondary auditory processing across the entire STC (Mauchand & Zhang, 2022; Schirmer, 2018). Coactivation of auditory cortices with bilateral amygdala suggests that complaints are not just acoustically salient, but emotionally relevant to the listener (Pannese et al., 2016). Meanwhile, the combined involvement of amygdala with STC, insula and orbitofrontal regions is known to be associated with in-depth analyses of the affective nature of emotional signals and their contextual implications (Grandjean, 2021). Increased activation of these brain regions implies that prosody acts as a communicative device to elicit the emotive involvement of the listener in complaining interactions (Caffi & Janney, 1994; Selting, 2010). For the speaker, it allows the reconstruction of a strong feeling (suffering) to serve as a communicative act directing the listener's affective state and behavior (Scarantino, 2017). For the listener, it serves as social information that can be processed in a context- and task-relevant manner (Van Kleef, 2009); in this case, when empathizing with the speaker. This finding complements recent neurophysiological data which highlighted the rapid uptake and neural differentiation of prosodic information in a similar set of complaining and neutral utterances, a process which seems to initially *prioritize* emotive vocal information in complaints (Mauchand & Pell, 2022b). Together, these results underline the critical role of prosody in conveying motivationally relevant, affective information that is processed immediately and across multiple levels of perception and affective cognition.

Procedures for evaluating complaining prosody (possibly linked to empathy) extended beyond voice-sensitive areas, as indicated by increased activity in the Theory of Mind network (left TPJ, precuneus, and mPFC) for complaints over neutral utterances. The ToM network is typically involved in mentalizing and intention processing efforts (Lombardo et al., 2010; Molenberghs et al., 2016; Young et al., 2010), usually highlighted in tasks such as the Reading the Mind in the Eyes (Adams et al., 2010; Thye et al., 2018) or false-belief story (Kobayashi et al., 2006; Saxe & Kanwisher, 2003). It has been described as a critical network for *understanding* the feelings of others and to reason about the causes and consequences of those feelings (Schurz et al., 2021). Here, the TPJ in particular appeared to have a critical role in mediating the effect of complaining prosody over participant's impressions of speaker suffering: complaint-related activation in the left TPJ significantly overlapped with its parametric involvement in behavioral responses. While the right TPJ is traditionally more associated to cognitive empathy (Hétu et al., 2012; Mai et al., 2016), the left TPJ has also been shown to directly affect behavioral performance in ToM-related tasks similar to the present experimental design (Kanske et al., 2015;

Samson et al., 2004; Spunt & Adolphs, 2014). Its co-activation with the amygdala in guiding behavior from prosody also suggests that forming impressions about a complaining speaker requires *inferential* processing, not only about the affective content of speech, but about how these cues are linked to the speaker's mental state.

The perception of suffering from speech cues also correlated with activity in the dACC and anterior insula, reaffirming and extending the central role of the salience network in the perception of pain (Jauniaux et al., 2019; Rotge et al., 2015). Whereas the ToM network is often associated with cognitive empathy, salience network activity may reflect a more affective component of the phenomenon, driven by a vicarious experience of other's suffering (Fan et al., 2011). This experience affected behavioral ratings, such that increased signal in the network was associated with higher ratings of speaker pain, as has been reported in several studies. Complaining prosody appeared to partially activate the salience network when compared to neutral speech, marginally overlapping with the parametric modulation of the left anterior insula. This suggestive finding is in line with previous evidence highlighting the role of the AI in the behavioral evaluation of affective prosody (Kanel et al., 2019; Lang et al., 2011; Sachs et al., 2018). Still, it underlies that while the salience network is critical in the empathic processing of suffering from voices, its sensitivity is not limited to prosodic signals and may interface with other characteristics of the attended stimuli. In the present study, all utterances describe an event that involves speaker suffering from various situations, and from various speakers. The parametric activation of the salience network as a function of pain evaluation reveals its sensitivity to stimuli that are salient in the speaker's perspective, rather than specific unidimensional manipulations (Perini et al., 2018).

5.4.2. Accent-bound empathic appraisal

Although the speaker's manner of vocal expression (i.e., complaining prosody) largely governed behavioral decisions and activated "classic" emotion processing and empathy networks regardless of speaker culture, accent-based contrasts revealed noteworthy differences. These patterns strongly suggest that perceived group characteristics (in-group vs. out-group speaker) alter how vocal signals are appraised and evoke different forms of empathic perspectives in the listener.

Building on the dual definition of affective (salience network) and cognitive (ToM) empathy, most studies investigating empathy from a cross-cultural perspective have reported in-group biases in affective empathy, associated with increased ACC and AI activity for in-group pain (Cheon et al., 2010). Interestingly, in the present study listening to in-group speakers did not yield greater brain activity in these areas, nor were they specific to the more "painful" condition of complaining prosody. A first, partial explanation for both of these phenomena (as well as the limited salience network activity in the prosody effect) may reside in the fact that every utterance presented was a description of a painful scenario. The presence of a constant, objective cue for judging speaker pain on every trial could have diminished the effect of in-group voices on impressions of suffering within the salience network. Rather, here in-group voices activated the supplementary motor cortex (SMA), a region adjacent to the ACC. Often grouped with mid- and anterior cingulate, the SMA is strongly associated with affective empathy and has been reported to show greater activity when subjects exhibit racial biases in response to other's suffering (Sheng et al., 2014; Xu et al., 2009). With regards to voice perception, the SMA is critically involved in sensorimotor representations of speech (Froese & González-Grandón, 2019) and high-arousal emotions (S. K. Scott et al., 2010; Wildgruber et al., 2002), and has also been shown to be sensitive to accent-based in-group preferences (Jiang et al., 2018).

The idea that in-group utterance processing involved sensorimotor mechanisms to a greater extent is further suggested by widespread bilateral activity across motor, primary somatosensory, and association cortices. While these areas are not usually associated with acoustic processing, they may suggest a form of mirroring of the speaker's described experience (Baird et al., 2011). Such sensorimotor activity has indeed been reported in empathy for visual pain (Avenanti et al., 2005), but also during imagery from reading (Yang & Shu, 2014) and listening (Froese & González-Grandón, 2019). Hence, sensorimotor resonance is not limited to direct action perception (Landmann et al., 2011); however, it does seem sensitive to in-group biases (Avenanti et al., 2010), and stimulus familiarity and preference (Pereira et al., 2011). The description of speaker suffering in a familiar accent may thus facilitate the vicarious engagement of the listener with that experience, although this does not directly affect their impressions of suffering (C. Chen et al., 2012). This cross modal sensory involvement also appears to extend to visual mental imagery, as suggested by enhanced activity in lingual gyrus and visual cortices (Spence & Deroy, 2013; Yang & Shu, 2014). Additionally, the distribution of the activation pattern for in-group accents across the dorsal attention network may be suggestive of a reactive, stimulus-driven attention, in opposition to the default mode activity shown for outgroup utterances.

