Speaking of causality

On the role of prosody in communicating subjective and objective causality in discourse

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Spreken over causaliteit

Over de rol van prosodie bij het communiceren van subjectieve en objectieve causaliteit in het discours

(met een samenvatting in het Nederlands)

Proefschrift

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For grandma

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Hume once said in his book that "*Causality is the cement of universe*." I can't say for the universe, but I can say that causality is the cement of my life, in which all the major events are linked together in a perfect causal chain, with the tremendous help from many people whom I am so blessed to know. Now it is the moment to thank them properly.

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Chapter 1

Introduction

1.1 Introduction

> "Our sense of causality, Hume noted, is 'the cement of the universe.'"
> — Steven Pinker

What immediately caught everyone's attention on the playground was the sound of children crying. At the first sound of crying, everyone immediately dropped whatever they were engaged in and stuck their necks out like ostriches, trying to track down the source of the sound. Children howl for various reasons, such as losing a fight over a shovel, falling off sports facilities, or getting upset over something their best friends said, such as "*You are not my best friend anymore."* Sometimes parents are lucky enough to see the incident that brought on the howling. When asked about what just happened, parents are able to describe the cause and consequence using a sentence like the following:

(1) My daughter had a fight with her best friend, so she was crying.

However, parents often miss the event that led to crying. In such cases, they can ask their children what happened, but if the children are not old enough to retell events clearly, the parents can only infer the cause from the clues available in the surroundings, e.g., the angry and aggravated look on the friend's face. What would the parent say if asked to describe what happened? The following may be one of many possible answers.

(2) My daughter was crying, so maybe she had a fight with her best friend.

There is a third scenario, though. Suppose you see a child crying but do not see his/her guardian around. How would you react? As you approach to check if the child needs help, you might look around, wondering:

(3) The child is crying, so where is the guardian?

One commonality between the three utterances above is that they all express causality. Our sense of causality is a fundamental principle in cognition (Graesser, Singer, & Trabasso, 1994; Singer, Graesser, & Trabasso, 1994). It is what we rely on to establish physical, psychological, and motivational links between events, actions, and states (Fletcher & Bloom, 1988; Schank & Abelson, 1977; Trabasso & van den Broek, 1985; Trabasso, van den Broek, & Suh, 1989; van den Broek, 1990) and to make sense of what is going on in the world and how we should react.

However, the causal relations expressed in sentences (1) to (3) are different. The causal relation expressed in (1) is physical because it describes a CAUSE-CONSEQUENCE relation between two events that occur in the real world, with the event stated in the first clause being a cause ("*My daughter had a fight with her best friend")* and the event in the second clause being a consequence (*"She was crying"*). In contrast, the causality expressed in (2) is mental because it is established by the cognitive reasoning of the speaker, which generates mental products such as inferences ("*So maybe she had a fight with her best friend")* or opinions based on the evidence in the surroundings (e.g., the angry and aggravated look on her friend's face). Similar to the causality expressed in (2), the causality expressed in (3) also involves the speaker's cognitive reasoning. However, unlike the causality expressed in (2), the causality expressed in (3) does not involve an opinion or inference, but poses a question that requires an action, such as searching for the guardian.

Previous studies on causality have proposed different categorizations for the causal relations represented by sentences (1) – (3). Using a trichotomous approach, Sweetser (1990) refers to the causality expressed in (1) – (3) as causality in the content, epistemic, and speech act domains, respectively. Other researchers propose a dichotomous classification that distinguishes between "real-world" causality (causality that can be observed in the real world, i.e., causality that belongs to the content domain as defined by Sweetser, 1990) and "mental-world" causality (causality that depends on the cognitive reasoning of a speaker (or author or character), i.e., causality that falls into the epistemic and speech act domains). Studies following this approach refer to the "real-world" versus "mental-world" causality as *objective* versus *subjective* causality (Pander Maat & Degand, 2001; Sanders & Spooren, 2015), *semantic* versus *pragmatic*

causality (Sanders, Spooren, & Noordman, 1992; van Dijk, 1979), *external* versus *internal* (Halliday & Hasan, 1976), *simple-causal* versus *diagnostic* (corresponding to *epistemic* relations defined by Sweetser, 1990) relations, and *subject matter* versus *presentational* causality (Mann & Thompson, 1988). In this dissertation, we adopt the terminology of Pander Maat & Degand (2001) and Sanders & Spooren (2015), referring to "real-world" causality as *objective* causality and "mental-world" causality as *subjective* causality.

Note that the subjective causality studied in this dissertation involves only subjective causality involving the logical inference of the speaker, i.e., causality in the epistemic domain as defined by Sweetser (1990), and not that involving speech acts, i.e., causality in the speech act domain as defined by Sweetser (1990). Hence, in the remainder of this dissertation, subjective causality refers exclusively to subjective causality in the epistemic domain. The reason for excluding causality in the speech act domain is that it occurs relatively less frequently than causality in the epistemic domain in both spoken and written discourse (Xiao, Li, Sanders, & Spooren, 2021; Li, Evers-Vermeul, & Sanders, 2013) and because it can potentially be divided into several subtypes such as offering, promising, and commanding (Stukker & Sanders, 2012), which introduces complexity going beyond the scope of the current research.

1.1.1 The use of discourse markers in expressing subjective and objective causality

When conveying objective and subjective causality, as in sentences (1) and (2), speakers produce utterances that are composed of an obvious component: lexicon (bounded by syntactic rules). Among the words that make up the utterances produced by the speaker, some words or phrases (e.g., modal particles, sentential adverbs, cue phrases, etc.) signal the type of causality that the speaker intends to convey and thus are called lexical markers (or, discourse markers, or coherence markers, Taboada, 2006) of subjective and objective causality. To mention a few examples, cue phrases such as *for that reason* and *that's why* as well as adverbial expressions such as *hence* are well-recognized markers of objective causality, while *in my opinion* and *I think* as well as sentential adverbs such as *probably, definitely*, and *must* are lexical markers of subjective causality (Pander Maat & Sanders, 2006; also see Bross, 2012 for a review of modal particles in German). In addition to cue phrases and adverbial expressions,

subjective and objective causality can also be distinguished by specialized causal connectives. To date, identified objective causal connectives are *daardoor* 'so' in Dutch, *yushi* 'so' in Mandarin (Li et al., 2013), *parce que* 'because' in French (Zufferey, 2012), and *weil* 'because' in German (Stukker & Sanders, 2012); and the matching subjective ones are *dus* 'so' in Dutch, *kejian* 'so' in Mandarin, *car* and *puisque* 'because' in French, and *denn* 'because' in German. Research has shown that these lexical markers facilitate the processing of these two types of causality, serving as processing instructions for readers or listeners in constructing the causality that the speaker or writer intends to convey. For example, Canestrelli, Mak, and Sanders (2013) have found that in processing Dutch subjective and objective causality marked by the specialized causal connectives *want* 'because' and *omdat* 'because', a processing delay occurs in the region immediately following the causal connective *want* but not in the region following *omdat*. Li, Mak, Evers-Vermeul, & Sanders (2017) found that in Mandarin Chinese, subjective (in the authors' term, epistemic) causal relations marked with subjective causal connective *kejian* 'so' result in shorter reading time compared to those marked by an underspecified causal connective *suoyi* 'so'. Moreover, Wei, Mak, Evers-Vermeul, and Sanders (2019) have found that specialized causal connectives allow addressees to make predictions about the upcoming context; the addressees' gaze fixated on an image depicting a person being interviewed by an interviewer after hearing a subjective causal connective, suggesting that the addressees were expecting a subject's consciousness to be involved in the construction of the causality to come.

Although specialized causal connectives have the function of distinguishing between subjective and objective causality, they are rarely used in some languages. Instead, causal connectives that can be used to express both types of causality – referred to as general causal connectives – are preferred. A typical example of a language with this preference is English, where the subjective causal connective *therefore* is used less frequently than the general causal connective *so,* which can be used for all types of causality, as shown in sentences (1)-(3) at the beginning of this chapter. Using a general causal connective such as *so* to express causality does not provide any information about the type of causality the addresser intends to convey. If other lexical cues for subjective and objective causality are also absent, addressees can only rely on contextual

information to establish the causal link between clauses. As a result, the processing delay associated with subjective causality (reflected in longer reading time) occurs towards the end of the second clause (Traxler, Bybee, & Pickering, 1997), much later than the delay observed in utterances involving specialized causal connectives, as observed in Dutch.

1.1.2 The use of prosody in expressing meaning or function

Although lexicon is a key ingredient in human speech, it is not the only ingredient in the recipe. Another critical component of spoken language is how a message is delivered—the speaker's gestures, facial expressions, and prosody. In particular, prosody refers to variations in pitch, loudness, or timing over a speech unit larger than a segment (Ladd, 1996; Warren, 1999). Prosody serves many functions in speech communication. One is that it gives human speech its naturalness and fluency, qualities that many Text-to-Speech (TTS) systems lack (Smith, 2004).

The other function of prosody, which is of more interest to this dissertation, is that it conveys meanings and functions in speech communication (for extensive reviews, see Cutler, Dahan, & Van Donselaar, 1997; Cole, 2015; Wagner & Watson, 2010, with a focus on prosodic prominence and phrasing; Hirschberg, Beňuš, Gravano, & Levitan, 2020, with a highlight on the use of prosody related to discourse communication; Jasinskaja, Mayer, & Schlangen, 2004, with a focus on the prosodic realization of discourse structure and information structure). For example, prosody distinguishes words by indexing word stress patterns in stress-timed languages and by revealing tonal patterns in tone languages (e.g., van Heuven & Sluijter, 1996), conveys semantic relationships (Cutler et al., 1997), signals syntactic structures (e.g., early vs. late closure, Schafer, Speer, Warren, & White, 2000), serves as cues to discourse structure and rhetorical structure (e.g., Hirschberg & Grosz, 1992; den Ouden, Noordman, & Terken, 2009; Tyler, 2013; Swerts, 1997), marks focus and information status (Brown, 1983; Büring, 2011; Nooteboom & Terken, 1982), conveys pragmatic meanings such as attitudes (e.g., uncertainty, irony, and sarcasm; Dijkstra, Krahmer, & Swerts, 2006; Chen & Boves, 2018; see Mitchell & Ross, 2013 for an extensive review) and emotions, assists interlocutors in taking turns in dialogues, and discloses speakers' social-indexical identities such as region, gender, and ethnicity.

Most relevant to the current study is that prosody also conveys subjectivity (or, in many other equivalent terms, epistemic stance, sentiment, and attitude; see Jaffe, 2009). For example, Heritage (2013) has claimed that rising tunes in English is associated with subjectivity (or, in the author's term, epistemic stance), and mobilizes the listener's response. Roseano, González, Borràs-Comes, and Prieto (2016) have found that prosody and gesture convey subjectivity (or, in the authors' terms, epistemicity). Freeman (2014) has found that stance-expressing phrases (e.g., opinions) had faster speaking rates, longer stressed vowels, and more expanded vowel spaces than stance-neutral phrases (e.g., guest introductions). Evidence for prosody expressing subjectivity in phrases is also provided by research taking a computational approach. Ward, Carlson, and Fuentes (2018) have found that several prosodic features, including intensity, the height and range of fundamental frequency (f0), speaking rate, and hyper-articulation, were beneficial for computational models to classify utterances expressing facts vs. opinions. However, most of the existing studies focus only on words or phrases without touching on compound or complex sentences expressing causality. Thus, to date, whether prosody is involved in expressing subjectivity in causality is largely unknown.

The question of whether prosody is used to express subjectivity in causality, however, is not first raised by the current study. In fact, discourse analysts have long proposed to examine this question (Rutherford, 1970; Sweetser, 1990; Couper-Kuhlen, 1996; Sanders & Evers-Vermeul, 2019). Researchers generally predicted that the conceptual difference between subjective and objective causality would lead to differences in prosodic phrasing (Rutherford, 1970; Sweetser, 1990). Establishing subjective causality demands a change in perspective from the physical world to the mental world, so utterances expressing subjective causality should consist of two intonation units; establishing objective causality does not involve a change of perspective, so utterances expressing objective causality should consist of only one intonation unit. To date, this prediction has not been thoroughly evaluated, except for a few preliminary attempts. For example, Couper-Kuhlen (1996) and Günthner (1996) observed a pitch reset at the beginning of the second unit of utterances expressing subjective causality, which seems to support the claim of "two intonation units." However, given that the method used in these two studies is

only to visually inspect f0 contours, it remains unknown whether the finding can be generalized across utterances and speakers. Furthermore, as discussed in the previous paragraph, utterances expressing subjective versus objective causality may differ in many other acoustic dimensions in addition to prosodic phrasing, but no studies have tested those predictions.

The fact that the topic in question does not feature centrally in either the prosody or discourse fields may reflect the disparity between these two fields on certain topics. While research on prosody has not yet paid much attention to the prosodic realizations of subjective and objective causality, discourse studies on subjectivity in causality mainly focus on how subjective and objective causality is expressed at the lexical level rather than at the prosodic level. However, such kind of disparity may lead to incomplete or even inaccurate accounts of language use in discourse communication. For example, researchers who focus only on the morphological forms of sentence-initial pronoun-verb combinations such as *I think* and *I believe* concluded that the function of these word combinations is ambiguous in a given context. For example, the exact function of *I think* in a discourse—whether it functions as the main clause or serves as an epistemic adverbial or discourse marker—is implicit judging from the morphological composition of the phrase. However, researchers who examined the prosody of these word combinations have found that the prosodic realizations of these phrases vary with the functions of these phrases, serving as prosodic cues to the functions performed by the phrases (Dehé & Wichmann, 2010). In recent years, a growing number of researchers who once focused on the lexical aspects of language have realized the risk of ignoring prosody when studying the meanings and functions of words and phrases, and have advocated an integrated approach to study meaning and function that incorporates different communicative strategies (Fodor, 2002; Prieto & Roseano, 2021). The rationale for following this approach lies in the fact that both morphology and prosody are subsystems of spoken language and, more importantly, that in many cases, these two subsystems do not operate independently but in an interactive fashion (Fodor, 2002; Prieto & Roseano, 2021), showing a trade-off relationship between them. Against this background, we set the first goal for the current study: to investigate whether there is a trade-off relationship between the use of lexical and prosodic devices in expressing subjective and objective causality.

1.1.3 A functional trade-off between prosody and lexical information?

An interesting phenomenon widely observed within and outside language is that the (linguistic or biological) features serving the same (communicative or survival) goal often share a trade-off relationship. In the biological world, a classic example of such a trade-off, as cited in van Heuven (2017), referring to Boulger (1878), is the relationship between flower color and fragrance in attracting insects for pollination. White flowers look less attractive but smell better than colorful flowers; colorful flowers smell less pleasant than white flowers but are more visually appealing. As a result, white and colorful flowers are roughly equal in terms of attractiveness to insects and hence have roughly equal chances of pollination.

Crucially, this functional trade-off principle also applies to how we use different communicative means in communication. Although we have a variety of means to express meanings or functions, such as morphosyntactic ones including morphology, semantics, and syntax, as well as non-lexical ones such as gestures, facial expressions, and prosody, in many cases we do not use these means simultaneously to convey a single message. Instead, we decide how much linguistic marking is needed and which cues to use based on various factors. One widely recognized factor affecting the amount of linguistic marking is the predictability (defined in different ways) of information. Extensive research has shown that there is a trade-off between the amount of linguistic marking needed and how easily the information under communication can be derived from context. Highly predictable information, i.e., information readily provided by context or words and phrases with high frequencies, tends not to receive lexical or non-lexical coding; in contrast, information that is hard to derive from context, or forms with a low frequency of occurrence, tends to be more frequently marked. This pattern has been observed at almost all levels of linguistic representation. At the phonological level, substantial evidence has shown that speakers modulate production intelligibility by balancing phonological load with the information provided by linguistic context (e.g., Hunnicutt, 1985; Lieberman, 1963; Lindblom, 1990). At the phonetic level, it has been found that words with low predictability have longer durations (Seyfarth, 2014), greater vowel space, and less reduced vowel articulation

(Lindblom, 1989), and are often more prominent in terms of prosody than predictable words (Biber & Staples, 2014). At the morphosyntactic level, studies have shown that more predictable grammatical meanings are more likely to be expressed without case-marking than less predictable grammatical meanings (Kurumada & Jaeger, 2015). At the syntactic level, researchers have found that speakers only provide reliable prosodic cues to syntactic structure when the context does not strongly support their intended meaning (e.g., Snedeker & Trueswell, 2003).

Several theoretical models of speech production clearly describe the correlation between predictability and articulation, including audience design (Clark & Carlson, 1982) and the Smooth Signal Redundancy Hypothesis and the Uniform Information Density (UID) Hypothesis (Aylett & Turk, 2004; Levy & Jaeger, 2007). Despite differences in theoretical details, these models commonly hold that if the information is highly predictable from context, it is efficient not to use overt cues; if, on the other hand, information is not easily recoverable from context, it would be easier for addressees to recover the information if addressers provide additional cues for the information intended. In particular, the Smooth Signal Redundancy Hypothesis or the Uniform Information Density Hypothesis holds that speakers prefer to maintain a constant rate of information transfer (Aylett & Turk, 2004; Levy & Jaeger, 2007): unexpected relations need to be marked; otherwise, deriving such relations would require too much information from context and hence create a peak in information density; on the other hand, expected relations tend not to be marked by prosody, or else it would result in a trough in information density.

Trade-offs have also been observed between the use of different cues within a communicative channel. Within the morphosyntactic channel, Koplenig, Meyer, Wolfer, and Müller-Spitzer (2017) demonstrated a trade-off between information expressed by word order and word structure. Berdicevskis, Schmidtke-Bode, & Seržant (2020) provided typological data showing that languages with subject indexing (verbal affixes and clitics) more frequently allow for the omission of subject pronouns. Hoek, Zufferey, Evers-Vermeul, and Sanders (2018) found that coherence relations that are explicitly marked by a connective (e.g., *although*) tend not to contain other coherence markers such as a cue phrase (e.g., *except for that*). Within the prosodic channel, a trade-off

between cues is also observed. By quantitatively comparing the grammatical strategies used to mark polar questions between tonal and non-tonal languages, Torreira, Roberts, and Hammarström (2014) have found that tone languages tend not to use utterance-level intonation but prefer grammatical devices (such as particles and changes in word order) to mark polar questions, in contrast to non-tonal languages.