Indeed, the processing of an outgroup accent clearly enhanced activity in the mPFC and PCC, two key nodes of the default mode network (DMN) together with the right TPJ.

Although this network is traditionally associated with resting-state activity and reduced cognitive demands (Greicius et al., 2003), growing evidence points to its role in social cognition and ToM (Li et al., 2014; Schurz et al., 2021). Engaging the DMN may reflect self-referential processing (Gusnard et al., 2001), a critical function when forming impressions of others' personality and to predict their behavior (Hassabis et al., 2014; Knyazev et al., 2021). While DMN is often influenced by culture, many studies actually report more *de*activation for out-group compared to in-group empathy (Cheon et al., 2013; Mathur et al., 2012), mentalizing (Adams et al., 2010) as well as during the (non-empathic) processing of accented speech (Hernández et al., 2019), a pattern usually attributed to a more cognitively demanding processing of out-group signals.

The fact that we observed the opposite pattern suggests that outgroup accents did not exact comprehension-related processing costs but may have instead triggered different types of empathic thinking than for members of the ingroup. PCC, mPFC and TPJ are known to be involved during social stereotyping (Contreras et al., 2012; Quadflieg & Macrae, 2011), potentially reflecting the integration of associative memory and propositional beliefs about out-group speakers into their evaluation of outgroup speech (Gawronski & Bodenhausen, 2006; Mauchand & Pell, 2022a). This introspective processing may be the product of the peculiar social context of participants: as recent French immigrants in Québec, their novel exposure and integration to the outgroup can affect their empathic reactions and biases differently than in traditional in- vs. outgroup experimental settings (Zhou et al., 2022). This may also explain the marginal effect of outgroup accent increasing behavioral responses, as a bias-correction mechanism

(Mauchand & Pell, 2022a), although this may also be explained by more emotionally charged utterances from out-group speakers, as described below.

Interestingly, default mode involvement was complemented by increased activity in STC, AC, and right amygdala, with enhanced right AC activity specifically for out-group complaints, a pattern that is already more common when processing unfamiliar accents (Adank et al., 2015; Jiang et al., 2018). This activation of localized portions of the EVAs may also reflect the overall affective expressivity of out-group utterances, as a previous study using similar stimuli revealed that Québécois voices showed pitch variations that conveyed more anger and surprise than French voices (Mauchand & Pell, n.d.). More generally, these results are reflective of the complex distribution of the functional roles carried out by the EVAs when processing emotionally salient and/or relevant stimuli (Frühholz & Grandjean, 2013). Together with DMN involvement, this activity indicates a complex interplay between the acoustic detection of specific cues and stereotype-based cognition when empathizing with out-group voices and complaints.

These accent-based contrasts have shown that while emotive prosody is a reliable signal when empathizing with spoken complaints, accent perception entails a group-specific empathic appraisal of speech signals. In-group perception activates a dorsal stream, which may reflect more reactive and immersive empathic processing, potentially including sensorimotor resonance and mental imagery of the pain expressed in the spoken statements. Meanwhile, out-group processing involves a ventral stream responsible which could be associated to more elaborative, mentalizing efforts based on self-referential intention processing and stereotype-based inference. This distinction shows important overlap with other perspective-based models of empathy which distinguish between the "how" (dorsal stream) and the "why" (ventral stream) of mentalizing (Spunt & Adolphs, 2014). Similarly, adopting an involved empathic perspective has been shown to activate sensorimotor areas, while a more detached perspective preferentially activates TPJ and mPFC (Borja Jimenez et al., 2020). The present results suggest that the perception of accent can determine this change of perspective, and even somewhat alter the behavioral outcome of pain evaluation, although without interfering with the effect of prosody.

5.5. Conclusion

The present study sheds new light on the phenomenon on empathy by describing its occurrence and underlying processes in an example of everyday social interaction: third-party complaints. As intended by complainers, highly expressive and emotive complaining prosodies drove most of the empathic response, activating Emotional Voice Areas and the ToM network which correlated with behavioral impressions of speaker suffering. Results also confirmed the critical role of the salience network in empathic reactions, although not in a prosody-dependent manner. While only showing marginal interferences at the behavioral level, speaker accent appeared to determine the listener's perspective in appraising signals of pain, yielding a more involved, sensorimotor perspective in response to in-group speech and a more detached, mentalizing perspective for out-group voices. Taken together, these results affirm the complex array of sensory, affective, and cognitive mechanisms that underlie the phenomenon of empathy in vocal communication, and how they are dictated by affective signals, social-relational factors, and contextual constraints.

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GENERAL DISCUSSION

The present thesis constitutes a comprehensive investigation of emotive speech processing, with complaints as its focal point and empathy as its framework. Across five chapters, it assessed how vocal signals in complaints are produced, perceived, and processed in the brain, using a robust stimulus set designed and tailored specifically for these research questions. Employing the same stimuli across the whole thesis allowed to keep a clear continuity between experiments despite using a wide range of methods and relying on varied theoretical backgrounds. As a result, while each of these chapters provides a unique, stand-alone perspective on the processing of third-party complaints, consistent patterns emerge from all of them put together. Specific to complaints, this thesis brings experimental acoustic, behavioral, and neuro-cognitive evidence for phenomena that were previously only examined from a pragmatic standpoint. Regarding empathy, it extends the literature beyond visual pain and integrates it within the field of affective speech processing. It also emphasizes the critical role of social-relational factors such as culture, showing how it affects emotive interactions across various levels of human cognition and behavior.

Prosody is a reliable emotive signal

The first element pervading from every single chapter of this thesis is the undeniable role of speech prosody in expressing complaints. When compared to neutral speech, complaining voices showed systematic differences making them acoustically, perceptually, and neurally identifiable. Acoustically, complaints were marked by changes in expressivity across multiple dimensions, especially fundamental frequency parameters related to the perception of pitch. These changes were clearly perceived as defining features of complaining behavior (Chapter 2), but also as markers of various emotions (Chapter 1) and, ultimately, speaker pain (Chapters 3-5). The fact that prosodic signals expressed by speakers so efficiently conveyed their intended affective state to the listeners denote a form of agreement between both parties regarding what a complaint is (Acuña-Ferreira, 2002; Ogden, 2007). In everyday communication, this tacit knowledge is critical for interlocutors to understand when they are engaged in a complaining interaction (Alicke et al., 1992; Drew & Walker, 2009).

Importantly, while listeners perceive pain and other emotions in a complaining speaker's voice, they are clearly aware that the utterances they hear are complaints and not true expressions of pain. In other words, they tacitly accept that what they hear is a reconstructed (but still genuine) form of affect and willingly participate in the interaction by empathizing (Caffi & Janney, 1994; Selting, 1994). These results emphasize that complaining - and by extension, empathy - is a collaborative and interactive phenomenon. When appraising other's feelings, we naturally assume that others are, indeed, feeling. Conversely, when complaining, speakers must assume that listeners will be sensitive to the feelings they express. Prosody hence provides a common interface through which these feelings can be reliably conveyed and be used as social information to fulfill both speakers' and listeners' goals (Scarantino, 2017; van Berkum, 2019; Van Kleef, 2009).