More relevant to the current study is that trade-offs have been repeatedly observed between the uses of morphosyntactic cues and non-lexical cues in expressing meanings or functions. Several researchers have explicitly or implicitly stated that speakers intuitively fine-tune the intelligibility of the information they express by monitoring the amount of information expressed by the two types of cues, with the presence of one type of cues canceling out or reducing the need to deploy the other type of cues (Braun & Chen, 2010; Snedeker & Trueswell, 2003). Evidence for this phenomenon has been found in the marking of word boundaries (Mattys & Melhorn, 2007), in the expression of questions versus statements (Petrone & Niebuhr, 2014; van Heuven, 2017b), in disambiguating syntactic ambiguity (Snedeker & Trueswell, 2003), in marking information structure (Braun & Chen, 2010), in distinguishing different functions of discourse markers (see Hirschberg, Beňuš, Gravano, & Levitan, 2020 and Cole, 2015 for extensive reviews), and in expressing higher levels of linguistic meanings such as sentiment (Morency, Mihalcea, & Doshi, 2011), commitment (Prieto & Roseano, 2021), and sarcasm (Afflerbach, 2015; Chen & Boves, 2018). Taking the expression of questions and statements as an example, it has been found that when a question is expressed by lexical or syntactic markers, it tends to contain less prosody marking; when on the other hand, a question contains no lexical or syntactic marking, it is more likely to be marked by prosody such as a final rise (Haan, 2001). Based on this finding, Haan (2001) has proposed the Functional Hypothesis, which argues that prosody is more likely to be resorted to when information is not sufficiently expressed at the morphosyntactic level.

The widely observed trade-offs between the use of morphosyntactic and non-lexical cues lead to the first question that the current research aims to explore: Does this principle apply to the expression of subjective and objective causality? Based on the Functional Hypothesis (Haan, 2001) and its considerable

supporting evidence, we hypothesize that the use of prosody would be inversely correlated with the presence of lexical markers for subjective and objective causality in expressing these two types of causality. Presumably, if general causal connectives are used, leaving the type of causality underspecified, as in (1) and (2) introduced at the beginning of this chapter, it would be necessary to use prosody to distinguish one type of causality from the other. On the other hand, if lexical cues such as specialized causal connectives are used to express subjective versus objective causality, specifying the type of causality the speaker intends to convey, it would be less necessary to use prosody to distinguish between the two types of causality. These two predictions are assessed empirically in Chapters 2 and 3 of this dissertation.

1.1.4 The role of prosody in discourse processing

As reviewed in Section 1.1.2, prosody is actively involved in expressing meaning and function at several linguistic levels. The question then arises: Does prosodic information affect spoken language comprehension? This has been an active area of research (see Cole, 2015 and Hirschberg et al., 2020 for reviews). Existing research has identified two possible ways in which prosody can contribute to speech comprehension. One is that certain prosodic features, such as raised pitch, attract the listener's attention and, in turn, facilitate comprehension (Bugental & Lin, 1997). The other is that prosody directly encodes meanings or functions, contributing to the decoding or establishment of the meanings or functions. For example, listeners make use of prosodic information to resolve syntactic ambiguity (e.g., Schafer et al., 2000; Snedeker & Trueswell, 2003), to keep track of the progress of a discourse (paragraph initial/medial/final), to interpret focus or information status and resolve referential ambiguity (given/new; Dutch: Terken & Nooteboom, 1987; German: Weber, Braun, & Crocker, 2006; British English: Chen, Den Os, & De Ruiter, 2007; American English: Birch & Clifton, 1995; Dahan, Tanenhaus, & Chambersc, 2002; Ito & Speer, 2008; Watson, Tanenhaus, & Gunlogson, 2008), to establish the structure of a discourse (Herman, 2000), to grasp illocutionary force and affective meaning (e.g., impoliteness: Culpeper, 2011; sarcasm: Chen & Boves, 2018), to manage turn-taking in dialogues, and to determine the function of poly-functional words or phrases in a given context (Gravano, Benus, Chávez, Hirschberg, & Wilcox, 2007; Didirková, Crible, & Simon, 2019), to

discriminate low/high attachment in syntactic structure (Mayer, Jasinskaja, & Kölsch, 2006) and coordination/subordination in discourse structure (Tyler, 2014). However, it remains completely unknown whether prosody affects the comprehension of subjective and objective causality. This dissertation aims to shed some light on this issue. The question that we aim to tackle is whether the prosody information contained in utterances expressing subjective versus objective causality allows listeners to predict the type of causality the speaker intends to convey.

1.2 Research questions and chapter overview

In a nutshell, this dissertation aims to shed light on two crucial yet long unresolved questions about the expression of subjectivity in causality: 1) whether prosody plays a role in expressing subjective and objective causality, and 2) whether prosody helps listeners interpret subjective and objective causality. The first question is addressed in Chapters 2 and 3, and the second question in Chapter 4.

The hypothesis assessed in Chapters 2 and 3 is that there is a trade-off relationship between the use of lexical and prosodic means in expressing subjective/objective causality. Specifically, the hypothesis predicts that whether prosody is involved in expressing subjective and objective causality would depend on the profiles of the causal connectives used to express these two types of causality; prosody is more likely to be used to distinguish between these two types of causality if these two types of causality are not distinguished by lexical markers such as specialized causal connectives than if they are already distinguished by lexical markers. Chapter 2 concentrates on one side of the issue, namely, the use of prosody in the absence of specialized causal connectives (i.e., in the presence of a general causal connective), setting out to address the following research question (RQ1):

RQ1: Are there prosodic differences between subjective and objective causality in the *absence* of specialized causal connectives?

This question is addressed by examining the prosody of subjective and objective causality in English, which are more often expressed with a general

causal connective (*so* or *because*) than with specialized causal connectives. Before examining the prosody, it is important to note that the *antecedens P* and the *consequens Q* involved in causality can occur in two orders, namely, the forward order, in which *P* precedes *Q* (*P* → *Q*), and the backward order, in which *Q* precedes *P* (*Q* ← *P*). Take objective causality as an example. The event that is perceived as the cause of a consequence can be introduced either before the consequence (CAUSE → CONSEQUENCE) as in "*My daughter had a fight with her best friend, so she was crying*" or after it (CONSEQUENCE ← CAUSE) as in "*My daughter was crying because she just had a fight with her best friend."* Given the possibility that the order of *P* and *Q* might have an influence on the prosody of an utterance, we conducted two production experiments, with Experiment 1 focusing on subjective and objective causality in the backward causal order (CONSEQUENCE *because* CAUSE, CLAIM *because* ARGUMENT), and Experiment 2 on causality in the forward order (CAUSE *so* CONSEQUENCE, ARGUMENT *so* CLAIM). In each experiment, utterances expressing subjective and objective causality are elicited from speakers using a dialogue task. In the task, the participants converse with an interlocutor about information presented on PowerPoint slides in a naturalistic conversational setting reminiscent of everyday conversions.

Using the same experimental design, Chapter 3 continues to examine the other side of the issue, that is, the use of prosody in expressing subjective and objective causality in the presence of specialized causal connectives. The main research question that this chapter aims to address is:

RQ2: Are there prosodic differences between subjective and objective causality in the *presence* of specialized causal connectives?

This question is addressed by two production experiments investigating the use of prosody to use causality in languages that frequently use specialized causal connectives, namely, Mandarin (Experiment 3) and Dutch (Experiment 4). According to previous studies, the causal connectives *kejian* 'so' and *yushi* 'so' are systematically used in Mandarin to express subjective and objective causality, respectively. Given that these specialized causal connectives already specify the type of causality the speaker intends to convey, we predict that prosody will be

used to a lesser extent in distinguishing between the two types of causality. Like Mandarin, the Dutch language also possesses and frequently uses specialized causal connectives to express different types of causality. For example, the causal connective *daardoor* 'so' is a prototypical objective causal connective often used to express objective causality, and *dus* 'so' a prototypical subjective causal connective. However, what makes Dutch a special case for study is that the prototypical subjective causal connective *dus* 'so' can also be used to express objective causality (Pander Maat & Degand, 2001; Stukker, Sanders, & Verhagen, 2009), seeming to have a general usage, like *so* in English. In this light, we predict that the prosodic differences between the two types of causality will be more pronounced when *dus* is used as a general connective to express both subjective and objective causality than when *dus* is used restrictively as a causal connective for subjective causality.

Interestingly, corpus studies also found that the actual use of *dus* – as a subjective causal connective or as a general one – varies greatly among language users with different discourse goals and characteristics. Some prefer to use *dus* as a specialized causal connective, while others prefer to use it as a general causal connective. In Chapter 3, we first examine whether this is the case for our data. We then investigate whether speakers with difference preferences use prosody in different ways to express subjective and objective causality (hence RQ3):

RQ3: Do participants' preferences for specialized causal connectives affect their use of prosody to express subjective and objective causality?

To address this issue, we first use odds ratios (ORs) to describe speaker preferences for connectives and then statistically test for the interaction effect between ORs and causality types on prosody.

Chapters 2 and 3 investigate how speakers use prosody to express subjectivity in causality in speech production. In Chapter 4, we turn to the listeners, investigating whether prosodic characteristics of these two types of causality can help listeners to interpret the two types of causality (RQ4):

RQ4: Can listeners predict the type of causality intended by the

speaker based on prosodic information contained in an utterance?

To explore this question, we carried out a perception experiment online. The experiment involved a forced-choice discourse completion task in which the participants listened to sentence fragments recounting real-world events followed by the connective *so* (e.g., "*Jim got his nose pierced so*"). Each fragment had two different prosodic realizations, one featuring subjective causality and the other objective causality. After each sentence, the participants were tasked with choosing a continuation for the sentence fragment they just heard. Two options were provided on the screen, one being an opinion or inference about the event described in the stimulus, thus forming subjective causality with the previous sentence, and the other stating the consequence of the event, thus forming objective causality. The idea is that if the prosodic information in the sentence encodes information about subjective and objective causality, listeners should choose subjective continuations more often upon hearing stimuli pronounced with subjective prosody than upon hearing the matching version with objective prosody.

In Chapter 5, the final chapter of this dissertation, we summarize the main findings from Chapters 2 to 4, put our findings in perspective, discuss in-depth the implications of our findings, and pose questions for future research.

1.3 Methodological highlights

To address the above research questions, this dissertation adopts an experimental approach. However, compared to previous experimental studies on prosody, this dissertation has several methodological highlights. First, we use a newly designed interactive dialogue task to elicit utterances expressing different types of causality, rather than having the participants read from scripts. In addition, the prosodic realization of the utterances is characterized not only in terms of static measurements such as f0 maximum and minimum, but also in terms of the overall shape of the f0 trajectory. Furthermore, instead of the widely used frequentist approach, we adopt a Bayesian approach to analyze the data, which allows for a more intuitive understanding of the effect of interest. In the following, we explain in detail each of these methodological decisions.

1.3.1 A naturalistic dialogue task

A long-standing debate in the field of prosody research is whether to work with natural speech or speech recorded in a lab (Schafer et al., 2000). Each type of data has clear advantages but also limitations. Natural speech truthfully captures the way people use prosody in daily conversation. However, it usually encompasses multiple types of linguistic information, which exert joint influence on prosody in an inevitable yet undesirable way from the perspective of researchers. Consequently, if prosodic differences were found, researchers cannot attribute those differences with absolute certainty to the effect of interest. If, on the other hand, no prosodic differences were found, researchers cannot determine whether the effect of interest was not present in the first place or if it is masked by other factors (Fowler & Housum, 1987). Another common and probably more serious issue with working with natural speech is that existing corpora of natural speech usually do not involve a sufficient number of speakers or readily contain enough instances for many research goals (Schafer et al., 2000). As a result, studies based on natural speech data usually involve a minimal number of speakers (Cutler & Pearson, 1986) and a very limited number of instances. In contrast to natural speech, lab speech tends to involve only the effects of interest with other confounding factors under control (Xu, 2010). However, the biggest criticism against the speech elicited in an experimental context is that the prosody of the speech recorded in a lab setting (read speech in particular) may deviate from the prosody of natural conversations and therefore should be completely avoided (Hawkins, 2003; Kohler, 2004) (but see Xu (2010, 2012) for defense of lab speech).

As a compromise between using natural speech and read speech, researchers use interactive tasks to elicit speech samples. Interactive speech incorporates the advantages of both natural and read speech; it is produced by speakers with the genuine goal of communicating with an interlocutor, and it involves only the effects that the researchers are interested in. Successful implementations of such interactive tasks include map tasks (Anderson et al., 1991), in which speakers navigate the listeners around a map, picture description tasks, in which speakers get pictures to describe (Bock & Loebell, 1990), descriptions of networks of colored nodes, in which speakers describe networks (Levelt & Cutler, 1983), a cooperative game task, in which two speakers use

utterances from a predetermined set to negotiate moves around a game board (Schafer et al., 2000), and a simulated telephone conversation task (Chen & Boves, 2018), in which speakers participate in phone conversations with an interlocutor. Inspired by the many successful precedents, we designed a dialogue task to elicit pre-scripted utterances conveying subjective and objective causality. In the task, participants read PowerPoint slides and interacted with an interlocutor by answering her questions about the information on the slides. With this design, we assume that the utterances produced by the speakers are natural in terms of prosody and comparable in terms of information structure, word choices, and sentence length.

1.3.2 A Bayesian statistical approach

The statistical method that is predominantly used in linguistic research and many others research fields is frequentist statistics. In simplified terms, frequentist statistics assesses the significance of an effect by counting how frequently it occurs across (hypothetical) repetitions of data-generating process. It starts out assuming that a null hypothesis is true (hence the name Null Hypothesis Significance Testing, NHST), which assumes that the effect of interest is absent (for example, there is no difference in average height between females and males in a population). Then, it looks at the evidence contained in the data collected. If the data is sufficiently unlikely to occur under the null hypothesis, then it is considered as evidence against the null hypothesis. The measure that indicates how unlikely the data is in the light of the null hypothesis is known as the *p*-value. If the analysis yields a *p*-value smaller than a threshold, for example, the conventional .05, the null hypothesis can be rejected, and the effect under investigation is claimed to be "significant"; if the *p*-value yielded excesses .05, the null hypothesis could not be rejected, and the effect of interest is considered to be "insignificant".

Though being a useful method, the frequentist approach to hypothesis testing has several drawbacks.

First, it forces the user to think about the effect of interest in a black-and-white way: believing either that the null hypothesis is true or that it is not true (Kruschke, 2015). In some situations, this information might be of interest to the researcher. But in many and perhaps most situations, it would be more informative to know the magnitude of the effect and how uncertain

researchers are about the magnitude (Kruschke & Liddell, 2018).

Second, a *p*-value, a notion central to frequentist statistics, is not a reliable measurement. It can easily fall below .05 when the sample size is extremely large, or the effect size is incredibly small, suggesting that the effect under estimation is statistically significant. However, this kind of statistical "significance" perhaps bears little, if any, practical meaning. As illustrated in Grabe, Kochanski, and Coleman (2007), with large amounts of data, f0 differences of less than 1 Hz between two pitch accent categories could turn out to be statistically significant. However, the f0 difference of this size is too small to be perceived by the human ear and would not be used to form pitch accent contrasts, and therefore is meaningless.

The third, and perhaps more serious, drawback of frequentist data analysis is that, after all the trouble of collecting data and conducting the analysis, researchers end up with information that they DO NOT really wish to know or that what they think they know – that there is a 95% probability that the effect of interest is present in the data, or that the probability that the null hypothesis is true is less than 5% (Bland & Altman, 1998). While we conduct experiments to estimate how likely it is that a certain state of an event will occur (e.g., the probability of rain tomorrow), the frequentist approach tells us how frequently an event will occur in the long run (e.g., if tomorrow is repeated 100 times, how many times will it rain). The frequency of an event and the probability of a single event are two very different concepts (certainly, for events like flipping a coin, the frequency of the coin landing heads-up (which is 50%) equals the probability of the coin landing on heads (which is .5), but this does not mean that the two concepts are the same). Knowing the frequency of an event is not that instructive for understanding a lot of problems because the assumption behind it has little bearing on reality and is purely a figment of researchers' imagination (McElreath, 2016). The frequentist approach assumes that a scenario in which an event occurs can be repeated many times. For most, if not all, real-life problems, this assumption is atypical for the simple reason that, in reality, events unfold only once. We cannot rewind the same scenario over and over again (a paradigm example is that the 2016 Summer Olympics only takes place once in reality, not one hundred times, and it is not possible, no matter how mighty an individual thinks he or she is, to repeat the game one hundred times).

Fourth, the frequentist approach assumes a single fixed true value for the parameter of interest (for example, 0.15 meters for the average height difference between females and males) (Bland & Altman, 1998). In most circumstances, if not all, this information is insufficient to understand the state of an affair. Instead, it would be more informative to know all possible outcomes of an event and how uncertain we are about each outcome, namely, the probability distribution of all possible outcomes of an event.

Last but not least, the frequentist approach completely ignores a crucial trait of human thinking; that is, we constantly update our credence about events in light of new evidence. In our everyday lives, we constantly gather evidence from our surroundings and update our decisions based on the new evidence that we collected. In the context of academic research, our prior knowledge or belief about a hypothesis (e.g., the base rate of a certain disease) has a significant impact on the posterior probability of the hypothesis.