The reliability of prosody in expressing emotivity also transpired from its cross-cultural robustness. Although the perception of accented speech did elicit group-based responses, especially in the brain, it barely altered the effects of prosody in the final, behavioral evaluations of complaints. This is a reminder that complaints, despite being an intentional speech act, remain rooted in a universal basis of affect (Elfenbein & Ambady, 2002; Laukka & Elfenbein, 2020). Indeed, they are meant to efficiently communicate suffering to a wide social range (Boxer, 1993); social and cultural display rules are but variations on a "core" ruleset based on a genuine expression of pain that anyone can access (Lautenbacher et al., 2017; Raine et al., 2019; Rao, 2013). This access may be more or less difficult, and in-group facilitation does occur for signals that are more familiar. However, in these experimental tasks, which were not meant to be particularly demanding or deceiving (as would complaints be in a natural setting), this facilitation was only really visible at the neural level.

Prosody drives empathic responses to complaints

The fact that listeners are "aware" of the nature of complaints and of what is expected from them does not make them cold and distant emotion recognition devices. It does, however, motivate their attention towards signals that are relevant to the task at hand, which is to detect suffering and empathize. This was indexed by nearly immediate affective responses at the onset of complaints in the ERP experiment, paralleled by strong activations of the emotional voice areas (EVAs) and the salience network in the fMRI experiment. These results bring together recurrent patterns from two research fields. On one hand, they show clear similarities with the "affective" components of empathy: in ERPs, the early immediate responses associated with an initial, automatic appraisal of pain (J. Chen et al., 2020; Fan & Han, 2008; Galang et al., 2021; Sessa, Meconi, & Han, 2014); in fMRI, the "core empathy network" and affect-sensitive regions (Fan et al., 2011; Jauniaux et al., 2019; Lamm et al., 2011). On the other hand, they are perfect exemplars of responses to motivationally and emotionally relevant signals in speech perception: P200/EPN in ERPs (Jaspers-Fayer et al., 2012; Mittermeier et al., 2011; Paulmann et al., 2011; Steber et al., 2020), and EVAs in fMRI (Ethofer et al., 2012; Grandjean, 2020; Mauchand & Zhang, 2022). Together, they suggest that affective empathic responses to complaints are founded on prosody-sensitive neural systems.

Emotive voices also elicited brain patterns related to more inferential processes. In ERPs, they appeared as late effects in meaning resolution stages, at utterance onset but also during the semantic and pragmatic processing of lexical information (Aurnhammer et al., 2021; Meconi et al., 2018; Paulmann et al., 2013). In fMRI, they were indicated by the mobilization of the Theory of Mind (ToM) network, often associated to cognitive empathy (Cheon et al., 2011; Schurz et al., 2021), and more generally recruited during intention processing and mentalizing efforts across several modalities, including speech (Lombardo et al., 2010; Molenberghs et al., 2016; Young et al., 2010). Similar to earlier effects, the late "cognitive" components of traditional empathy models collide with well-known brain patterns in speech processing. These patterns further confirm that complaining prosody is more than a simple salience marker and conveys critical social information that engage sustained and continuous inferential efforts about how the speaker feels (Ong et al., 2018; Scarantino, 2017; Van Kleef, 2009). Such empathic efforts are, in the case of complaint perception, rooted in our discourse processing abilities, and depend on contextual demands, individual empathic and social skills, and - as will be discussed later - culture.

These patterns suggest that while empathy is ultimately motivated by a common ground - an ability to project ourselves and access others' feelings, its proximate bases are underpinned by mechanisms that depend on the modality of perception (Preston & de Waal, 2002) - in this case, emotive speech. Neural responses to emotive speech conceptually align within the framework of empathy, highlighting affective and cognitive responses that are temporally and spatially comparable to responses to visual pain, social exclusion, or misery. Yet, when observed in isolation, many of these responses find their source within speech-specific processes (P200, N400, EVAs, etc.). In other words, empathy does not have a discrete, transient neural signature but manifests itself in a modality- and context-dependent manner.

One can complain about anything

The studies discussed above have revealed a relatively unique aspect of empathy: when attending to another's pain, subjective impressions of their affective state are more important that objective descriptions of their pain. While this phenomenon has been at the core of the pragmatic literature on complaints (Alicke et al., 1992; Boxer, 1993), it is seldom discussed in empathy research; the present thesis is the first to provide experimental evidence in this regard.

The primacy of the speaker's subjective state over the real cause of its pain was first evident from behavioral results: complaining prosody yielded much greater effects than content manipulations when assessing both complaining behavior and speaker suffering. Hence, innocuous topics described in a complaining voice were found to be more complaining and more hurtful than painful topics described neutrally. These results may seem somewhat peculiar; in speech perception research, prosody has often been relegated as a secondary stream, as verbal content usually offers more tangible and concrete information for listeners. Several multimodal investigations of speech thus report minimal effects of prosody compared to semantics (Deliens et al., 2018; Regel et al., 2011; Regenbogen, Schneider, Gur, et al., 2012; Wambacq & Jerger, 2004), even when targeting empathy (Regenbogen, Schneider, Finkelmeyer, et al., 2012). More recently, however, new research perspectives have been considering prosody not as collateral information but as an interpersonal window into other's feelings and intentions beyond the content of their speech (for a review, see Pell & Kotz, 2021). In the light of these perspectives, the present results show that when attending to speaker pain, listeners favor prosodic signals which directly indicate how the speaker feels, even if they may be less precise than verbal information on how they *should* feel. Still, speech content does hold a significant weight and - as shown in Chapter 2 - remains a useful signal when prosodic appraisal fails.

Neurophysiological data further explain how prosody supersedes content in complaint processing. Evidence from Chapter 3 shows that prosody is the very first emotive signal that listeners can access, much earlier than any relevant lexical information. By the time this information is explicitly provided, listeners have already formed an impression of the speaker's emotivity, thus constraining interpretation processes towards a feeling of pain, as described in Chapter 4. As such, innocuous events, whose meaning should be more demanding to retrieve in a pain evaluation context, are more easily processed (Brouwer et al., 2017; Delogu et al., 2019). This echoes observations that complaints can be about any topic and shows once more that empathy is not an exceptional phenomenon reserved for extreme contexts but a daily, mundane occurrence which fuels our social interactions.

Speaker accent determines culture-based empathic perspectives

Feeling empathy for our peers can allow our *rapprochement* and strengthen affiliative bonds; reciprocally, our empathic abilities emerge from, and are modulated by, our capacity to perceive similarity and proximity between us and others (Cheon et al., 2010; Hollan, 2012). Complaints are not excluded from this back-and-forth interplay: they are critical relationship building tools over a wide range of social contexts, and social distance can affect how they are perceived (Boxer, 1993; Edwards, 2005; Selting, 2010). In the present thesis, this was materialized by a cultural grouping based on speaker accent, whose effects were most visible at the neural level.

Most cultural models of empathy describe a direct modulation of traditional empathic components in the form of an on/off switch: when perceiving out-group pain, cultural (usually racial) biases appear to reduce or block affective (and sometimes cognitive) empathic responses that are otherwise found for in-group pain (Cheon et al., 2011; Sessa, Meconi, Castelli, et al., 2014; Xu et al., 2009). Evidence from Chapters 3 to 5 somewhat departs from these models by suggesting that speaker accents affect complaint perception at a higher order of abstraction. In the ERP experiment, in- and out-group accents yielded distinct prosody-driven empathic time-courses, highlighting that out-group complaints did elicit early responses, although different from in-group, and also required additional empathic efforts. In the fMRI experiment, accent had a more global effect mostly irrespective of prosody, with greater sensorimotor resonance for in-group voices and elaborative mentalization processes for out-group. These results suggest that out-group accent perception was not associated with an absence of certain empathic processes, but rather by a general change in perspective that affected how emotive signals were appraised.

Before continuing, it is important to address a major difference between the ERP and fMRI experiments: while the former showed mostly interactive effects of accent and prosody, the latter suggested a prosody-independent main effect of accent. These differences may have methodological explanations: each experiment involved different participant samples, slightly different stimulus sets, used different analyses techniques, etc. However, there is a more fundamental distinction between the two sets of results: they simply do not reflect the same thing. While ERP showed specific processes at specific critical moments of utterances, fMRI revealed activity for the utterance as a whole, making their results not contradictory, but complementary. During early stages of voice perception, competing cues of identity and emotivity naturally interact in complex manners, such that listeners allocate attentional resources to immediately relevant stimulus features; this explains why early accent effects are only visible for complaining voices. As the utterance unfolds (Chapter 4), and when interpreted wholly (Chapter 5), information about prosody and accent is better categorized, and their role becomes more visible: the former drives empathic responses, while the latter determines empathic perspectives.

These accent-based changes in perspective may be explained by two intertwined phenomena: familiarity and social identity perception. In-group voices being more familiar, they elicit motivated attention (Jiang et al., 2020), reduce cognitive demands during interpretation (Regel et al., 2010), and facilitate a more immersive, stimulus-driven projection into speaker's feelings. Meanwhile, unfamiliar accented voices require a slower, more inferential appraisal of emotive signals (Laukka & Elfenbein, 2020; Thierry et al., 2015). This is exacerbated by social categorization processes: emotive signals are not perceived at face value, but through the lens of associative and propositional inferences made about out-group speakers (Billig & Tajfel, 1973; Gawronski & Bodenhausen, 2006). Importantly, this does not necessarily reflect a "negative" bias; in the present case, the population of interest show positive propositional beliefs about the outgroup, potentially due to their immigrant status within the outgroup (Mauchand & Pell, 2022a). This may explain sustained empathic efforts and marginally greater impressions of pain in certain cases (Sheng & Han, 2012; Zhou et al., 2022).

Limitations and future directions

As a multidisciplinary and exploratory approach, the present thesis takes on novel perspectives and provides unique data that may create more questions than it provides answers. Combining backgrounds and methods from several research disciplines naturally requires compromising, choosing, and loosening criteria while narrowing others. Across these chapters, it allowed to for a rich framework for an extensive investigation of complaint processing; still, it came with a few limitations that ought to be noted.

One such limitation arises from adopting a somewhat reductionist approach of complaints. In order to create a robust and consistent stimulus set, it was necessary to restrict the definition of complaints to single utterance. This leaves out an important interactional aspect of complaining, which is usually carried out cooperatively across extensive sequences of conversation. While the present experiments provide initial "core" evidence on how complaints are processed, further research is required to develop how these results extend to more complex contexts of natural discourse. In particular, evidence suggests that affiliation in not always immediate from the first expression of a complaint; negotiating this affiliation may engage new forms of empathic processes that a single utterance would not be sufficient to elicit. Complaining can also convey other feelings, such as moral indignation or dissatisfaction, that may involve different interactional and neural processes from those investigated.

Other related limitations may include concerns about the ecological validity of the experimental paradigms presented in the thesis. On the one hand, speakers were producing short, acted utterances that may not reflect their natural emotional speech, as is often the case in emotion expression experiments. On the other hand, listeners were presented these utterances without context, and asked to perform a rating task. While these issues are almost always unavoidable in this type of research, the present study already takes a step forward in solving them - or rather, circumventing them by taking advantage of the nature of complaints. While acted-out, posed emotions are often very different from genuine emotional expressions, complaints are by nature reconstructed and “acted-out”, which makes our experimental utterances closer to real complaints. At the same time, real-life recipients of complaints are tacitly required to pay attention and evaluate the suffering of the complainer, much like the listeners in the presented experiment. Still, novel paradigms using richer contexts, different task demands, and more natural settings would extend these initial findings to more applicable and relatable scenarios.

The cross-cultural paradigm presented throughout the thesis is limited by its incompleteness. Indeed, from Chapter 3 on, only one side of cultural effects is investigated, leaving out Québécois listeners to focus on French listeners. This choice, made necessary by research restrictions during the development of the thesis, allowed more thorough analysis of simpler analysis models; however, it left some results up to speculation on whether they were specific to the population of interest (recent French immigrants in

Canada), or generalizable to other groups. Reproducing these experiments on Québécois listeners would allow a more global picture of cultural effects, determining the relative role of each accent, comparing how each group perceive in- and out-group accent and how it may depend on various biases, stereotypes, status, and familiarity. Extending these paradigms to other populations (e.g., non-immigrant French, Canadian English, other linguistic groups) would also be informative directions for future research. The limited sample of speakers, although already larger than most similar studies, also questions how representative the culture effects in complaint production (and perception) are for each cultural group. More generally, reproducibility of these results over larger samples would be necessary to support the robustness of the discussed interpretations.

Conclusion

The present thesis provides extensive, multi-disciplinary evidence on how emotive speech such as complaining is produced, perceived, and processed in the brain. At the neural level, complaints elicit affective and cognitive empathic processes primarily through the expressive use of prosody. Emotive prosody is detected early on, continuously analyzed, and constrains the processing of other upcoming information. Meanwhile, vocal cues about speaker identity, such as accent, determines in a more indirect manner how vocal signals are appraised through group-specific neural routes. At the behavioral level, listeners use prosody to form impressions of complaints, emotions, and suffering, even when the speaker's pain is not obvious from lexical information. At the interaction level, emotive signals provide bivalent affective and social information allowing speakers to efficiently convey their affective state, and listeners to access this state through empathy-based but prosody-driven mechanisms. Overall, this thesis emphasizes the critical role of the voice in our daily social interactions, communicating and shaping the way that we feel.