In short, the frequentist approach tests how frequently an event occurs in the long run, rather than the probability of a single event occurring. It assumes that the scenario for an event to occur can be repeated many times. It hinges on a *p*-value. It does not leave room for the prior belief of a hypothesis to be incorporated. And it treats the state of an affair as static rather than ever-evolving. As an alternative to frequentist statistics, Bayesian inference has become increasingly popular in recent years.

Unlike frequentist statistics, which views the probability of an event as long-term frequency of the event occurring over many repetitions of the same data collection process, Bayesian data analysis determines the probability of a single event occurring (McElreath, 2016). It provides an answer to a question in the form of a posterior probability distribution, which is mathematically defined from Bayes' theorem formulated by Reverend Thomas Bayes (1701-1761):

$$\text{prob}(\text{Hypothesis}|\text{Data}) = \frac{\text{prob}(\text{Hypothesis}) \times \text{prob}(\text{Data}|\text{Hypothesis})}{\text{prob}(\text{Data})}$$

In the equation, prob(Hypothesis|Data) on the left-hand side is called the posterior probability, which is our credence in the hypothesis after we have seen the data. Take the medical diagnosis of Covid-19 as an example.

Prob(Hypothesis|Data) refers to how certain we are that we actually have the disease after getting a positive test result. Prob(Hypothesis) on the right-hand side is the prior probability (or "priors"). It is our credence in the hypothesis before we look at the evidence. In the context of Covid-19, it could be the base rate of the disease, namely, the prevalence of the disease in the region you live. Prob(Data|Hypothesis) is the likelihood, namely, how likely the evidence or data is to appear if the hypothesis is true. In the Covid-19 example, it refers to how likely a person would get a positive test result if they do have the disease. Prob(Data) in the denominator is the marginal probability, which is the probability of the evidence turning up across the board. In the context of Covid-19, it refers to the population that received positive test results, including both true positive cases and false positives.

The theorem essentially says that the probability of a hypothesis given the evidence (i.e., posterior probability) is equal to our prior credence in the hypothesis (i.e., prior probability), multiplied by how likely the evidence would be observed if the hypothesis is valid (i.e., likelihood), and divided by how common that evidence is across the board (i.e., marginal likelihood). More importantly, what makes Bayesian data analysis the closest embodiment of the human way of thinking is that it treats the state of an event as well as people's belief of the state of an event as ever-evolving in the light of new evidence instead of retaining a constant state. In practice, it updates posterior probability in light of new data, allowing the posterior probability estimated from one round of looking at the evidence to be used as the prior probability for the next round, just as we update our decisions or beliefs based on new evidence gathered from our surroundings. This process is called Bayesian updating. In the example of Covid-19, this means that the posterior probability derived from the result of one test can be used as the prior probability for the next round of inference. In the context of academic research, this could mean that the findings of previous studies can serve as the prior knowledge for the present study.

However, Bayesian approaches are not without limitations. When the sample size is small, the prior probability of the effect being evaluated can influence the posterior probability of the effect. In addition, the choice of the prior can also influence the Bayes factors of the effect, which is the likelihood ratio between models with and without the effect of interest, indicating the extent

to which the effect of interest is present in the data. The common solution to this issue is to use multiple priors to fit the model and compute the Bayes factor multiple times.

In this dissertation, we adopt the Bayesian approach to analyze our data. To evaluate the presence or absence of the effect of interest, we compute Bayes factors for the effect. This is done by comparing a model containing an effect of interest (full model) to a model not containing the effect (null model). Further details for this method are provided in subsequent chapters.

1.3.3 Functional principal component analysis

One key acoustic dimension of speech is fundamental frequency (f0). A common approach to studying f0 is to measure a set of static values, such as the maximum, minimum, mean, and range of f0. These measurements are undeniably important for understanding the variation of f0. However, they are insufficient as they do not fully depict the trajectory of f0 changes, which often express meanings or functions. As such, a complementary approach is needed. One such approach is to describe f0 contours based on autosegmental-metrical (AM) frameworks (e.g., Bruce, 1977; Goldsmith, 1976; Pierrehumbert, 1980), which provide a fixed set of tonal patterns such as H*L and H* to describe the overall shape of f0 trajectories over a certain time span. This approach, however, has the limitation that it obscures subtle yet potentially important variations within a tonal category, such as variations in f0 peak alignment (early versus late) and curvature (concave versus convex) (Dombrowski & Niebuhr, 2005; Lohfink, Katsika, & Arvaniti, 2019). In order to capture these detailed f0 variations, f0 contours need to be modelled using mathematical methods. Existing curve-fitting algorithms include the Fujisaki model (Fujisaki, 1992), MOMEL (Hirst, Di Cristo, & Espesser, 1993), Tilt (Taylor, 2000), polynomials (Grabe et al., 2007), and Functional Principal Components Analysis (FPCA) (Gubian, Torreira, & Boves, 2015). Among these curve fitting techniques, FPCA is particularly relevant to phonetic research as the outcome of the analysis are just numbers, which can be used as regular dependent variables in statistical analyses like other acoustic measurements such as f0 maximum, duration, and articulation rate. Similar to polynomials, FPCA represents an f0 contour as a mathematical function that consists of a number of component curves. However, FPCA is more flexible than the polynomial approach because FPCA does not require the orthogonal shapes

to be pre-defined (Asano & Gubian, 2018). In a nutshell, FPCA takes a set of f0 contours as input and converts each contour in the set into a mathematical function of time. As shown in the equation below, the mathematical function of each curve consists of the average curve of all input curves *(μ(t))* and several FPCs (*FPC1(t), FPC2(t)*, and *FPC3(t)*, etc.), with each FPC associated with a weight (*s1, s2,* and *s3*) that entails the extent to which that FPC should be applied to the mean contour so that the original contour can be approximated with a reasonable balance between over- and under-fitting. Since the weight of each FPC is unique for each curve, the weights of the FPCs can represent the shape of a curve.

$$F0(t) \approx \mu(t) + s1 \cdot FPC1(t) + s2 \cdot FPC2(t) + s3 \cdot FPC3(t) + \cdots$$

In Chapter 2, FPCA is applied to model the f0 contours of utterances expressing subjective and objective causality to explore whether the f0 contours differ between these two types of causality.

FPCA has not only been used in production studies to understand differences in contour shape between different experimental conditions, but also in perception studies as a contour manipulation technique to prepare experimental stimuli (for existing use cases, see Gubian, Asano, Asaridou, & Cangemi, 2013 and also Asano, 2018). In Chapter 4, FPCA is used to prepare different f0 contours to study the effects of contour shapes on the interpretation of causality types.

1.4 Reading note

Chapters 2-4 are presented as stand-alone articles, each containing sufficient information about the background and methodology used in each chapter. Therefore, these three chapters can be read independently without referencing the previous chapters. However, for a more detailed review of the trade-off hypothesis, the distinctions between frequentist and Bayesian statistical analysis, and Functional Principal Component Analysis, readers are referred to Chapter 1.

Chapter 2

Prosody differs between objective and subjective causal relations in English[1]

Many studies have shown that prosody plays an important role in the construal of discourse. Is prosody also used to express the subtle distinction between subjective causality (CLAIM-ARGUMENT) and objective causality (CONSEQUENCE-CAUSE)? We investigated this question in English, a language in which the two types of causality are typically expressed using the same connective. Results of two production studies, on backward causality (Q *because* P) and forward causality (P *so* Q) respectively, showed that, relative to objective causality, subjective causality was produced with a larger f0 range and longer duration. The forward connective *so* also had a distinctive f0 contour in subjective context. These results indicate that prosody plays a role in expressing the distinction between subjective and objective causality in the absence of explicit lexical markers in English.

[1] Preliminary results of this chapter were presented at the 19th International Congress of Phonetic Sciences (ICPhS) and published in the conference proceedings as Hu, Chen, Quené, & Sanders (2019).

2.1 Introduction

Prosody carries various kinds of information in spoken communication. For example, it marks information structure, conveys speakers' social-indexical identities such as gender and ethnicity, and indicates speakers' states of mind such as emotions, attitudes, and intentions (see Cole, 2015; Hirschberg, Beňuš, Gravano, & Levitan, 2020 for extensive reviews). Of particular interest to the current study is that prosody also reflects relations between discourse units. Specifically, prosody differs between causally-related and non-causally-related utterances, with causally-associated phrases having a shorter pause between them and a faster articulation rate than non-causally-related ones (den Ouden, Noordman, & Terken, 2009). However, there are different types of causal relations depending on how they are constructed. What remains largely unknown is whether different types of causality are also expressed by prosody. This chapter aims to shed light on this issue.

The remainder of this section is organized as follows. First, we explain the cognitive differences between two different types of causality, i.e., subjective and objective causality. Then, we introduce the role of causal connectives in expressing these two types of causality, followed by a review of the literature on the role of prosody in expressing these two types of causality. Finally, we briefly describe the approach of the present study.

2.1.1 The cognitive difference between subjective and objective causality

Causality is a fundamental concept in language and cognition (Sanders & Sweetser, 2009; Stukker, Sanders, & Verhagen, 2008). It can be expressed in the form of a complex or compound sentence consisting of the *antecedens P* and the *consequens Q* connected by a causal connective. The order of *P* and *Q* reflects the order of causality. When *P* precedes *Q* (as in sentences (1) and (2) in Table 1), the causality is in forward order; when *Q* precedes *P* (as in (3) and (4) in Table 1), the causality is in backward order (Sanders, Spooren, & Noordman, 1992).

Table 1
Causality of different orders and different types (examples adopted from Traxler, Bybee, & Pickering, 1997)

		Order of causality	
		Forward *P* (C1) → *Q* (C2)	Backward *Q* (C1) ← *P* (C2)
Type of causality	Objective	*(1) Heidi won first prize at the art festival so she is thrilled.*	*(3) Heidi is thrilled because she won first prize at the art festival.*
	Subjective	*(2) Heidi won first prize at the art festival so she must be talented.*	*(4) Heidi must be talented because she won first prize at the art festival.*

There are two ways to establish the causal connection between *P* and *Q*. One way is through the logical reasoning of a thinking subject, be it the speaker, author, or a third person character in a discourse. In such a case, *P* introduces an actual event in the physical world and *Q* an inference or opinion (as in (2) and (4) in Table 1) (Sanders et al., 1992). Because *P* concerns the physical world and *Q* the mental world, discourse analysts typically assume that the senses of *P* and *Q* are relatively remote from each other and form two separate semantic units (Zufferey, 2012). The other way to construct causality, by contrast, does not involve one's reasoning but only reports events happening in the physical world, with *P* stating a cause and *Q* a consequence (as in (1) and (3) in Table 1). Because the events described in *P* and *Q* both take place in the physical world, the meanings of *P* and *Q* are more integrated than when they are connected by logical reasoning (Zufferey, 2012; Verhagen, 2005; Sweetser, 1990). In the discourse literature, the above mentioned two types of causality have been known under different terms[2]. Following Sanders & Spooren (2015) and Sanders & Sweetser (2009), we refer to the former type as *subjective* causality and the latter type as *objective* causality.

[2] Alternative terminologies include pragmatic versus semantic (Sanders et al., 1992) or epistemic versus content relations (Sweetser, 1990).

2.1.2 The role of causal connectives in expressing subjective and objective causality

In some languages, subjective and objective causality are often expressed by distinctive causal connectives, which provide addressees with explicit information about which type of causality should be inferred. For example, the causal connective words *kejian* 'so' in Mandarin and *dus* 'so' in Dutch are prototypical subjective causal connectives, signaling to addressees that the causal connection being conveyed is constructed by the addresser's cognitive reasoning. In contrast, the connectives *yushi* 'so' and *daardoor* 'so' are typically used for objective causality, informing addressees that the causality being communicated only concerns events occurring in the physical world (Stukker et al., 2008; Li, Evers-Vermeul, & Sanders, 2013)[3]. However, in other languages, such specialized causal connectives may exist in the lexicon but are rarely used in spoken language. Instead, common causal connectives are frequently used. A case in point is English, where the connective words *so* and *because* are frequently used to express both subjective causality and objective causality despite the existence of the typical subjective causal connective *since* (Couper-Kuhlen, 1996; Sweetser, 1990; Andersson, 2016; Taboada, 2006). Unlike specialized causal connectives, general causal connectives do not provide information about the type of causality, making it difficult for addressees to distinguish between subjective and objective causality (Traxler, Bybee, et al., 1997). This raises the question of whether subjective and objective causality without explicit lexical markers are expressed by prosodic means. This paper addresses this issue by exploring the prosodic differences between subjective and objective causality in two production experiments. Experiment 1 focuses on backward subjective and objective causality expressed by *because* and Experiment 2 forward subjective and objective causality expressed by *so*.

2.1.3 The role of prosody in expressing subjective and objective causality

Several theoretical frameworks suggest that prosody might play a role in

[3] Causal connectives with a subjective characteristic also include Dutch *want* (Sanders & Spooren, 2015), French *car* and *puisque* (Zufferey, 2012), German *denn* (Stukker & Sanders, 2012), and Mandarin *kejian* (Li et al., 2013); those with an objective characteristic are Dutch *omdat*, French *parce que*, German *weil*, and Mandarin *yin'er*.

expressing subjective and objective causality. Specifically, the Functional Hypothesis proposes that prosody is likely to be used to distinguish meanings or functions when lexical cues are absent (Haan, 2001). The Uniform Information Density hypothesis holds that relations with low expectedness need to be marked. Otherwise, deriving such relations would require too much information from context and thus create a peak in information density (Aylett & Turk, 2004; Levy & Jaeger, 2007). Compared to objective causality, subjective causality is cognitively more complex and hence less predictable if not presented with lexical markers (Traxler, Bybee, et al., 1997; Zufferey & Gygax, 2015). Thus, according to this theory, it is desirable to mark subjective causality with prosody if it is not expressed by a specialized causal connective.

Discourse analysts have long contemplated the potential role of prosody in expressing subjective and objective causality, with a particular interest in the difference in prosodic phrasing between the two types of causality. Rutherford (1970) and Sweetser (1990) proposed that the *P* and *Q* in subjective causality should be produced as two intonational units with a prosodic boundary between them because these two clauses formed two meaning units, and that the *P* and *Q* in objective causality should be produced as one integrated intonation unit without a prosodic boundary because they form one unified semantic unit. A few studies have evaluated this proposal, but so far, the evidence remains inconclusive. For example, Couper-Kuhlen (1996) and Günthner (1996) independently reported that subjective causality was uttered as two intonation units with an f0 reset at the beginning of the second unit, whereas objective causality was uttered as one intonation unit with an integrate f0 contour, seemingly supporting Rutherford (1970) and Sweetser (1990). However, these patterns were derived from auditory and visual inspection of f0 trajectories in sentences rather than statistical tests. Hence, it is not known to what extent their results are generalizable across speakers and utterances. Using a statistical approach, den Ouden (2004) compared the prosodic realizations of subjective and objective causality in read speech and found that the pause preceding the second clause was longer in subjective causality than in objective causality. Considering longer pauses could contribute to the perception of stronger prosodic boundaries (Wagner & Watson, 2010; Cole, 2015), this finding seems to support Rutherford (1970) and Sweetser (1990). However, one potential issue

with this study is that the subjective and objective causality being compared are not consistent in terms of causality order; the subjective causality used in the study is forward causality (ARGUMENT-CLAIM (CONCLUSION)*)*, whereas the objective causality is backward causality (CONSEQUENCE-CAUSE*)*. The difference in the order of causality may have caused the difference in the duration of the pause, casting doubt on the conclusion of the study.

Also directly relevant to the current research are the studies on prosodic realizations of stance (an umbrella term for subjectivity, evaluation, opinion, and assessment; Ward, Carlson, & Fuentes, 2018). These studies showed that words or simple sentences involving opinions had a wider pitch range, fewer pauses, faster speaking rates, and longer stressed vowels than utterances presenting facts (Morency, Mihalcea, & Doshi, 2011; Freeman, 2014; Freeman, 2019). We expect to see similar prosodic differences between complex sentences expressing subjective and objective causality because subjective causality involves opinions whereas objective causality only presents actual events.

In addition to the static prosodic properties above mentioned, the differences between subjective and objective causality might also be reflected in the overall pattern of f0 trajectories, such as the shape of f0 contour and the alignment of f0 peaks and valleys. Previous studies have found that the degree of 'matter-of-fact' conveyed in an utterance descends as the f0 peak position of the accented word in an utterance moves from an early to medial to late f0 synchronization, with early peaks conveying the highest degree of 'matter-of-fact' and late peaks speakers' evaluation (Kohler, 2005). Moreover, an attitudinal meaning contrast is reflected in the utterance-final rise versus fall contrast, with f0 final rises more strongly inviting the conversation partner to participate in the conversation than f0 final falls (Kohler, 2004). These findings suggest that utterances conveying subjective causality may have a later f0 peak and an f0 final rise compared to utterances expressing objective causality.

2.1.4 The current study

This study explored the role of prosody in expressing subjective and objective causality in the absence of specialized causal connectives (or other lexical markers for causality types). To this end, we conducted two experiments on the production of subjective and objective causality in English. Experiment 1 focused on the two types of causality in backward order (expressed with

because) and Experiment 2 in forward order (expressed with *so*). In the two experiments, we used a newly designed dialogue task to elicit utterances expressing subjective versus objective causality in a naturalistic conversation setting. A wide range of prosodic features was examined, including not only static acoustic-phonetic measurements such as f0 maximum, f0 minimum, articulation rate, and duration, but also the dynamic characteristics of f0 trajectories derived using Functional Principal Component Analysis (FPCA) (Gubian, Torreira, & Boves, 2015).