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APPENDIX

Table A1. Sentences constructed for the thesis with English translations (all chapters). Only the bolded final words differed between the Pain and Control version of one sentence root.

Experimental Stimuli		*English translation*	
Pain	Control	*Pain*	*Control*
Ils ont tout fait sans **moi**	Ils ont tout fait sans **boire**	*They did everything without me*	*They did everything without drinking*
Ils sont partis sans **moi**	Ils sont partis sans **barque**	*They left without me*	*They left without a boat*
Ils m'ont demandé de **partir**	Ils m'ont demandé de **rester**	*They asked me to leave*	*They asked me to stay*
Ils refusé de venir chez **moi**	Ils ont refusé venir chez **Marc**	*They decided not to come to my place*	*They decided not to come to Marc's*
Ils ont refusé **m'inviter**	Ils ont refusé de **mélanger**	*They refused to invite me*	*They refused to stir*
Ils ont décidé de pas **m'inviter**	Ils ont décidé de pas **mélanger**	*They decided not to invite me*	*They decided not to stir*
Ils ont décidé de pas jouer avec **moi**	Ils ont décidé de pas jouer avec **Marc**	*They decided not to play with me*	*They decided not to play with Marc*
Ils ont décidé d'y aller sans **moi**	Ils ont décidé d'y aller sans **masques**	*The decided to go without me*	*They decided to go without masks*
Il m'a choisi en **dernier**	Il m'a choisi en **deuxième**	*He chose me last*	*He chose me in second*
Elle veut que personne **m'aime**	Elle veut que personne **marche**	*She wants no one to like me*	*She wants no one to walk*
Il me parle **jamais**	Il me parle jeudi	*He never talks to me*	*He talks to me thursday*
Elle a profité de **moi**	Elle a profité de **l'offre**	*She took advantage of me*	*She took advantage of the sale*
Il m'a fait **pleurer**	Il m'a fait **parler**	*He made me cry*	*He made me talk*
Elle m'a répondu **méchamment**	Elle m'a répondu **normalement**	*He answered me harshly*	*He answered me normally*
Elle a dit qu'elle m'aimait **pas**	Elle a dit qu'il m'aimait **bien**	*She said he didn't like me*	*She said he appreciated me*
Il veut vraiment pas de **moi**	Il veut vraiment pas de **masque**	*He really doesn't want me*	*He really doesn't want a mask*
Elle continue de **m'ignorer**	Elle continue de **mesurer**	*She keeps ignoring me*	*She keeps measuring*
Il a dit que j'étais **stupide**	Il a dit que j'étais **sorti**	*He said I was stupid*	*He said I went out*
Elle a dit que j'étais **sale**	Elle a dit que j'étais **jeune**	*She said I was dirty*	*She told me I was young*
Il a dit que j'étais **gros(se)**	Il a dit que j'étais **grand**	*He said I was fat*	*He said I was tall*
Elle pense que je suis **mauvaise**	Elle pense que je suis **bronzé**	*She thinks I am bad*	*She thinks I am tan*
Ils pensent que je suis **méchant(e)**	Ils pensent que je suis **belge**	*They think I am mean*	*They think I am belgian*
Elle pense que je suis **peureux (se)**	Elle pense que je suis **parti(e)**	*Shee thinks I am scared*	*She thinks I am gone*
Il pense que je suis **faible**	Il pense que je suis **fier**	*He thinks I am weak*	*He thinks I am proud*
Ils font des blagues sur **moi**	Ils font des blagues sur **Mars**	*They made jokes about me*	*They make jokes about Mars*
Ils font des blagues sur **mon poids**	Ils font des blagues sur **Montréal**	*They make jokes about my weight*	*They make jokes about Montreal*
Elle déteste **mon idée**	Elle déteste **mélanger**	*She hates my idea*	*She hates stirring*
Il m'a fait passer pour un **fou**	Il m'a fait passer pour un **frère**	*He made me look like madman*	*He made me look like a brother*
Elle m'a donné une **claque**	Elle m'a donné une **glace**	*Shee gave me a slap*	*She gave me an ice cream*
Il m'a donné un coup de **pied**	Il m'a donné un coup de **main**	*He gave me a kick*	*He gave me help*
Il m'empêche de **m'amuser**	Il m'empêche de **glisser**	*He prevents me from having fun*	*He rpevents me from slipping*
Elle m'empêche de **dormir**	Elle m'empêche de **tomber**	*She prevent me from sleeping*	*She prevents me from falling*
Il continue de me **mentir**	Il continue de me **montrer**	*He keeps lying to me*	*He keeps showing me*
Elle continue de **m'insulter**	Elle continue de **mélanger**	*She keeps insulting me*	*She keeps stirring*
Il a marché sur **mon chien**	Il a marché sur **mon chemin**	*He stepped on my dog*	*He stepped on my path*
Elle a marché sur **ma main**	Elle a marché sur **ma route**	*She stepped on my hand*	*She stepped on my road*
Il a frappé **ma jambe**	Il a frappé **ma balle**	*He kicked my leg*	*He kicked my ball*
Elle a pris **ma place**	Elle a pris **ma main**	*She took my spot*	*She took my hand*
Il m'a fait **tomber**	Il m'a fait **comprendre**	*He made me fall*	*He amde me understand*
Elle veut me faire **rater**	Elle veut me faire **rester**	*She wants to make me fail*	*She wants to make me stay*
Il essaye de **m'énerver**	Il essaye de **mesurer**	*He's trying to annoy me*	*He's trying to measure*

Table A2. Summary tables of the linear mixed-effect models for each examined acoustic parameter (Chapter 1). Factors are centered such that for Prosody, Neutral = -.5 and Complaint = .5, and for Culture, French = -.5 and Québécois = .5.

Parameter	Factor	Estimate	SE	t	p
F0 M	(Intercept)	32.56	1.96	16.59	<.001
	Prosody	5.58	.15	36.73	<.001
	Culture	1.16	3.92	.30	.777
	Prosody:Culture	-.60	0.30	-1.98	.048
F0 SD	(Intercept)	.11	$7.03*10^{-3}$	15.50	<.001
	Prosody	.02	$3.56*10^{-3}$	5.82	<.001
	Culture	.01	$1.14*10^{-3}$	.55	.606
	Prosody:Culture	.02	$7.12*10^{-3}$	2.47	.014
F0 range	(Intercept)	4.62	.25	18.22	<.001
	Prosody	2.22	.19	11.94	<.001
	Culture	1.38	.42	3.25	.018
	Prosody:Culture	2.35	.37	6.32	<.001
Loudness M	(Intercept)	.20	$1.53*10^{-2}$	12.84	<.001
	Prosody	.02	$.27*10^{-2}$	6.16	<.001
	Culture	-.02	$3.03*10^{-2}$	-.62	.559
	Prosody:Culture	-.01	$.55*10^{-2}$	-2.13	.034
Loudness SD	(Intercept)	.58	$1.24*10^{-2}$	46.91	<.001
	Prosody	.03	$.55*10^{-2}$	4.74	<.001
	Culture	.10	$1.66*10^{-2}$	6.23	.002
	Prosody:Culture	.02	$1.09*10^{-2}$	1.63	.104
HNR	(Intercept)	8.18	.82	9.98	<.001
	Prosody	1.78	.09	20.43	<.001
	Culture	-.37	1.62	-.23	.827
	Prosody:Culture	-1.49	.17	-8.52	<.001
Jitter	(Intercept)	$4.18*10^{-2}$	$4.37*10^{-3}$	9.57	<.001
	Prosody	$-.03*10^{-2}$	$1.52*10^{-3}$	-.18	.859
	Culture	$.45*10^{-2}$	$8.37*10^{-3}$	.54	.610
	Prosody:Culture	$1.07*10^{-2}$	$3.03*10^{-3}$	3.53	<.001
Shimmer	(Intercept)	1.13	.09	12.42	<.001
	Prosody	-.17	.02	-9.00	<.001
	Culture	.04	.17	.25	.814
	Prosody:Culture	.13	.04	3.62	<.001

Parameter	Factor	Estimate	SE	t	p
F1 M	(Intercept)	527.80	20.19	26.14	<.001
	Prosody	28.41	3.82	7.43	<.001
	Culture	-16.24	39.73	-.41	.697
	Prosody:Culture	29.21	7.65	3.82	<.001
Hammarberg index	(Intercept)	30.66	.63	48.78	<.001
	Prosody	-.57	.20	-2.84	.005
	Culture	-2.88	1.19	-2.42	.053
	Prosody:Culture	-.11	.40	-.29	.776
Spectral Slope 500-1500Hz	(Intercept)	$-19.6*10^{-3}$		-14.10	<.001
	Prosody	$1.79*10^{-3}$	$.29*10^{-3}$	6.21	<.001
	Culture	$2.09*10^{-3}$	$2.71*10^{-3}$	.77	.470
	Prosody:Culture	$3.20*10^{-3}$	$.58*10^{-3}$	5.56	<.001
Number of voiced segments per second	(Intercept)	3.21	.16	20.38	<.001
	Prosody	-.16	.05	-3.11	.002
	Culture	-.01	.25	-.04	.972
	Prosody:Culture	.21	.10	2.04	.042
Mean voiced segment length	(Intercept)	.25	.02	16.11	<.001
	Prosody	.01	.01	1.94	.053
	Culture	-.04	.02	-1.89	.120
	Prosody:Culture	-.02	.01	-1.85	.065
Mean unvoiced segment length	(Intercept)	$9.13*10^{-2}$	$.69*10^{-2}$	13.29	<.001
	Prosody	$.92*10^{-2}$	$.23*10^{-2}$	4.09	<.001
	Culture	$1.73*10^{-2}$	$1.28*10^{-2}$	1.35	.228
	Prosody:Culture	$.28*10^{-2}$	$.45*10^{-2}$	.61	.542
Duration	(Intercept)	1.34	.08	16.85	<.001
	Prosody	.08	.01	6.03	<.001
	Culture	.21	.15	1.40	.212
	Prosody:Culture	-.12	.03	-4.65	<.001
Final word duration	(Intercept)	.46	$2.45*10^{-2}$	18.9	<.001
	Prosody	.07	$.80*10^{-2}$	9.2	<.001
	Culture	.08	$4.13*10^{-2}$	1.9	.114
	Prosody:Culture	.00	$1.60*10^{-2}$	.00	.986

Table A3. Summary tables for the linear mixed-effects models for each emotion in the Emotional Association task (Chapter 1). Factors are centered such that for Prosody, Neutral = -.5 and Complaint = .5, and for ListenerCulture and SpeakerCulture, French = -.5 and Québécois = .5.

Emotion	Factor	Estimate	SE	t	p
Anger	(Intercept)	1.80	0.31	5.89	<.001
	Prosody	1.33	0.09	14.13	<.001
	ListenerCulture	0.19	0.23	0.84	0.408
	SpeakerCulture	1.57	0.57	2.74	0.026
	Prosody:ListenerCulture	-0.10	0.19	-0.53	0.595
	Prosody:SpeakerCulture	0.63	0.19	3.37	0.001
	ListenerCulture:SpeakerCulture	0.41	0.19	2.19	0.028
	Prosody:ListenerCulture:SpeakerCulture	0.40	0.38	1.06	0.288
Sadness	(Intercept)	2.54	0.23	11.25	<.001
	Prosody	1.07	0.12	9.15	<.001
	ListenerCulture	-0.38	0.35	-1.08	0.287
	SpeakerCulture	-0.71	0.31	-2.30	0.052
	Prosody:ListenerCulture	0.00	0.23	-0.01	0.993
	Prosody:SpeakerCulture	-0.65	0.23	-2.78	0.006
	ListenerCulture:SpeakerCulture	-0.06	0.23	-0.26	0.797
	Prosody:ListenerCulture:SpeakerCulture	0.33	0.47	0.70	0.483
Surprise	(Intercept)	1.53	0.23	6.68	<.001
	Prosody	2.34	0.09	26.28	<.001
	ListenerCulture	0.04	0.27	0.13	0.897
	SpeakerCulture	0.44	0.38	1.17	0.277
	Prosody:ListenerCulture	0.03	0.18	0.16	0.870
	Prosody:SpeakerCulture	0.50	0.18	2.81	0.005
	ListenerCulture:SpeakerCulture	-0.13	0.18	-0.75	0.454
	Prosody:ListenerCulture:SpeakerCulture	-0.30	0.36	-0.84	0.400
Fear	(Intercept)	0.24	0.05	4.62	<.001
	Prosody	0.32	0.04	7.70	<.001
	ListenerCulture	-0.04	0.08	-0.42	0.674
	SpeakerCulture	-0.04	0.07	-0.58	0.578
	Prosody:ListenerCulture	-0.06	0.08	-0.70	0.487
	Prosody:SpeakerCulture	0.01	0.08	0.15	0.882
	ListenerCulture:SpeakerCulture	0.05	0.08	0.55	0.585
	Prosody:ListenerCulture:SpeakerCulture	0.00	0.17	0.00	1.000
Disgust	(Intercept)	1.11	0.16	6.94	<.001
	Prosody	0.45	0.07	6.09	<.001
	ListenerCulture	-0.62	0.29	-2.10	0.042

	SpeakerCulture	0.55	0.15	3.78	0.006
	Prosody:ListenerCulture	-0.10	0.15	-0.66	0.507
	Prosody:SpeakerCulture	0.56	0.15	3.80	<.001
	ListenerCulture:SpeakerCulture	0.07	0.15	0.49	0.621
	Prosody:ListenerCulture:SpeakerCulture	0.28	0.30	0.95	0.344
Happiness	(Intercept)	0.02	0.01	2.03	0.05
	Prosody	0.00	0.01	-0.25	0.80
	ListenerCulture	0.00	0.02	-0.16	0.88
	SpeakerCulture	0.02	0.01	1.90	0.06
	Prosody:ListenerCulture	-0.06	0.03	-2.40	0.02
	Prosody:SpeakerCulture	0.03	0.03	1.07	0.28
	ListenerCulture:SpeakerCulture	-0.03	0.03	-1.24	0.22
	Prosody:ListenerCulture:SpeakerCulture	-0.07	0.05	-1.41	0.16

Figure B1. Correlation between participant's D-scores on the Implicit Association Test (IAT) and PCA loadings of the EPN for Ingroup Complaints (Chapter 3). A higher D-score suggests greater ingroup positive bias / outgroup negative bias.