Based on the theoretical frameworks discussed in the previous section and on the findings of previous studies, we hypothesize that prosody would play a role in expressing subjective and objective causality in English in the absence of lexical markers. We have the following specific predictions. First, we predict that the two clauses of subjective causality would be produced as two intonation units because the meanings of the two clauses form two semantic units, and that those of objective causality as one intonation units because they form one unit. To test this prediction, we examined the duration of the pause (the silent interval) preceding the connective. Considering that a longer pause is a strong cue to a larger prosodic boundary (Wagner & Watson, 2010; Cole, 2015), we predict that the pause between the two clauses would be longer in subjective causality than in objective causality. Second, we predict that subjective causality would be produced with a wider pitch range and faster speaking rates than objective causality because it involves opinions. We also explored whether utterances expressing subjective and objective causality had different shapes of f0 contours. Our prediction is that compared to objective causality, subjective causality would be expressed by a later f0 peak and by a final rise at the end of an intonation unit. In this study, we focused on the f0 contour of the first clause and that of the connective *so*.

2.2 Experiment 1: Backward causality

2.2.1 Participants

Fifteen native speakers of American English (11 females, 4 males; age range: 22-25 years; mean age: 23 years) took part in the experiment. The participants were recruited from Utrecht University through the university's international

office and the first author's social networks. All of the participants had self-reported normal hearing and speaking abilities and declared no experience in acting. The participants received €10 after completing the experiment.

2.2.2 Task

A dialogue task was used to elicit utterances conveying subjective causality or objective causality. This task created a naturalistic conversational setting reminiscent of daily conversations and ensured that all speakers used the same sentences.

On each trial, the participants first read a PowerPoint slide, which automatically showed three pieces of information in sequence at 10-second intervals (see Figure 1 for the timeline). First, the participants saw a background story (texts in italics; see Figure 1) and an image, which set up the conversational context and primed the participants for upcoming information (Scholman & Demberg, 2017). In the objective causality condition, the stories told the participants that they were in direct contact with an imaginary acquaintance (e.g., chatting, as shown in Figure 1), and the acquaintance told the participants about actual events that occurred in reality. In the subjective causality condition, in contrast, the stories encouraged the participants to consider the upcoming information as their own opinions or evaluations of the character or event under discussion (e.g., "*You have the following impression about him"*). By means of these two different types of background stories, we expected to elicit utterances that expressed different types of causality, and each utterance expressed the same type of causality as the one designed. Ten seconds after the background information was shown, four short sentences appeared simultaneously on the slide, with a causal (or concessive) relationship between the second and third sentences (see the next section for details). Finally, a green button appeared in the bottom-right corner, prompting the participants that the dialogue was to start with the experimenter asking the first question.

By presenting information in this way, we ensured that the participants read all the information shown on the slides without skipping any information. In the meantime, we gave the participants enough time to process the discourse link between the sentences, especially the link between Sentences 2 and 3. In this way, we hoped to reduce the participants' cognitive pressure when conceptualizing subjective causality, thereby reducing the possible impacts of their physiological

states on prosody (Paulmann, Furnes, Bøkenes, & Cozzolino, 2016).

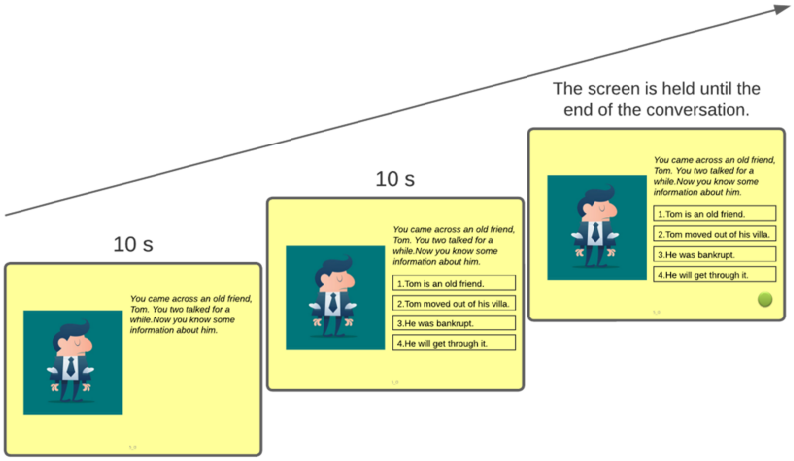


Figure 1. An example slide (for the objective item "*Tom moved out of his villa because he was bankrupt"*)

After reading each slide, the participants received three questions from the experimenter, the first question initiating the conversation, the second eliciting an utterance expressing subjective or objective causality (or a filler utterance expressing a concessive relation), and the third ending the conversation. In the target condition, the second question was "*Tell me something about X* (or a question with a similar meaning)." The questions eliciting filler items varied depending on the context.

Prior to the task, the participants received instructions on how to answer these questions (see Appendix A). They learned from the instructions that they were expected to use the first and last sentences on the slide to answer the first and third questions, respectively. To answer the target question, i.e., the second question, the participants had to combine the second and third sentences into one sentence using either *because* or *however* without changing the order of the two sentences. Take the slide in Figure 1 as an example. The sentence the participants were expected to produce in response to the second question was

"*Tom moved out of his villa because he was bankrupt."* These sentences were validated with respect to the causality they each conveyed before being embedded in the task (see the next section for details).

During the task, the participants independently processed the relationship between sentences 2 and 3 and chose the connective they saw fit. They received no feedback from the experimenter regarding the correctness of the answer. They were strongly encouraged to treat the sentences as their own words and produce them as naturally as they would in a real conversation, rather than reading them off the screen.

2.2.3 Materials

As described in the previous section, combining Sentences 2 and 3 on each slide using a correct connective yielded a sentence expressing subjective or objective causality. In total, each speaker produced thirty such sentences, all conveying backward causality with the connective *because*. Some of these sentences were taken from previous studies on subjectivity in causality (Canestrelli et al., 2013; Rodríguez-Gómez et al., 2016; Sanders & Evers-Vermeul, 2019; Traxler et al., 1997) and the rest were newly composed.

The thirty target sentences formed 15 pairs, each pair consisting of one objective causality sentence (see (5)) and one subjective causality sentence (see (6)) (see Appendix C for a complete list of sentences). The sentences were comparable in length and syntactic complexity.

(5) [Tom moved out of his villa]$_{C1}$ [because he was bankrupt]$_{C2}$.

(6) [Tom knew nothing about business]$_{C1}$ [because he was bankrupt]$_{C2}$.

For two items in each pair, the subordinate *because*-clauses (i.e., the second clauses, denoted by "C2" in subscripts in (5) and (6)) were identical, introducing the same real-world event (for example, "*He (Tom) was bankrupt*" in (5) and (6)), whereas the main clauses (the first clauses, denoted by "C1" in (5) and (6)) were different. The first clause stated the actual consequence of the event stated in C2 in the objective condition (e.g., "*Tom moved out of his villa*" in (5)) and expressed an opinion or conclusion regarding the event stated in C2 in the subjective condition (e.g., "*Tom knew nothing about business*" in (6)).

These items were proofread by several native speakers of American English before being embedded in the task. In addition, the authors verified the causal relation conveyed in each item using a paraphrase test with sentence frames (Sanders, 1997; Pander Maat & Degand, 2001). The sentence frame used to test objective causality was "*The fact that [P] led to the consequence that [Q]*." The one used for subjective causality was "*The fact that [P] leads to one's conclusion (claim or advice) that [Q]*." An item was considered valid if its paraphrase had the same meaning as the original sentence. All items passed the paraphrase test.

The target items were then divided into two lists, each containing approximately the same number of items for the two causal categories, but only one item from each pair. List 1 contained seven subjective items (from pairs 1-7) and eight objective items (from pairs 8-15); List 2 consisted of eight subjective items (from pairs 8-15) and seven objective items (from pairs 1-7). To conceal the purpose of the study, we added ten filler items to each list, the fillers all conveying concessive relations involving *however*.

2.2.4 Procedure

The participants were tested individually in a sound-treated booth in the phonetics lab at the Utrecht Institute of Linguistics OTS.

Upon each participant's arrival, the experimenter (the first author) informed the participant, without disclosing the real research goal, that the experiment was to collect natural speech samples for teaching purposes. The experimenter then introduced the interlocutor, a female native speaker of American English, to the participant. The participant was asked to treat the interlocutor as a friend and interact with her naturally during the experiment as if they were in real-life conversations. Afterward, the experimenter invited the participant into a sound booth and sit with the interlocutor at a table with a recorder and a computer monitor facing the participant's direction.

After being seated, the participant listened to the interlocutor explain the dialogue task, the design of the slides, and the instructions. Then, they performed two practice trials. After the practice trials, the participant completed trials on Lists 1 and 2 (or in reverse order) with a five-minute break in between. The items on each list were presented in random order. After each trial, participants clicked the mouse to proceed. The conversations were recorded in a PCM (.WAV) audio format using a ZOOM 1 portable digital recorder (sampling rate of 44.1 kHz, 16

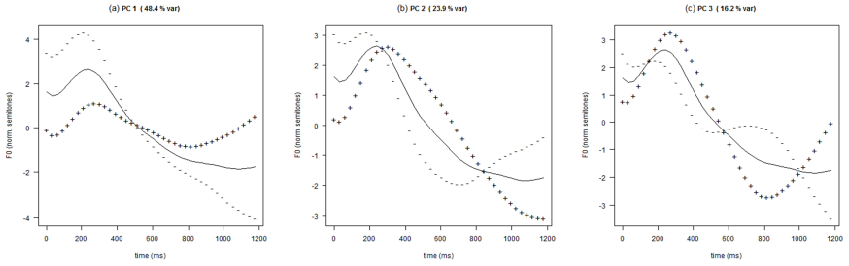
bit, stereo). The experiment took about 1 hour to complete.

2.2.5 Data annotation and measurements

The recordings obtained from the dialogue task were processed using *Praat* (Boersma & Weenink, 2018) as follows. First, the onset and offset of the target utterance, i.e., the utterance elicited by the second question, were marked in each dialogue. Then, the target utterances were extracted, yielding 450 utterances, four of which were discarded because they contained disfluencies. Third, each remaining utterance was annotated for the boundaries of three regions of interest: the first clause, the second clause, and the connective. For region-initial words starting with plosives, the initial boundary was set at the burst of the plosives. Fourth, the f0 contour of each utterance was inspected and octave jumps were manually corrected. Fifth, several prosodic measurements were extracted, including the f0 maximum and f0 minimum (in semitones (st) relative to 1 Hz) in each clause, the duration of the connective (in seconds (s)), and the duration of the silent interval preceding the connective. We also calculated the articulation rate in each clause, i.e., the number of syllables produced per second (Hardcastle, Laver, & Gibbon, 2010).

In addition to the static measurements mentioned above, we obtained several measurements describing the shape of f0 contours. These measurements were generated by modeling f0 contours using Functional Principal Component Analysis (hereafter FPCA; Gubian, Torreira, & Boves, 2015). The shape of f0 contour can also be described using phonological frameworks such as Tones and Break Indices (ToBI) (Beckman, Hirschberg, & Shattuck-Hufnagel, 2005), which describes the trajectory of f0 movement in terms of prosodic events using a set of predefined labels. For our purpose, FPCA is more suitable than phonological frameworks because FPCA can better handle the variability of f0 contours. In a nutshell, FPCA represents each f0 contour as a mathematical function consisting of the average contour of all f0 contours and several principal component curves (FPCs). Each FPC is associated with a weight indicating the extent to which that FPC should be applied to the average curve in order to adequately approximate an original f0 contour. In this chapter, FPCA was used to model the f0 contours of the first clause and those of the connective, respectively, following the procedure described in Gubian et al. (2015). First, the original f0 contours were smoothed by spline interpolation and linearly

normalized for duration. For the connective *because*, the smoothed contours were then scaled according to their common "landmarks", i.e. the boundary between the two syllables in *because*. Next, Functional PCA was performed to extract FPCs and calculate the weight of each FPC for each curve. Figure 2 demonstrates the effect of each FPC on the mean f0 contour (top row: the first clause; bottom row: the connective). In each panel, the solid line represents the mean f0 contour; the "+" and "-" curves represent the f0 contours after adding or subtracting one standard deviation of an FPC to or from the average contour, respectively; the vertical dash line in the bottom panel indicates the boundary between the two syllables in *because*. As can be observed in Figures 2.a and 2.d, FPC1 affects the overall linear slope of the mean f0 contour. For the f0 contour of the first clause, a positive weight of FPC1 makes the slope of the contour flatter and a negative weight of this FPC increases the steepness of the contour; for the f0 contour of the connective, the effects of the positive and negative weights of FPC1 are reversed. FPC2 mainly modifies the curvature of the mean contour. For the f0 contour of the first clause (Figure 2.b), a positive weight of FPC2 shifts the onset of the f0 fall towards the right end of the contour, making the fall less steep; a negative weight of FPC2 moves the onset of the fall towards the left end of the contour, resulting in a steeper fall. For the f0 contour of the connective *because* (Figure 2.e), a positive weight of FPC2 shifts the onset of the f0 rise towards the left end of the contour, making the middle of the contour more convex; a negative weight of FPC2 moves the onset of the rise towards the right end of the contour, making the middle of the contour less convex. FPC3 adjusts the temporal alignment of peaks and valleys in both cases, with a positive weight delaying the occurrence of a peak or valley and a negative weight advancing a peak or valley in time (Figures 2.c and 2.d).



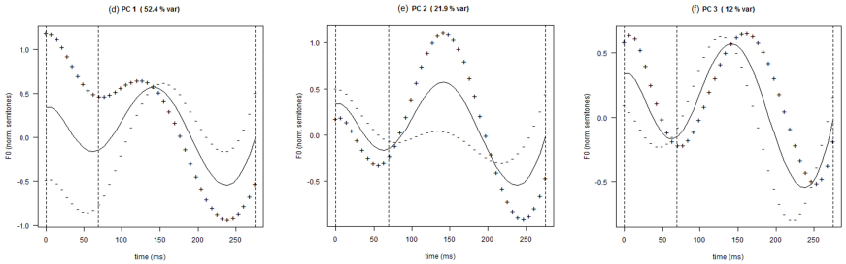


Figure 2. The effect of each FPC on the mean f0 contour of the first clause (top row) and on that of the connective (bottom row) (from left to right: FPC1, FPC2, FPC3). In each panel, the solid line represents the mean f0 contour (normalized f0 in semitones over time in ms); the "+" line illustrates the outcome curve after one standard deviation of a FPC is added to the mean f0 curve; the "-" line illustrates the outcome curve after one standard deviation of a FPC is subtracted from the mean f0 curve. The vertical dotted lines in the bottom panel represent syllable boundaries in *because*. The x-axis is the time in ms, the y-axis frequency values in semitones.

In total, 14 measurements were obtained; see Table 2 for the complete list.

Table 2

Measurements used in Experiment 1

Measurements	Descriptions
connectiveDur	The duration of the connective *because*
pauseDur	The duration of the silent interval between C1 and C2
PC1, PC2, PC3	The weights of the first three FPCs for the f0 contour of the connective
C1f0Maxst, C2f0Maxst, C1f0Minst, C2f0Minst	The f0 maximum and f0 minimum in C1 and C2
C1AR, C2AR	The articulation rate in C1 and C2, respectively
PC1_C1, PC2_C1, PC3_C1	The weights of the first three FPCs for the f0 contour of C1

2.2.6 Statistical analysis

The effect of `subjectivity` on each measurement was evaluated in `R` (version

3.6.3, R Core Team, 2020) using Bayesian statistics with the package `brms` (Bürkner, 2017), the wrapper package of the probabilistic programming language `Stan` (Carpenter et al., 2017). Since we were primarily interested in the presence or absence of the effect of `subjectivity`, we computed Bayes factors for this effect using the function `bayes_factor (m1, m0)`, which compared a full model (`m1`) containing the effect of `subjectivity` (contrast-coded, with subjective causality as +0.5 and objective causality as -0.5) and a null model (`m0`) not containing that effect (see Table 3 for the two models). The part of `m1` without the effect of `subjectivity` was identical to `m0`, consisting of `subject` and `item` as varying effects with random intercepts and `gender` as a constant effect (male versus female, contrast-coded as +0.5 and -0.5, respectively), which has known effects on several of our acoustic-phonetic measurements (see Cole, 2015 for a review). We also evaluated the interaction effect between `subjectivity` and `gender` (`subjectivity:gender`) on each measurement to see whether the interaction effect should be included in the models. After preliminary models showed that this interaction had no effect on any of the measurements (see Appendix B for detailed summaries), it was removed from our models.

Table 3

The full model (`m1`) and the null model (`m0`) used to compute the Bayes factors for `subjectivity`

Model	Formula
`m1`	`~ gender + subjectivity + (1|subject) + (1|item)`
`m0`	`~ gender + (1|subject) + (1|item)`

The resulting Bayes factors, referred to as BF_{10} (with the subscripts 1 and 0 referring to `m1` and `m0`, respectively), indicate the extent to which the evidence supports `m1` over `m0`, akin to the ratio of likelihoods of the two models (Lee & Wagenmakers, 2014; Nicenboim & Vasishth, 2016). For evaluation purposes, BF_{10} values of 10-30, 3-10, 2-3, and close to 1 indicate strong evidence, weak evidence, very weak evidence, and no evidence supporting `m1`, respectively; and BF_{10} values less than 0.1 indicate that the evidence is in favor of `m0` (Jeffreys,

1998). Because the Bayes factors for an effect are sensitive to the prior distributions of the effect, Bayes factors were computed multiple times under different priors, following Vasishth, Nicenboim, Beckman, Li, & Kong (2018) and Nicenboim, Vasishth, & Rösler (2020). The priors we used were normal distributions `normal (0, SD)` with an increasingly larger `SD` (standard deviation). Appropriate hyperparameters for the priors were derived from previous studies on the prosodic correlates of discourse structure (den Ouden, et al., 2009) (see statistical summaries in Appendix B for the priors used in each model). The Bayes factors were computed by bridge sampling with four chains and 10,000 iterations, 2000 of which were in the warm-up phase.