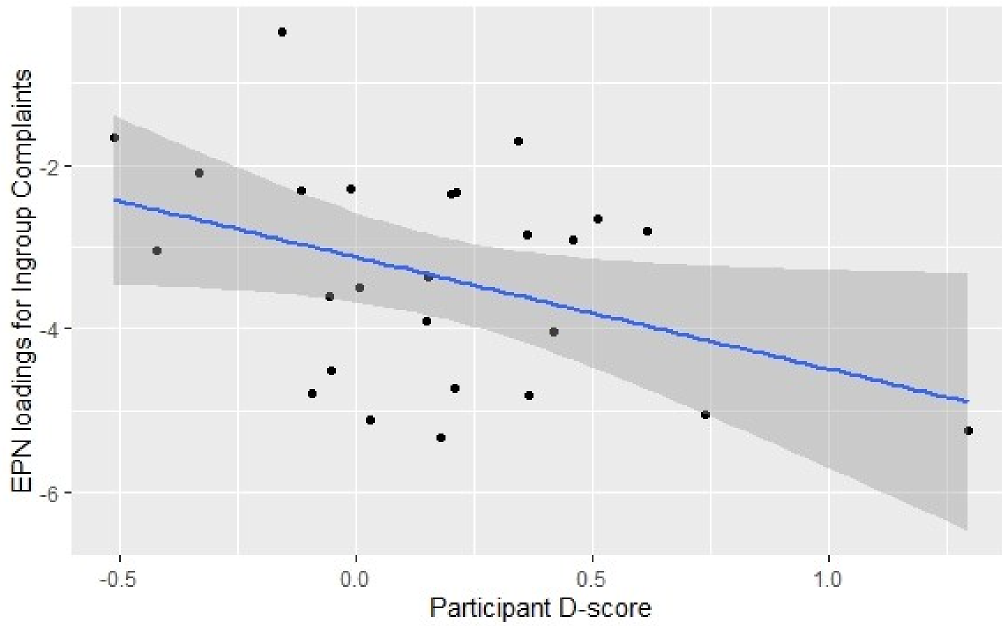

Figure B2. Correlation between participant scores on the Perspective-Taking subscale of the Interpersonal Reactivity Index (IRI) and PCA loadings of the N400 for Ingroup Complaints (Chapter 3). A higher score suggests greater perspective-taking abilities.

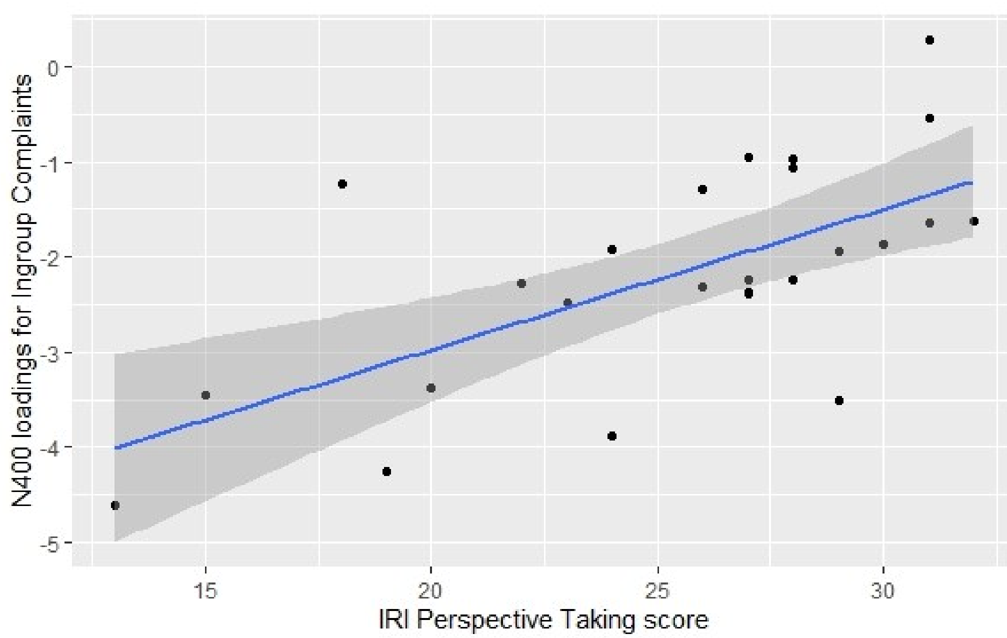

Figure B3. Correlations between N400 loadings and behavior.
Top left: Correlation between PCA loadings of the N400 for Outgroup Complaints and behavioral ratings for Outgroup Complaints.
Top right: Correlation between PCA loadings of the N400 for Outgroup Complaints and behavioral ratings for Ingroup Complaints.
Bottom: Correlation between PCA loadings of the N400 for Ingroup Complaints and behavioral ratings for Outgroup Complaints.