In the result sections below, we reported the mean and 95% credible interval (95% CrI, an equal-tailed interval) of the posterior distribution of the model parameter corresponding to `subjectivity`, as well as the BF_{10} for this effect computed under different priors. If the effect was credible (BF_{10} greater than 3), we also showed in a figure the highest density interval (HDI) of the posterior distribution, which was the most plausible range of posterior values (for detailed discussions on the differences between HDI and CrI, see Kruschke, 2014). Unless otherwise stated, the posterior distributions mentioned in the main texts were all estimated by the model involving the prior with the largest `SD` (i.e., the least informative prior).

2.2.7 Results

2.2.7.1 Duration

Table 4.a shows that the BF_{10} evaluating the effect of `subjectivity` on pause duration was larger than 10 under all incorporated priors, indicating strong evidence for the effect (Estimate = 0.05 s, 95% CrI [0.02 s, 0.08 s]; also see Figure 3 for the HDI). The model predicted that the pause duration preceding the connective was 50 ms longer in subjective causality than in objective causality.

For the duration of the connective, the BF_{10} evaluating the effect of `subjectivity` was less than 0.1 (Table 4.b) for all priors used, showing no support for the effect of `subjectivity` (Estimate: 0.00 s, 95% CrI [-0.02 s, 0.01 s]).

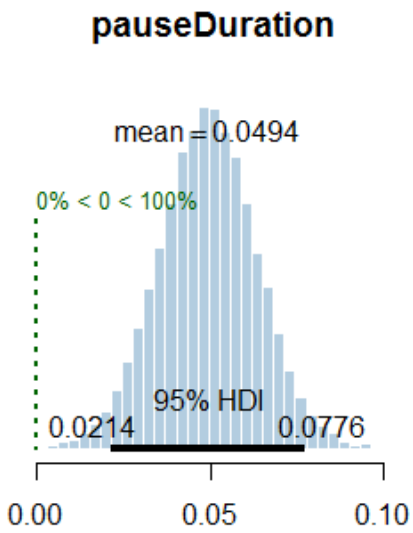


Figure 3. The posterior distribution of the effect of `subjectivity` on the duration of the pause preceding the connective, generated by the model containing `subjectivity` (prior `Normal (0, 0.2)`) and `gender` as constant effects, shown with the name of the variable at the top of the figure, the mean above the histogram, the highest density interval (HDI) as the horizontal black bar on the floor, and the proportion of the distribution below and above the value of zero as percentages.

Table 4

Overview of the priors used to calculate the Bayes factors evaluating the presence or absence of the effect of subjectivity on durational measurements: (a) the duration of the pause; (b) the duration of the connective. Also reported are Bayes factors evaluating the effect of subjectivity, the mean of its posterior distribution, and the lower and upper boundaries of the 95% credibility interval of its posterior distribution.

a. Pause duration

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 0.05)	41.86	0.05	0.02	0.08
	Normal(0, 0.1)	29.63	0.05	0.02	0.08
	Normal(0, 0.2)	16.60	0.05	0.02	0.08

b. Connective duration

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 0.1)	0.07	-0.00	-0.02	0.01
	Normal(0, 0.3)	0.02	-0.00	-0.02	0.01
	Normal(0, 0.5)	0.01	-0.00	-0.02	0.01

2.2.7.2 The shape of f0 contour

There was no evidence that `subjectivity` had an effect on the shape of the f0 contour of the first clause or on that of the connective, as suggested by the small BF_{10} (around 1 in the former case and less than 0.1 in the latter case; see Table 3 and Table 6 in Appendix B for details).

2.2.7.3 f0 maximum and minimum

For the *first* clause, there was weak evidence (BF_{10} between 3 and 10) that `subjectivity` had an effect on its f0 maximum (Estimate = 0.60 st, 95% CrI = [0.16 st, 1.04 st], see Figure 4.a). According to the model, the f0 maximum in the first clause was higher in subjective causality than in objective causality. In addition, there was evidence that `subjectivity` had an effect on the f0 minimum (Estimate = -0.70 st, 95% CrI = [-1.17 st, -0.24 st], Figure 4.b). With the most informative prior, the evidence was strong (BF_{10}>10); with a relatively diffuse prior, the evidence became weaker (BF_{10} around 8). The model predicted that the f0 minimum in the first clause was lower in subjective causality than in objective causality.

For the *second* clause, there appeared to be no evidence for `subjectivity` having an effect on its f0 maximum and minimum, as BF_{10} remains less than 1 (see Tables 4.c and 4.d).

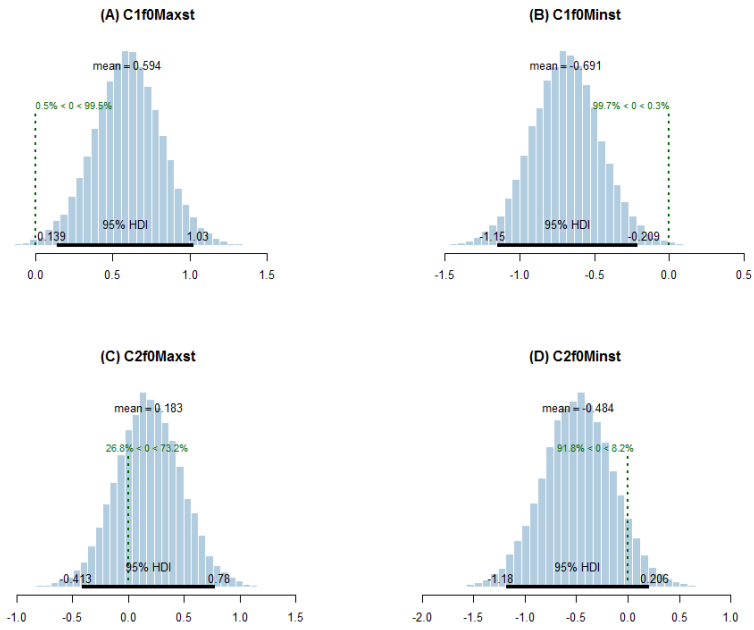


Figure 4. The posterior distribution of the effect of `subjectivity` on (a) the f0 maximum in the first clause, (b) the f0 minimum in the first clause, (c) the f0 maximum in the second clause, and (d) the f0 minimum in the second clause, estimated by the model with `subjectivity` (prior `normal (0, 2)`) and `gender` as constant effects, shown with the name of the variable at the top of each panel, the mean above the histogram, the highest density interval (HDI) as the horizontal black bar on the floor, and the proportion of the distribution below and above the value of zero as percentages.

Table 4

Overview of the priors used to calculate the Bayes factors evaluating the presence or absence of the effect of `subjectivity` on f0-related measurements: (a) f0 maximum in the first clause; (b) f0 minimum in the first clause; (c) f0 maximum in the second clause; (d) f0 minimum in the second clause. Also reported in the tables are the Bayes factors for the effect of `subjectivity`, the mean and the lower and upper bounds of the 95%

credibility interval of the posterior distribution of the model parameter corresponding to `subjectivity`.

a. C1f0Maxst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 0.5)	6.96	0.57	0.13	1.00
	Normal(0, 1)	6.21	0.59	0.15	1.03
	Normal(0, 1.5)	4.69	0.59	0.15	1.04

b. C1f0Minst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 0.5)	12.84	-0.67	-1.12	-0.21
	Normal(0, 1)	9.72	-0.69	-1.15	-0.24
	Normal(0, 1.5)	7.85	-0.69	-1.16	-0.22

c. C2f0Maxst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 1)	0.35	0.17	-0.40	0.74
	Normal(0, 1.5)	0.23	0.18	-0.41	0.77
	Normal(0, 2)	0.17	0.18	-0.41	0.78

d. C2f0Minst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 1)	0.83	-0.44	-1.10	0.23
	Normal(0, 1.5)	0.62	-0.47	-1.14	0.22
	Normal(0, 2)	0.47	-0.48	-1.18	0.21

2.2.7.4 Articulation rate

The very small BF_{10} shown in Tables 5.a and 5.b indicate that there was no evidence for `subjectivity` having an effect on the articulation rate in the first or the second clause.

Table 5

Overview of the priors used to calculate the Bayes factors evaluating the

presence or absence of the effect of `subjectivity` *on articulation rates: (a) that in the first clause; (b) that in the second clause. Also reported in the tables are the Bayes factors evaluating the effect of* `subjectivity`*, the mean and the lower and upper boundaries of the 95% credibility interval of the posterior distribution of the model parameter corresponding to* `subjectivity`*.*

a. C1AR

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 1)	0.35	0.20	-0.37	0.77
	Normal(0, 1.5)	0.24	0.21	-0.36	0.78
	Normal(0, 2)	0.18	0.21	-0.34	0.79

b. C2AR

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 1)	0.24	-0.02	-0.53	0.49
	Normal(0, 1.5)	0.17	-0.02	-0.55	0.50
	Normal(0, 2)	0.13	-0.02	-0.55	0.51

2.2.8 Discussion

The results of Experiment 1 clearly showed that subjective and objective causality in backward order had different prosodic realizations. Specifically, we found a longer pause preceding the connective in subjective causality than in objective causality, suggesting that the two clauses included in subjective causality are more prosodically detached compared to the two clauses involved in objective causality, reflecting the conceptual distinction between the two types of causality proposed in the discourse literature (Zufferey, 2012). Moreover, since a longer pause preceding a phrase tends to contribute to the perception of a stronger prosodic boundary before that phrase (Ferreira, 1993; Swerts & Geluykens, 1994), our result suggests that complex sentences expressing subjective causality are more likely to be produced as two information units than those expressing objective causality, in support of the claim made in discourse literature (Rutherford, 1970; Sweetser, 1990; Couper-Kuhlen, 1996).

In addition, we found that subjective causality had a *higher f0 maximum* and a *lower f0 minimum* (hence an *expanded f0 range*) than objective causality, in line with our predictions based on previous studies on the prosodic realizations

of stance (Morency et al., 2011).

Although we found several prosodic differences between subjective and objective causality in the backward order, it remains unknown whether these findings apply to subjective and objective causality in the forward order, in which *P* precedes *Q*. This question is addressed in Experiment 2.

2.3 Experiment 2: Forward causality

2.3.1 Participants

Fifteen native speakers of American English (11 females, 4 males; age range: 22-26 years; mean age: 24 years) participated in Experiment 2, which was conducted six months after Experiment 1. The participants were recruited from Utrecht University through the university's international office and the first author's social networks. Of the fifteen participants, three had participated in Experiment 1, but they had remained naïve about the real research goal and claimed to have no recollection of the utterances in Experiment 1. All participants reported no experience in acting.

2.3.2 Task and procedure

The participants were tested in a sound-treated booth in the phonetics lab at the Utrecht Institute of Linguistics OTS. They completed the same dialogue task as used in Experiment 1, following the same procedure (see Sections 2.2.2 & 2.2.4 for details). As in Experiment 1, the task used in the current experiment used PowerPoint slides to present information. The design of the slides was the same as that of the slides used in Experiment 1, except that the positions of sentences 2 and 3 on each slide were reversed, thereby changing the order of causality between these two sentences from the backward to the forward order. The instructions given to the participants were identical to those given in Experiment 1, except that the two optional connectives became *so* and *but*. The participants received a participation fee of 10 euros.

2.3.3 Materials

The target utterances elicited by the task were adapted from the items used in Experiment 1, all expressing forward causality with the causal connective *so*. As in Experiment 1, there were 15 pairs of such items in the current experiment,

each pair consisting of one subjective causality sentence and one objective causality sentence. For the two items in each pair, the first clauses (denoted by "C1" in the subscripts in (7) and (8)) were the same, introducing a real-world event (e.g., "*Tom was bankrupt*" in (7) and (8)), and the second clauses (denoted by "C2" in the superscripts) were different. It stated the consequence of the event described in C1 in the objective condition (e.g., "*He moved out of his villa*" in (7)) and expressed an opinion regarding that event in the subjective condition (e.g., "*He knew nothing about business*" in (8)).

(7) [Tom was bankrupt]$_{C1}$ [so he moved out of his villa]$_{C2}$.
(8) [Tom was bankrupt]$_{C1}$ [so he knew nothing about business]$_{C2}$.

The current experiment made use of the filler items used in Experiment 1 to disguise the real research goal.

2.3.4 Data annotation and statistical analysis

The recordings obtained from the experiment were processed in the same steps as used in Experiment 1 (see Section 2.2.5 for details). We also used FPCA to model the f0 contour of the first clause and that of the connective *so*. Figure 5 shows the effects of the first three FPCs on the mean f0 contour of the first clause (top panel) and that of the connective *so* (bottom panel). As can be observed from the top panel, the effects of the three FPCs on the average contour of the first clause were similar to those reported in Experiment 1 (see Section 2.2.5 for detailed descriptions). As for the effects of the three FPCs on the f0 contour of the connective *so*, it can be observed in Figure 5.d that FPC1 affects the overall linear slope of the mean f0 contour. A positive weight of FPC1 makes the slope of the contour steeper and a negative weight flatter. FPC2 modifies the curvature of the mean curve, with a positive weight increasing the curve's concavity and a negative weight increasing the curve's convexity (Figure 5.e). FPC3 seems to mainly moderate the intercept of the curve with the y-axis, with a positive weight making the intercept larger and a negative weight making the intercept smaller (Figure 5.f).

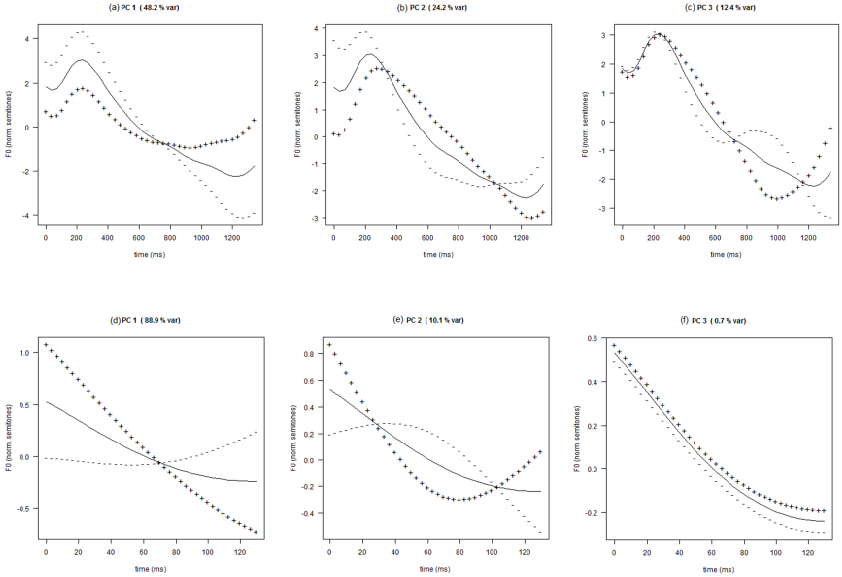


Figure 5. The effect of each FPC on the mean f0 contour of the first clause (top row) and on that of the connective (bottom row) (from left to right: FPC1, FPC2, FPC3). In each panel, the solid line represents the mean f0 contour (normalized f0 in semitones over time in ms); the "+" line illustrates the outcome curve after one standard deviation of a FPC is added to the mean f0 curve; the "-" line illustrates the outcome curve after one standard deviation of a FPC is subtracted from the mean f0 curve. The x-axis denotes time in ms, the y-axis frequency values in semitones.

The measurements and the statistical method used to analyze the effect of `subjectivity` on each measurement were identical to what were used in Experiment 1 (see Sections 2.2.6 for details).

2.3.5 Results

2.3.5.1 Duration

As shown in Table 6.a, for all priors incorporated, the Bayes factors evaluating the effect of `subjectivity` on *pause duration* were very small (around 0.1), in favor of the model without the effect of `subjectivity`, showing that

`subjectivity` did not have an effect on the *pause duration* between the two clauses in our data.

For the effect of `subjectivity` on the *duration of the connective so*, the Bayes factors were greater than 100 (see Table 6.b) for all priors incorporated, indicating strong support for the presence of the effect (Estimate: 0.05 s, 95% CrI [0.03 s, 0.07 s]; also see the 95% HDI shown in Figure 6). The estimates suggest that the duration of the connective is greater in subjective causality than in objective causality, with an estimated mean difference of 50 ms.

Table 6

Overview of the priors used to calculate the Bayes factors evaluating the presence or absence of the effect of `subjectivity` *on duration: (a) the duration of the pause; (b) the duration of the connective. Also reported in the tables are the Bayes factors evaluating the effect of* `subjectivity`*, the mean and the lower and upper bounds of the 95% credibility interval of the posterior distribution of the model parameter corresponding to* `subjectivity`*.*

a. Pause duration

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 0.1)	0.13	-0.01	-0.02	0.01
	Normal(0, 0.3)	0.04	-0.01	-0.02	0.01
	Normal(0, 0.5)	0.02	-0.01	-0.02	0.01

b. Connective duration

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 0.1)	>>100	0.05	0.03	0.06
	Normal(0, 0.3)	>>100	0.05	0.03	0.07
	Normal(0, 0.5)	>>100	0.05	0.03	0.06

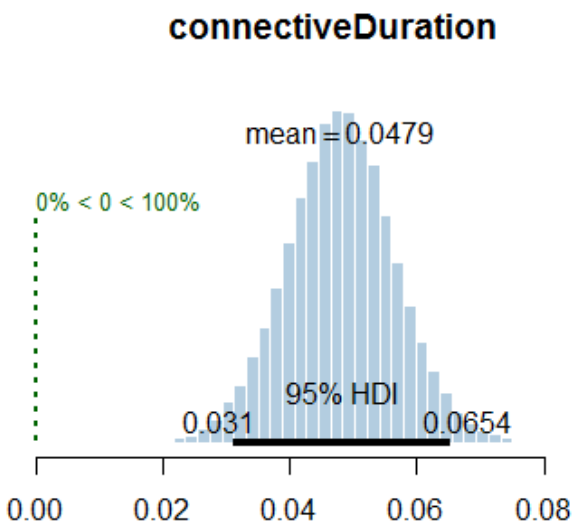


Figure 6. The posterior distribution of the effect of `subjectivity` on the duration of the connective *so*, estimated by the model containing `subjectivity` (prior `Normal (0, 0.5)`) and `gender` as constant effects, shown with the name of the variable on top, the mean above histogram, the highest density interval (HDI) as the horizontal black bar on the floor, as well as the proportion of the distribution below and above the value of zero as percentages.

2.3.5.2 The shape of the f0 contour

For the f0 contour of the connective *so*, Table 7.a shows that there is some weak evidence (BF_{10} between 6.24 and 9.41) for `subjectivity` having an effect on the weight of FPC2 (Estimate = 0.85, 95% CrI [0.24, 1.46]). This estimation indicates that FPC2's weight was on average 0.85 units larger in subjective causality than in objective causality. In descriptive terms, this result means that the shape of the f0 contour of the connective is more concave in subjective causality than in objective causality. Table 7.b shows very weak evidence that `subjectivity` has an effect on the weight of FPC3 (Estimate: -0.09, 95% CrI

[-0.19, 0.00]). When calculated under the most informative prior (`normal (0, 0.1)`), BF_{10} equals 2.06. However, with a less informative prior (`normal (0, 0.5)`), BF_{10} decreases to 0.64. The model predicts that the weight of FPC3 is 0.09 units smaller in subjective causality than in objective causality. In descriptive terms, it means that the f0 contour of the connective *so* has a smaller intercept with the y-axis in subjective causality than in objective causality. For FPC1, `subjectivity` has no effect on our data; see Table 9 in Appendix B.

Table 7

Overview of the priors used to calculate the Bayes factors evaluating the presence or absence of the effect of `subjectivity` *on the weights of the FPCs: (a) FPC2; (b) FPC3 (for the summary of the estimates related to FPC1, see Table 9 in Appendix B). Also reported in the tables are the Bayes factors evaluating the effect of* `subjectivity`*, the mean and the lower and upper bounds of the 95% credibility interval of the posterior distribution of the model parameter corresponding to* `subjectivity`*.*

a. FPC2

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 1)	9.41	0.79	0.20	1.37
	Normal(0, 1.5)	7.59	0.83	0.23	1.44
	Normal(0, 2)	6.24	0.85	0.24	1.46

b. FPC3

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 0.1)	2.06	-0.08	-0.16	0.01
	Normal(0, 0.3)	1.00	-0.09	-0.19	0.01
	Normal(0, 0.5)	0.64	-0.09	-0.19	0.00

For the f0 contour of the first clause, however, the results showed that `subjectivity` did not have any effect on the shape of the f0 contour; BF_{10} examining the effects of `subjectivity` on the weights of the three FPCs were all less than 1 (see Table 12 in Appendix B).

2.3.5.3 F0 maximum and minimum

There was no evidence that `subjectivity` affected the f0 maximum and minimum in the first clause, as indicated by the small BF_{10} shown in Table 8.a and 8.b.

For the second clause, the evidence strongly favored the presence of the effect of `subjectivity` on its *f0 maximum*, as the BF_{10} was greater than 10; see Table 8.c. The model gave an estimated mean of 0.71 st with a 95% CrI [0.27 st, 1.16 st] (see the HDI in Figure 7), meaning that the f0 maximum in the second clause was 0.71 st higher in subjective causality than in objective causality. As for the *f0 minimum in the second clause*, the small Bayes factors indicated no evidence supporting the effect of `subjectivity` in our data.

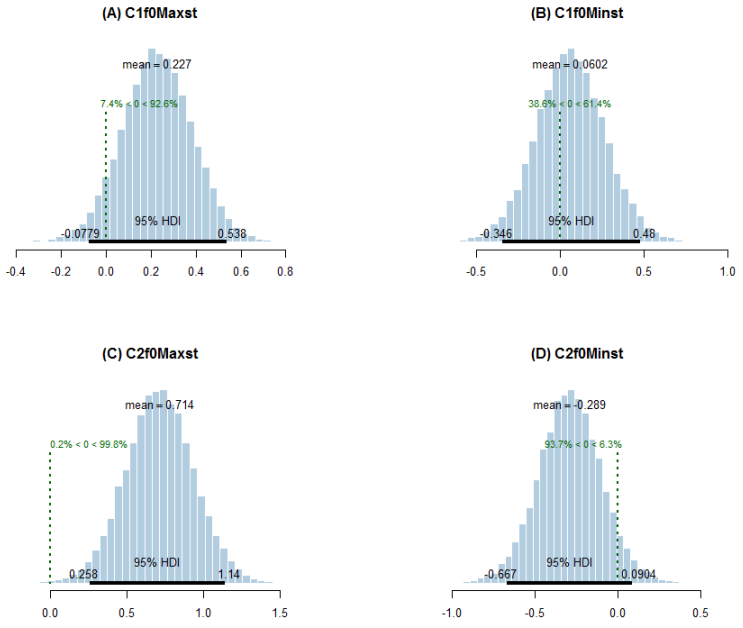


Figure 7. Posterior distributions of the effect of `subjectivity` on the f0-related measurements: (a) the f0 maximum in the first clause, (b) the f0 minimum in the first clause, (c) the f0 maximum in the second clause, and (d) the f0 minimum in the second clause, generated by the model containing `subjectivity` (prior `normal (0, 2)`) and `gender` as constant effects,

shown with the name of the variable at the top of each panel, the mean above each histogram, the highest density interval (HDI) as the horizontal black bar on the floor, as well as the proportion of the distribution below and above the value of zero as percentages.

Table 8

Overview of the priors used to calculate the Bayes factors evaluating the presence or absence of the effect of `subjectivity` *on f0-related measurements: (a) f0 maximum in the first clause; (b) f0 minimum in the first clause; (c) f0 maximum in the second clause; (d) f0 minimum in the second clause. Also reported in the tables are the Bayes factors evaluating the effect of* `subjectivity`*, the mean and the lower and upper bounds of the 95% credibility interval of the posterior distribution of the model parameter corresponding to* `subjectivity`*.*

a. C1f0Maxst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 1)	0.46	0.22	-0.08	0.53
	Normal(0, 1.5)	0.32	0.23	-0.08	0.53
	Normal(0, 2)	0.22	0.23	-0.08	0.53

b. C1f0Minst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 1)	0.21	0.06	-0.34	0.46
	Normal(0, 1.5)	0.13	0.06	-0.35	0.47
	Normal(0, 2)	0.10	0.06	-0.35	0.47

c. C2f0Maxst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 1)	19.72	0.69	0.24	1.12
	Normal(0, 1.5)	15.37	0.71	0.26	1.14
	Normal(0, 2)	12.46	0.71	0.27	1.16

d. C2f0Minst

Constant effect	Prior	BF_{10}	Posterior

			Estimate	Lower	Upper
subjectivity	Normal(0, 1)	0.63	-0.28	-0.65	0.09
	Normal(0, 1.5)	0.41	-0.29	-0.66	0.09
	Normal(0, 2)	0.32	-0.29	-0.67	0.09

2.3.5.4 Articulation rate

Tables 9.a and 9.b show that the Bayes factors evaluating the effects of `subjectivity` on the articulation rate in the first and second clauses are very small, in favor of the model without the effect of `subjectivity`.

Table 9

Overview of the priors used to calculate the Bayes factors evaluating the presence or absence of the effect of `subjectivity` on the two articulation rates: (a) that in the first clause; (b) that in the second clause. Also reported in the tables are the Bayes factors evaluating the effect of `subjectivity`, the mean and the lower and upper bounds of the 95% credibility interval of the posterior distribution of the model parameter corresponding to `subjectivity`.

a. C1AR

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 1)	0.30	0.00	-0.56	0.58
	Normal(0, 1.5)	0.19	0.00	-0.60	0.59
	Normal(0, 2)	0.14	0.00	-0.60	0.62

b. C2AR

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
subjectivity	Normal(0, 1)	0.35	-0.20	-0.68	0.31
	Normal(0, 1.5)	0.24	-0.20	-0.72	0.32
	Normal(0, 2)	0.18	-0.20	-0.72	0.32

2.3.6 Discussion

Our results showed several prosodic differences between subjective and objective causality in forward order. Specifically, the connective *so* had a longer duration in subjective causality than in objective causality. Further analyses

showed that both the consonant and vowel in *so* were lengthened in the subjective condition (the consonant: Estimate = 15 ms, 95% CrI [6 ms, 25 ms], BF_{10} = 36.2; the vowel: Estimate = 22 ms, 95% CrI [10 ms, 30 ms], BF_{10} >> 100). Previous studies have shown that word-initial lengthening can result in a perceptual prosodic boundary preceding a word (Fougeron & Keating, 1997; Keating, Cho, Fougeron, & Hsu, 2004). Thus, our result suggests a high likelihood that utterances expressing subjective causality involve two intonation units, while utterances expressing objective causality one intonation unit, supporting the claim of previous discourse studies (Rutherford, 1970; Sweetser, 1990; Couper-Kuhlen, 1996).

We also found that, compared to objective forward causality, subjective forward causality had a higher f0 maximum (hence an expended f0 range), consistent with our prediction. This result is also compatible with the prosodic characteristics of utterances conveying a stance (Morency et al., 2011).

In addition to the distinctions in static prosodic features mentioned above, we found that the two types of causality differed in the f0 trajectory across the connective *so*. However, unlike what we predicted, the difference is not in f0 peak alignment or final f0 movement but in the curvature of the f0 contour of the connective, which is more concave in subjective causality than in objective causality.

2.4 General discussion

This chapter aimed to shed light on the role of prosody in expressing subjective and objective causality in the absence of specialized causal connectives. To this end, we conducted two experiments on the production of subjective and objective causality in English, which is often expressed using a general causal connective. Experiment 1 focused on the two types of causality in a backward causal order, and Experiment 2 those in a forward causal order.

We had three specific predictions about the prosodic distinctions between the two types of causality. First, we predicted that in utterances expressing causality, the pause between the two clauses would be longer when the utterance expresses subjective causality than when it expresses objective causality. The result of Experiment 1 confirms this prediction, suggesting that subjective backward causality is more likely to have a stronger prosodic boundary before

the second clause than objective backward causality, consistent with the claims in earlier discourse literature (Rutherford, 1970; Sweetser, 1990; Couper-Kuhlen, 1996). In Experiment 2, we found that the length of the pause did not differ between the two types of causality, but the duration of the initial consonant in the connective *so* was longer in the subjective condition than in the objective condition. Considering that the lengthening of the consonant at the word-initial position can lead to a perceptual prosodic boundary preceding the word (Fougeron & Keating, 1997; Keating et al., 2004), our result suggests that the two clauses in subjective causality are more likely to be produced as two information units, compared to clauses in objective causality, supporting the claim made in discourse literature.

Our second prediction was that subjective causality would be produced with a wider pitch range than objective causality. The results of the two experiments confirm this prediction, suggesting that the presence or absence of stance in establishing causality affects prosody, in line with previous studies on the prosodic characteristics of stance-expressing utterances (Morency et al., 2011).

We also explored whether subjectivity would affect the overall shape of the f0 contour. For forward causality, we found that the shape of the f0 contour of the connective was more concave in subjective causality than in objective causality. For backward causality, however, no distinction in f0 contour shape was found between the two types of causality. Previous studies have found that the concave-convex contour distinction is related to the perceived degree of harshness or softness of the utterance (Yang & Campbell, 2001). Our results extend this finding by showing that it is also associated with the subjective-objective contrast in English discourse expressing forward causality.

To summarize, we found several prosodic differences between subjective and objective causality in English in the absence of lexical markers for each causality type. Compared to objective causality, subjective causality had an expanded f0 range and longer duration. Note, however, that these features appear in a different location in forward subjective causality than they do in backward subjective causality. For backward subjective causality, the expanded f0 range was found in the first clause; for forward subjective causality, it was in the second clause. Given that these clauses convey opinions in subjective causality (the other clauses state facts), our finding suggests that although subjectivity

serves to connect the two clauses in subjective causality and has an effect on f0, its effect is limited to the clause containing the opinion rather than spreading over the entire utterance. Regarding duration, we found that backward subjective causality (Experiment 1) had a longer pause between the main clause and the subordinate clause, whereas subjective forward causality (Experiment 2) had a lengthened clause-initial connective *so*. The different locations of lengthening may be related to the difference in the syntax-prosody interface between backward and forward constructions. In the backward construction, the "*because*-clause" has a subordinating relation with the main clause and is typically not produced with a pause between it and the main clause (e.g., Lelandais & Ferré, 2016; Tyler, 2013). Our results suggest that speakers exploit the acoustic space between the main clause and *because* to encode subjectivity, by producing a longer pause in backward subjective causality. In the forward construction, the "*so*-clause" and the preceding clause are coordinated clauses, and are typically produced with a pause between them. The acoustic space between the first main clause and *so* is thus used for marking syntactic structure regardless of causality. In this case, speakers vary the duration of the first word after the pause, i.e., the connective *so*, to distinguish different types of causality. The difference in the locus of duration-related difference can also be explained by the order of *P* and *Q*. In backward subjective causality, *Q* precedes *P*, the opposite of the natural order in which events occur, thus creating a discontinuity in mental representation and therefore a temporal gap in speech. In forward subjective causality, in contrast, *P* precedes *Q*, the order in which *P* and *Q* naturally occur, and thus there is no acoustic gap between *P* and *Q* in production.

To our knowledge, the current study is the first to experimentally investigate the prosodic distinctions between lexically underspecified subjective versus objective causal relations. Our findings suggest that English speakers, who often leave the distinction between subjective and objective causality implicit at the lexical level, use prosodic means to distinguish between these two types of causality. The current study also stimulates follow-up research concerning the role of prosody in the production and perception of subjective versus objective causality. Questions awaiting investigation include: Does prosody still play a role in expressing subjective and objective causality if specialized causal connectives are used? Do the prosodic patterns found in the

production studies have any perceptual relevance to listeners in comprehending subjective and objective causality? These two questions are investigated in Chapters 3 and 4, respectively.

2.5 Conclusions

This study explored the prosodic differences between two types of cognitively distinctive yet lexically underspecified causal relations: subjective and objective causality in English. Two production experiments were conducted, focusing on backward and forward causality, respectively. The results showed that the two types of causality differed in terms of f0 and duration: subjective causality had a larger f0 range and longer duration than objective causality. Also, the connective *so* used in forward causality had a more concave f0 contour in subjective causality. These results reveal that the distinction between subjective and objective causality is indeed expressed by prosodic means in the absence of explicit lexical markers.

Chapter 3

The role of prosody in expressing subjective and objective causality: A cross-linguistic perspective[4]

Studies have shown that subjective causality and objective causality are often expressed by different lexical cues. In contrast, the role of non-lexical cues, such as prosody, in expressing these two types of causality is not fully understood. In expressing different meanings and functions, a trade-off relationship has been proposed between the use of prosody and the use of lexical means. This implies that prosody will be more actively involved in expressing subjective and objective causality when the two types are not distinguished by lexical cues than when they are. Earlier studies have suggested that prosody indeed plays an active role in expressing these two types of causality when lexical cues are absent. The current study concerns the extent to which prosody is used when lexical cues for subjective and objective causality are already in use. Two production experiments were conducted. Experiment 1 explored this issue in Mandarin,

[4] Preliminary results of Experiment 1 in this chapter were presented at Speech Prosody 2022 and published in the conference proceedings as Hu, Chen, Li, Quené, & Sanders (2022).

where specialized causal connectives are commonly used to express the two types of causality. Experiment 2 focuses on Dutch, where specialized causal connectives can be used above and beyond prototypical usage as a general causal connective. Our results support the proposed trade-off relationship: prosody is less likely to be used when the two types of causality are already distinguished by specialized causal connectives (*kejian* 'so' and *yushi* 'so' in Mandarin, *dus* 'so' and *daardoor* 'so' in Dutch) than when they are expressed by a general causal connective (*dus* in Dutch). Additionally, our data also showed considerable variation in the use of *dus*. This raised the question as to what extent speakers' preference for causal connectives influenced how they used prosody. We hypothesize that speakers with a higher tendency to use specialized causal connectives will use prosody to a lesser extent compared to speakers with a higher tendency to use a general causal connective. Our data provided only very weak to inconclusive evidence for this latter hypothesis.

3.1 Introduction

Causality is a concept of primary importance in human life and thought. In the real world, we often encounter causally-related events. For example, a temperature below zero causes the lake to freeze over, as in example (1a), where "*The temperature was below zero"* is a cause, and "*The lake was frozen"* is the consequence. In our mental world, too, we draw causal inferences (e.g., constructing causal relations involving hypothesized states or events) from facts observed in the real world. Take sentence (1b) as an example. The causal connection between the two clauses in the sentence is established by reasoning – *"They are not at home"* is an inference based on the fact that "*Their car is not there"* (Sanders & Spooren, 2015).

(1a) The temperature was below zero for weeks. So the lake was frozen.

(1b) Their car is not there. So they are not at home.

(Adapted from Stukker, Sanders, & Verhagen, 2009)

The primary distinction between these two types of causality is that the first type only involves events that happen in reality, whereas the second type relies on human reasoning. In the discourse literature, these two causality types have been referred to as *content* versus *epistemic* relations (Sweetser, 1990), *semantic* versus *pragmatic* relations (Sanders, Spooren, & Noordman, 1992), or *objective* versus *subjective* causality (Pander Maat & Sanders, 2000; Sanders & Sweetser, 2009), respectively. In this study, we will use the last two terms.