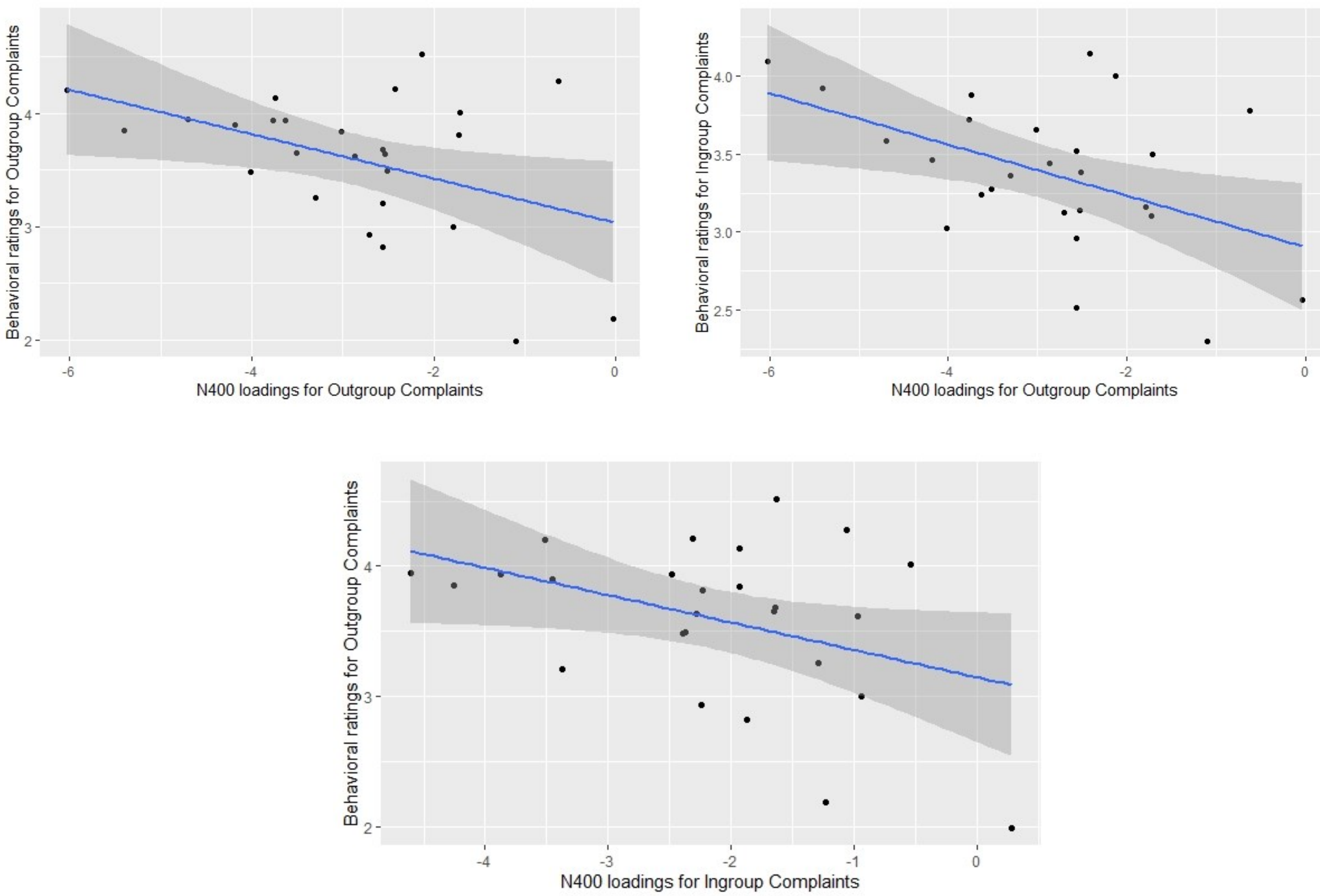

Figure C1. ERP-PCA waves and topographic maps showing the effects of Accent, Prosody, and Statement on factor TF5SF2 (N400). Top: Prosody and Statement effects for utterances produced by Ingroup speakers. Bottom: Prosody and Statement effects for utterances produced by Outgroup speakers.

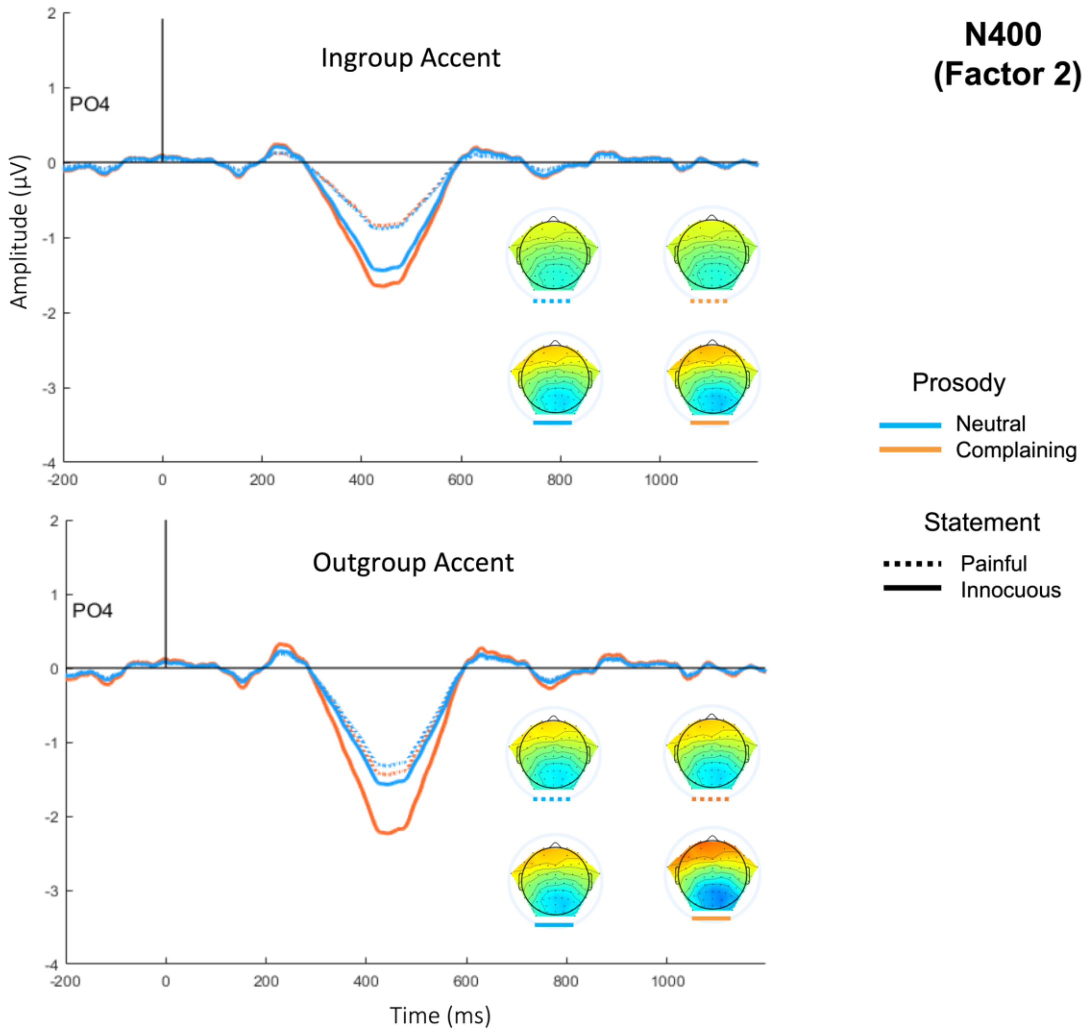

Figure C2. ERP-PCA waves and topographic maps showing the effects of Accent, Prosody, and Statement on factor TF4SF2 (P600). Top: Prosody and Statement effects for utterances produced by Ingroup speakers. Bottom: Prosody and Statement effects for utterances produced by Outgroup speakers.