3.1.1 The role of causal connectives in expressing subjective and objective causality

A large body of research has been devoted to exploring how subjective and objective causality are expressed in language, focusing primarily on the use of morphosyntactic devices such as words, phrases, and syntactic structures (see Stukker & Sanders, 2012, for an overview). In particular, studies have found that in some languages these two types of causality can be distinguished by causal connectives. For instance, in Mandarin, the causal connective *kejian* 'so' has a strong subjective profile and is used exclusively to express subjective causality,

whereas the causal connective *yushi* 'so' has an objective profile and is often used to express objective causality, as seen in examples (2a) and (2b), respectively (Li, Evers-Vermeul, & Sanders, 2013). Causal connectives with such strong characteristics are also observed in other languages, including Dutch, where *daardoor* 'so' is specialized in objective causality (Stukker, Sanders, & Verhagen, 2008; Stukker, Sanders, & Verhagen, 2009), and German, where *weil* 'because' and *denn* 'because' are for objective and subjective relations, respectively (Stukker & Sanders, 2012). Since these causal connectives can only be used to express specific types of causality, they function as lexical markers of causality types in communication, signaling to the reader (listener) the type of causality the author (speaker) intends to convey.

(2a) 今天天气很好，于是我去游泳了。
[It was a lovely day, *yushi* I went swimming.]
It was a lovely day, so I went swimming.

(2b) 他们的车不在，可见他们不在家。
[Their car is not there, *kejian* they are not at home.]
Their car is not there, so they are not at home.

In other languages, however, specialized causal connectives are not used as frequently to express causality, despite their presence in the languages' vocabularies. Instead, causality is generally expressed by a general causal connective. A case in point is English. Take causality in the forward order (CAUSE-CONSEQUENCE and ARGUMENT-CLAIM) as an example. Although the connective, *therefore,* is specialized in expressing subjective causality (e.g., "*Their car is not there, therefore, they are not home"*), it is used much less frequently than the general causal connective *so*, as in sentences (1a) & (1b) (Andersson & Sundberg, 2021; Andersson, 2016; Taboada, 2006).

In still other languages, specialized causal connectives coexist with general causal connectives, both commonly used to express subjective and objective causality. A typical example is Dutch. As mentioned earlier, the causal connective *daardoor* 'so' is a prototypical objective causal connective used exclusively to express objective causality, akin to Mandarin *yushi*, and the connective word *dus* 'so' is a prototypical subjective causal connective often

used to express subjective causality. However, *dus* can also be used above and beyond its typical usage to express objective causality (Pander Maat & Degand, 2001; Stukker et al., 2009), appearing to be more of a general causal connective, similar to *so* in English. Moreover, corpus studies have revealed that the actual use of *dus*—whether to use it as a subjective causal connective or a general one—depends on various factors, including 'discourse goals' and the characteristics of the author (speaker) (Stukker & Sanders, 2012).

3.1.2 The role of prosody in expressing subjective and objective causality

Spoken language contains not only lexical information but also non-lexical information. One type of non-lexical information is prosody. Do speakers use prosody to distinguish subjective and objective causality? Several theories suggest that the answer might largely depend on whether or not these two types of causality are already specified at the lexical level, for example, by means of specialized causal connectives. Specifically, the Functional Hypothesis (Haan, 2001) holds that there is a trade-off relationship between the use of prosodic and morphosyntactic means in expressing meanings or functions. When information is not sufficiently expressed at the lexical level, speakers may seek to express that information via prosody. A similar view is expressed by the Smooth Signal Redundancy Hypothesis (Aylett & Turk, 2004) and the Uniform Information Density Hypothesis (Levy & Jaeger, 2007), both of which hold that speakers tend to maintain a constant rate of information transfer. Unexpected relations need to be marked; otherwise, deriving such relations would require too much information from context, thereby creating a peak in information density. Evidence for the trade-off between the use of lexical and prosodic cues has been found in various linguistic scenarios, for example, when marking word boundaries (Mattys & Melhorn, 2007), when expressing questions versus statements (Petrone & Niebuhr, 2014; van Heuven, 2017b), when disambiguating syntactic ambiguities (Snedeker & Trueswell, 2003), when marking information structure (Braun & Chen, 2010), when distinguishing different functions of discourse markers (see Hirschberg, Beňuš, Gravano, & Levitan, 2020 and Cole, 2015 for extensive reviews), and when expressing higher levels of linguistic meanings such sentiment (Morency et al., 2011), commitment (Prieto & Roseano, 2021), and sarcasm (Afflerbach, 2015; Chen &

Boves, 2018). In the case of expressing subjective and objective causality, the Functional Hypothesis (Haan, 2001) predicts that when a general causal connective is used to express causality, thus leaving the type of causality underspecified, speakers should apply prosodic means to signal to listeners which type of causality should be inferred. This claim has long been put forward by discourse analysts, who argued that subjective causality would be produced as two intonation units and objective causality as one intonation unit (Rutherford, 1970; Sweetser, 1990). Subsequent work based on everyday conversational data corroborated these ideas (Couper-Kuhlen, 1996; Günthner, 1996). In Chapter 2, we have provided further experimental evidence for this claim, showing that in the absence of lexical cues for subjective versus objective causality, subjective causality tends to be produced with an expanded pitch range, longer duration, and a special f0 contour for the connective *so*, compared to objective causality in English.

Notably, the Functional Hypothesis also argues that if information is already adequately expressed through the lexical channel, then providing prosodic cues would be less necessary or even superfluous. In the case of expressing subjective and objective causality, if these two types of causality are already expressed by specialized causal connectives, then there is less need for speakers to use prosody to distinguish them, because their distinctions are already salient at the lexical level. To the best of our knowledge, this prediction has not yet been tested. This study aims to fill this gap.

3.1.3 The current study

As mentioned above, the primary goal of the current study is to test the extent to which prosody is involved in expressing subjective and objective causality when lexical markers for these two types of causality, namely, specialized causal connectives, are in use. Two production experiments are conducted with this goal in mind. Experiment 1 concerns subjective and objective causality in Mandarin, which are systematically expressed by the specialized causal connectives *kejian* and *yushi*, respectively, and Experiment 2 subjective and objective causality in Dutch, which can be expressed by specialized causal connectives *dus* and *daardoor*, respectively, or by the general causal connective *dus*. Our general hypothesis is that there is a trade-off relationship between the use of specialized causal connective words and different prosodic patterns to

express subjective and objective causality. This hypothesis entails that using specialized causal connectives to express subjective and objective causality would reduce or eliminate the need to use prosody to distinguish between these two types of causality. Thus, for Mandarin, we predict that subjective and objective causality expressed by specialized causal connectives, i.e., *kejian* and *yushi*, would contain fewer prosodic differences than subjective and objective causality expressed by a general causal connective, i.e., *so* in English. For Dutch, however, the prospect is less straightforward because the causal connective *dus* can serve as either a specialized subjective causal connective or a general one. In light of this, it seems only rational to assume that how prosody is used might depend on the use of *dus*. We predict that subjective and objective causality expressed with *dus* and *daardoor* respectively will exhibit fewer prosodic differences than subjective and objective causality both expressed with *dus*. As for how exactly these two types of causality differ in terms of prosody, we predict, based on the findings of Chapter 2, that utterances expressing subjective causality will have a larger pitch range and a longer duration of the connective than utterances expressing objective causality. The items involved in the current two experiments are adopted from Experiment 2 in Chapter 2 and elicited using the same dialogue task as used in Chapter 2. Therefore, the results of the current experiments are comparable with the results of Experiment 2 in Chapter 2. By integrating the results of these experiments, we can gain a comprehensive understanding of the trade-off relationship between the use of lexical and prosodic means in expressing subjective and objective causality.

In addition to the main goal stated above, we also explore the extent to which the use of Dutch *dus* in our data varies across participants and, furthermore, whether the participants' personal preferences for specialized causal connectives affected their use of prosody to express subjective and objective causality. Based on the trade-off hypothesis, we predict that speakers who prefer to use specialized causal connectives (i.e., *dus* for subjective causality and *daardoor* for objective causality) will use prosody to a lesser extent to distinguish between subjective and objective causality, compared to speakers who prefer to use *dus* as a general causal connective.

3.2 Experiment 1: Mandarin

3.2.1 Participants

Thirty native speakers of Mandarin (15 females, 15 males; age range 20-22; mean age: 21) took part in this experiment. The participants were recruited from Beijing International Studies University, China. All of them spoke the Beijing variety of Mandarin Chinese.

3.2.2 Task

Utterances conveying subjective or objective causality were elicited using the dialogue task used in Experiment 2 in Chapter 2. In the task, the participants engaged in conversations with a female interlocutor who is a native speaker of Mandarin, based on information displayed on PowerPoint slides (one conversation per slide, producing one target utterance). Four pieces of information were presented on each slide, including an image on the left side, illustrating the context of the conversation, a background story at the top, four short sentences shown in boxes numbered from 1 to 4, and a green button in the bottom right corner. These four pieces of information were displayed automatically in sequence at 10-second intervals. Figure 1 shows the timeline.

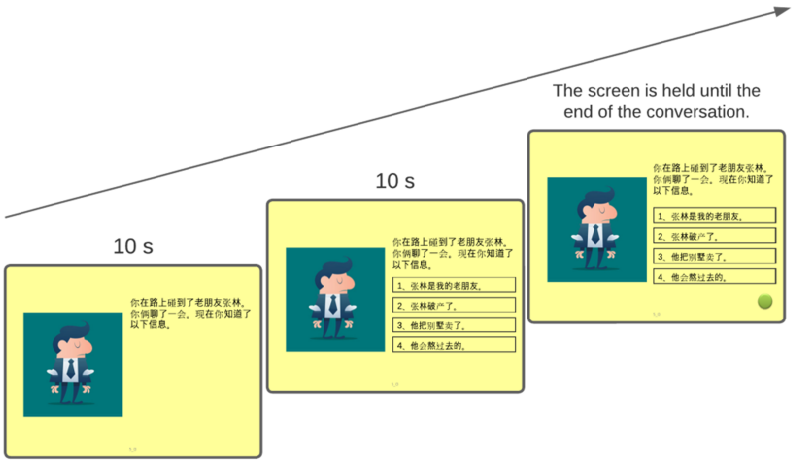


Figure 1. The timeline of a trial (for an item expressing objective causality) (See

Figure 1 in Chapter 2 for English translations)

As Figure 1 shows, in each trial, the background story and the image were shown first, setting the context for the conversation and signaling to the participants the type of causality that was about to occur (Scholman & Demberg, 2017). In the objective condition, the background story depicted a scenario in which the participants were in direct contact with another person – for example, on the phone with that person – from whom the participants directly learned information. The background story thus implied an objective interpretation of the upcoming information. In the subjective condition, in contrast, the background story suggested to the participants a subjective interpretation of the forthcoming information by telling them the information involved their own opinion/evaluation (e.g., "*You have the following impression about him"*). Ten seconds after the background story was shown, four short sentences appeared on the slide, the second and third of which had a causal (or, for filler items, concessive) relationship between them. Again, 10 seconds later, the green button appeared in the bottom-right corner, signifying to the participants that the experimenter was about to initiate the conversation.

After the participants read each slide, the interlocutor asked the participants three questions, the first question initiating the conversation (e.g., "*谁是张林? 'Who is Zhang Lin?*'"), the second eliciting a target utterance (e.g., "*你能告诉我一些关于张林的事吗?*'*Can you tell me something about him?*'"), and the third wrapping up the conversation. Prior to the task, the participants received instructions on how to answer these questions. They were told to use the first sentence on the slide to answer the first question and the last sentence the last question. As for the second question, the participants were expected to combine the second and third sentences into one sentence by choosing a connective from three options provided: *kejian, yushi*, and *danshi* 'but' (for fillers). They had to independently process the discourse link between the two sentences and make their own choices. They did not receive feedback from the interlocutor regarding the correctness of their answer. They were told not to alter the sequence of the sentences or read aloud from the screen, but to treat the lines as their own words and produce them as naturally as possible.

3.2.3 Materials

The dialogue task elicited 15 pairs of target utterances from each participant, each pair consisting of one utterance for subjective causality and one utterance for objective causality, all of which were Mandarin versions of the utterances used in Experiment 2 in Chapter 2. For the two utterances in each pair, the first clauses (hereafter "C1"), i.e., the clause preceding the connective, were identical, stating a real-world event (e.g., "*张林破产了 'Zhang Lin went bankrupt'*" as in (3a) and (3b)), while the second clauses (hereafter "C2"), i.e., the clauses following the connective, were different. For the objective item of a pair, C2 introduced the actual consequence of the event introduced in C1, e.g., "*他把别墅卖了 'he sold his mansion'*" as in (3a), whereas for the subjective item of a pair, C2 conveyed an opinion about the event in C1, e.g., "他不太懂做生意 *'He doesn't know much about business'* " as in (3b).

(3a) 张林破产了，于是他把别墅卖了。
[Zhang Lin went bankrupt, *yushi* he sold his mansion.]
Zhang Lin went bankrupt, so he sold his mansion.

(3b) 张林破产了，可见他不太懂做生意。
[Zhang Lin went bankrupt, *kejian* he doesn't know much about business.]
Zhang Lin went bankrupt, so he doesn't know much about business.

The items were pre-tested by the first author using a paraphrase test widely used in the discourse literature (Pander Maat & Degand, 2001; Sanders, 1997) to ensure that the type of causality conveyed by each item was not ambiguous. First, each item was rephrased using a sentence frame. For items expressing objective causality, the sentence frame was "*The fact that [P] led to the consequence that [Q].*" For those conveying subjective causality, the sentence frame was "*The fact that [P] leads to one's conclusion (claim/advice) that [Q].*" Then, the meaning of each paraphrase was checked. If the meaning of the paraphrase was identical to the meaning of the original item, then the item was considered valid. If otherwise, the original item was revised. All of the items passed the paraphrase test and were hence unambiguous with respect to the types of causality they conveyed.

The 15 pairs of target items were then divided over two lists, each list consisting of an equal number of subjective causality and objective causality items and only one item from each pair (List 1 consisted of 7 subjective items from pairs 1-7 and 8 objective items from pairs 8-15; List 2 contained the remaining items).

To conceal the real research goal, we adopted the 20 filler items used in Experiment 2 in Chapter 2. All filler items expressed concessive relations with the concessive connective *danshi* ('but'). The fillers were also presented using PowerPoint slides in the same way as the target items. The filler items were evenly divided between the two lists.

3.2.4 Procedure

The participants were tested individually in a quiet room at Beijing International Studies University, China. During the experiment, the participant sat comfortably at a table with an interlocutor as if they were friends sitting in a cafe. A recorder and a computer monitor were placed on the table, facing the participant's direction.

First, the interlocutor told the participant that the experiment was to collect speech samples for teaching purposes without revealing the true research goal. Second, the participants were asked to read some words from the screen. Five words, including two words of interest, i.e., *kejian* 'so' and *yushi* 'so', and three distractors, i.e., *danshi* 'but', *suoyi* 'so', and *yinwei* 'so', were presented as a list. The word list was played four times, each time showing the five words in a different order. This step was to obtain the inherent duration of the connective words *yushi* and *kejian* to serve as a baseline for standardizing the duration of these words in the conversation. Third, the interlocutor explained the task, the design of the slides, and instructions. Finally, the participants performed two practice trials to familiarize themselves with the instructions. The testing started when the participant was ready.

The two lists of items were tested trial by trial in two sessions with a short break in between. The order of items was randomized. After each trial, the participant clicked the mouse to move on to the next trial. The conversations were recorded using a ZOOM 1 digital recorder (sampling rate of 44.1 kHz, 16 bit, stereo). The whole experiment took about an hour to complete. The participants were paid 80 RMB for their participation.

3.2.5 Acoustic measurements

The obtained recordings were processed using Praat (Boersma & Weenink, 2018) in the following steps. First, the onset and offset of *kejian* and *yushi* recorded as individual words were marked, and the duration of each reading was extracted. Second, the onset and offset of each target utterance – the utterance elicited by the second question in each dialogue – were manually marked, and then the target utterance was extracted. Third, the boundaries of three parts of each target utterance (the first clause, the connective, and the second clause) were set manually. The onset of each part was set at the starting point of the first segment of that part. In the case of the first segment being a plosive, the onset was set at the burst of the plosive. Fourth, the f0 contour of each utterance was inspected, and octave jumps were manually corrected. Last, the acoustic measurements relevant to our predictions were extracted from the target utterances; see Table 1 for the list of measurements. Four f0-related measurements were obtained in semitones (st) relative to 1 Hz, including the maximum f0 (f0Max) and minimum f0 (f0Min) in the first clause (C1) and the second clause (C2). The duration of the connective (*kejian* or *yushi*) and the duration of the pause preceding the connective (i.e., the silent interval between the first clause and the connective) in each target utterance were obtained in seconds (s). Then, the extracted durations of the connectives were standardized to Z-scores (using the mean duration and standard deviation of the words recorded as individual words as a baseline). We also computed the articulation rate (AR) in each clause by dividing the number of syllables produced in a clause by the duration of that clause (Hardcastle et al., 2010).

Table 1

Acoustic measurements

Measure	Description
c1f0Maxst	the f0 maximum in the first clause (in semitones relative to 1 Hz)
c1f0Minst	the f0 minimum in the first clause
c2f0Maxst	the f0 maximum in the second clause
c2f0Minst	the f0 minimum in the second clause
pauseDur	duration of the silent interval between the first clause and the

	connective (in s)
connectiveDur	duration of the connective (in s)
c1AR	articulation rate in the first clause (number of syllables produced per second, i.e., syllables/s)
c2AR	articulation rate in the second clause

3.2.6 Analysis

3.2.6.1 The distribution of yushi and kejian between subjective and objective causality

We first inspected the distribution of the connective words *yushi* and *kejian* between subjective and objective causality. The pattern was consistent with what was reported in the literature: *yushi* occurred in 448 of 450 objective items and *kejian* in 449 of 450 subjective items, both demonstrating robust profiles.

3.2.6.2 Statistical analyses

Data analysis was performed in `R` (version 3.6.3, R Core Team, 2020) using a Bayesian approach with the package `brms` (Bürkner, 2017), the wrapper package of the probabilistic programming language `Stan`. We built a series of linear mixed-effect models of decreasing complexity. The most complex model, i.e., `m1` in Table 2, consisted of the constant effects of `subjectivity` (subjective versus objective, contrast-coded as +0.5 and -0.5, respectively) and `gender` (contrast-coded as -0.5 and +0.5 for female and male, respectively), a known factor affecting vocal characteristics (Cole, 2015), the interaction between `gender` and `subjectivity` (`gender: subjectivity`), as well as the varying effects of `subject` and `item` with random intercepts and fixed slopes. The prior distributions of these effects (the degree of belief the model has in a hypothesis before it sees the data) were chosen based on the findings of Experiment 2 in Chapter 2, all having normal distributions `normal (0, SD)` with `0` being the mean and `SD` being the standard deviation of the distribution. Posterior distributions were sampled by bridge sampling with four chains and 10,000 iterations each, 2000 of which belonged to a warm-up phase.

Table 2
Model overview

Model	Formula
m1	~ gender + subjectivity + gender: subjectivity + (1|subject) + (1|item)
m2	~ gender + subjectivity + (1|subject) + (1|item)
m3	~ gender + (1|subject) + (1|item)
m4	~ 1 + (1|subject) + (1|item)

Since we were interested in whether the constant effects mentioned above were present in our data, we evaluated each effect using Bayes factors calculated by the function `bayes_factor (m1, m0)`, where `m1` was the model containing the effect of interest and `m0` the model without the effect. The resulting value, referred to as BF_{10} (subscripts 1 and 0 refer to `m1` and `m0`, respectively), indicates the extent to which the evidence in the data supports `m1` over `m0` (Lee & Wagenmakers, 2014). In other words, how much more likely `m1` is compared to `m0`. In this sense, BF_{10} is akin to the ratio of likelihoods of the two models. An important property of BF_{10} is that it is susceptible to priors, posing a challenge for interpreting its value. To circumvent this issue, we followed Vasishth, Nicenboim, Beckman, Li, & Kong (2018) to fit each model three times using different priors (for the priors used in each model, see tables in Appendix) and compute BF_{10} multiple times. The values of BF_{10} were interpreted with reference to the following widely adopted guidelines: BF_{10} values of 10-30, 3-10, 2-3, and close to 1 indicate strong evidence, weak evidence, very weak evidence, and no evidence supporting `m1`; a BF_{10} value less than 0.1 indicate that the evidence is strongly in favor of `m0` (Jeffreys, 1998).

In the result sections below, we focus on the effect of `subjectivity` because it is the effect of main interest. We report the mean and 95% credible interval (95% CrI, the interval that contains the most credible values) of the posterior distribution of the model parameter corresponding to the effect, the Bayes factor evaluating the effect on each acoustic measurement computed under the most informative prior, as well as the prior used in each evaluation. Unless otherwise stated, the posterior distributions mentioned in the main text were all estimated by the model with the smallest `SD`. Statistical summaries for

the effect of `gender` and the interaction between `gender` and `subjectivity` are provided in the Appendix.

3.2.7 Results

Table 3 summarizes the Bayes factor, the prior used to calculate it, and the posterior distribution of the effect of `subjectivity` on each acoustic measurement. The results showed that utterances expressing subjective causality had a lower *f0 maximum* (estimate = -0.47 st, 95% CrI [-0.93 st, -0.01 st]) and a lower *f0 minimum* (Estimate = -0.56 st, 95% CrI [-1.03 st, -0.09 st]) in the second clause, compared to utterances expressing objective causality. Considering both posterior 95% credible intervals did not include zero, these results could suggest that `subjectivity` affected these two measurements. However, the Bayes factors were only 1-to-3.58 in favor of the model containing the effect of `subjectivity` even when calculated under the most informative priors (`normal (0, 1)`) (see Table 3), indicating very weak support for the effect.

For the effect of `subjectivity` on the *duration of the pause* preceding the connective, the model estimated a value of -0.05 s with a 95% CrI of [-0.09 s, -0.01 s], which seems to suggest that the pause duration was shorter in utterances expressing subjective causality than in utterances expressing objective causality. However, the Bayes factor, even calculated under the most informative prior (*Normal(0, 0.1)*), only showed weak support (BF_{10} = 4.70) for the full model; the model containing the effect was 4.7 times more likely than the model without the effect, given the data. Under less informative priors, the BF_{10} dropped to 1.10 (see Appendix), indicating that the model containing the effect of `subjectivity` was not any better than the model without the effect. Thus, there was no concrete evidence in our data that `subjectivity` had an effect on the duration of the pause.

As for the other measurements, namely, the f0 maximum and minimum in the first clause, the articulation rate in each clause, and the standardized duration of the connective in z-scores, the BF_{10} for the effect of `subjectivity` on each of these measurements was less than one, even under the most informative priors (see statistical summaries in Appendix). Also, the posterior 95% CrI spanned across zero, suggesting that the estimated mean could be zero. The evidence indicated that `subjectivity` had no effect on any of these measurements in

our data.

Table 3

Statistical summary of the effect of `subjectivity` *on each acoustic measurement. Reported in the table are the prior (the most informative of the three priors used) used to calculate the Bayes factor evaluating the effect of* `subjectivity`*, the Bayes factor, the mean and 95% credibility interval of the posterior distribution of the model parameter corresponding to the effect of* `subjectivity`*. Acoustic measurements with BF>3 (suggesting some effect of* `subjectivity`*) are printed in boldface.*

Acoustic measurement	**Prior**	**BF10**	**Posterior**		
			Estimate	**Lower**	**Upper**
c1f0Maxst	Normal(0, 1)	0.23	-0.07	-0.51	0.38
c1f0Minst	Normal(0, 1)	0.37	-0.23	-0.75	0.29
c2f0Maxst	Normal(0, 1)	1.93	-0.47	-0.93	-0.01
c2f0Minst	**Normal(0, 1)**	**3.58**	**-0.56**	**-1.03**	**-0.09**
c1AR	Normal(0, 1)	0.28	0.05	-0.53	0.62
c2AR	Normal(0, 1)	0.16	-0.02	-0.37	0.32
pauseDur	**Normal(0, 0.1)**	**4.70**	**-0.05**	**-0.09**	**-0.01**
connectiveDur	Normal(0, 0.1)	0.69	-0.00	-0.14	0.13

3.2.8 Interim summary

The goal of this experiment was to investigate whether prosody played a role in expressing subjective and objective causality when these two types of causality were already expressed using specialized causal connectives. To this end, we collected utterances expressing subjective and objective causality in Mandarin. In line with previous studies (Li et al., 2013), we found that *kejian* was exclusively used for subjective causality and *yushi* for objective causality. With respect to the use of prosody, our results clearly showed no difference between utterances expressing subjective causality and utterances expressing objective causality in terms of articulation rates, the duration of the connective, and the f0 maximum or f0 minimum in the first clause. As for the other acoustic features examined in the study, i.e., the duration of the pause preceding the connective and the f0 maximum and minimum in the second clause, we found some very

weak evidence in our data supporting the effect of subjectivity when the priors were very informative (i.e., when there was a strong belief in the presence of the effect). Under more diffuse priors (priors with larger SDs, i.e., weaker beliefs), the evidence supporting the effect of subjectivity became absent. This finding clearly contrasts with the findings of Experiment 2 in Chapter 2, which showed very strong evidence that subjectivity had an effect on the prosody of subjective and objective causality expressed by a general causal connective *so* in English. Our findings thus suggest that subjective and objective causality are less likely to be expressed by prosody when they are already expressed by specialized causal connectives, as in Mandarin Chinese, than by a general causal connective, as in English, in support of a trade-off between the use of prosody and specialized causal connectives in expressing subjectivity in causality, as suggested by the Functional Hypothesis (Haan, 2001).

3.3 Experiment 2: Dutch

3.3.1 Participant

Thirty-two native speakers of Dutch (25 females, 7 males; mean age 23, age range 21-26) participated in this experiment. The participants were recruited from Utrecht University. The participants were paid 10 euros for their participation.

3.3.2 Task and procedure

The participants were tested individually in a sound-treated booth in the phonetics lab at the Utrecht Institute of Linguistics OTS, following the same procedure as in Experiment 1. The participants completed the same dialogue task used in Experiment 1. To repeat briefly, the participants were tasked with answering questions from an interlocutor, a 23-year-old female native speaker of Dutch, about information presented on PowerPoint slides, which had the same design as the slides used in Experiment 1. After each slide, the participants answered three questions from the interlocutor, with the second question eliciting a target utterance expressing subjective or objective causality. To answer this question, the participants had to combine the second and third sentences shown on the slides using *daardoor* ‘so’ (used exclusively for objective causality), *dus* ‘so’ (subjective or objective causality), or *maar* ‘but’

(for concessive relations).

Before the conversations, we asked the participants to record these words individually to obtain the intrinsic duration of each word, which would be used as the baseline duration to normalize the duration of each word that appeared in conversations. These words were presented along with two other words (*kijken* 'look' and *goedemorgen* 'good morning') as a list, which was repeated four times, each time with these words appearing in a different order.

3.3.3 Materials

The dialogue task elicited 15 pairs of Dutch utterances from each participant, with two utterances in each pair, one expressing subjective causality and the other objective causality. The utterances were Dutch translations of the target utterances used in Experiment 1 with minor adjustments to align with Dutch culture and expressions (see Appendix E.2). Similar to the utterances in Experiment 1, the two utterances in each pair in the current experiment were identical in the first clause (C1), which expressed an actual event taking place in the real world, and different in the second clause (C2), which stated the actual consequence of the event stated in C1 in the objective condition (e.g., (4a)) and expressed an opinion about the event in C1 in the subjective condition (e.g., (4b)).

(4a) [Tom is failliet gegaan]$_{C1}$, daardoor [raakte hij zijn bedrijf kwijt]$_{C2}$.
Tom went bankrupt, so he lost his business.

(4b) [Tom is failliet gegaan]$_{C1}$, dus [hij weet niets van zaken doen]$_{C2}$.
Tom went bankrupt, so he knows nothing about business.

3.3.4 Measurements

The data annotation procedures and acoustic measurements used in Experiment 2 were the same as those used in Experiment 1 (see the full list in Table 1). As in Experiment 1, the extracted duration of *daardoor* and *dus* was normalized using z-scores.

3.3.5 Analysis

3.3.5.1 The distribution of daardoor and dus between subjective and objective causality

The task yielded a total of 960 target utterances (in 480 pairs), half of which expressed objective causality and the other half subjective causality. Of the 960 utterances, 25 were excluded for involving the use of *maar*, leaving 935 utterances (468 of which express objective causality and 467 subjective causality). We first examined the distribution of *daardoor* and *dus* between subjective and objective causality in our data. Results showed that *daardoor* was predominantly used to express objective causality, demonstrating a robust objective profile, while *dus* was used to express not only subjective causality (its prototypical usage) but also 35% of objective causality, demonstrating a general usage. Concerning the use of *dus*, previous studies implicated that there might be variations between language users (Stukker & Sanders, 2012). Given this, we examined the occurrence of *dus* and *daardoor* in objective causality[5] by participant. Figure 2(A) shows that, as suggested in the literature, the participants varied greatly in the frequency with which they used *dus* to express objective causality: some participants used it for all of the objective items (i.e., the participants in the lower right corner), others never used it (i.e., the participants in the upper left corner), and still others alternated between *daardoor* and *dus* to varying degrees between these two extremes.

[5] We did not do so for subjective causality because subjective causality was predominantly expressed by *dus*.

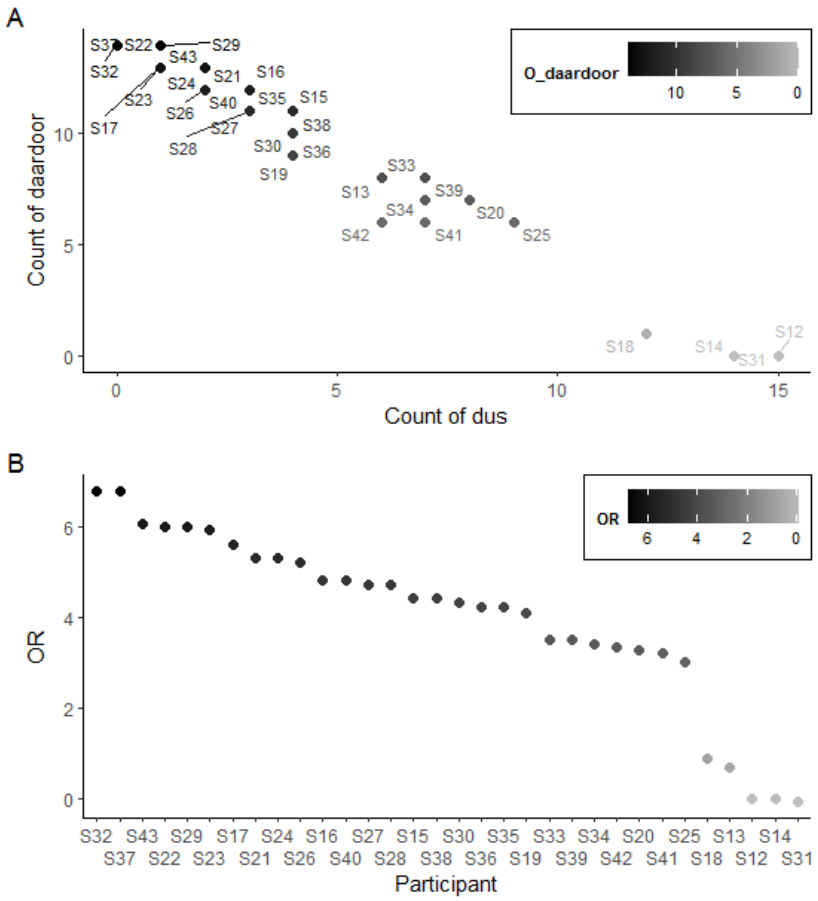


Figure 2. (A) Number of times each participant used *dus* and *daardoor* to express objective causality (X-axis: count of *dus*; Y-axis: count of *daardoor*); (B) Participants' ORs ranked from highest to lowest (participants' IDs on the X-axis).

The variation in participants' use of connectives to express objective causality in our data warranted the investigation of the side research question mentioned in the introduction – whether speakers' degree of preference for specialized causal connectives affects their use of prosody to express subjective and objective causality. As stated in the introduction, we predicted that speakers who preferred

to use *dus* as a specialized subjective causal connective (i.e., who more often used *daardoor* to express objective causality) would use prosody to a lesser extent than those who preferred to use *dus* as a general causal connective in distinguishing between subjective and objective causality. To test this prediction, we first described each participant's use of *daardoor*[6] as an odds ratio (OR)[7], i.e., the ratio of the odds of using *daardoor* to express objective causality (*Odds.O*) to the odds of using it to express subjective causality (*Odds.S*), using the method proposed by Fleiss (1994) (see Equation 1). The odds was calculated by dividing the number of times that *daardoor* was used to express a type of causality (e.g., *(n)O.daardoor* for objective causality) by the number of times it was not used to express that type of causality (thus *dus* was used, *(n)O.dus*). If any of these counts turned out to be zero, we followed Quené (2008) to add 0.5 to the count to make the equation computable. Following Kuperman & Bresnan (2012), the resulting numbers were log-transformed (base 10) to make their distributions more normal.

$$OR = \frac{\log(\text{Odds. O})}{\log(\text{Odds. S})} = \frac{\log(\text{(n)O. daardoor}/\text{(n)O. dus})}{\log(\text{(n)S. daardoor}/\text{(n)S. dus})} \quad (1)$$

The participants' ORs are shown in descending order in Figure 2(B) (Range [-0.07, 6.80], Mean = 4.03, variance = 3.70). The participants' ORs were also calculated for each test block to see whether there were any variations (Block 1: Range = [0.00, 5.54], Mean = 3.37, variance = 2.78; Block 2, Range = [-0.12, 5.54], Mean = 3.42, variance = 3.45). Levene's test showed no significant difference in the variance of OR values between the two test blocks (DF = 1, F = 1.34, p = 0.25). Given that the participants' choice of connectives was consistent in the subjective condition (thus, the denominator of the equation, i.e., *log*

[6] It might be more intuitive to calculate the odds ratio of using *dus* (Equation: $OR = \frac{\log(\text{Odds.O})}{\log(\text{Odds.S})} = \frac{\log(\text{(n)O.dus}/\text{(n)O.daardoor})}{\log(\text{(n)S.dus}/\text{(n)S.daardoor})}$). However, the denominators (n)O.daardoor) and (n)S.daardoor) in the equation were zero for some participants, which made the equation incomputable. Although adding 0.5 to these numbers solves the problem, the small denominators greatly inflated the resulting odds of using *dus*, rendering the method not useful.

[7] OR was not calculated in Experiment 1 and therefore was not included in the model formulas because there was little variation in the participants' choice of connective in each causality condition – the speakers consistently used *kejian* to express subjective causality and *yushi* objective causality.

(Odds.S), is a constant), the OR, according to Equation 1, essentially indicates how often a participant used *daardoor* to express objective causality; the participants with the largest OR values (e.g., S32 in Figure 2(B)) used *daardoor* to express objective causality most frequently (see S32 in the upper left corner in Figure 2(A)) than participants with smaller OR values, who tended to use *dus* instead of *daardoor* to express objective causality.

3.3.5.2 Statistical analysis

We conducted two sets of statistical data analyses using a Bayesian approach. The first set of analyses concerned the trade-off between the use of specialized causal connective and prosody in expressing subjective and objective causality. As described in the introduction, we predicted that prosody would be used to a lesser extent in distinguishing between subjective and objective causality when specialized causal connectives, namely, *dus* and *daardoor*, were in use than when the general causal connective *dus* was used. To test this prediction, we partitioned the obtained utterances into two subsets according to the connective(s) used in each pair of utterances: the utterance pairs involving only the use of *dus* were put in one set (hereafter, the *Dus* set), yielding 152 pairs, while those involving the uses of *dus* and *daardoor* were placed in the other set (hereafter, the *Dus* & *daardoor* set), yielding 290 pairs[8]. Then, we evaluated the effect of `subjectivity` on the prosody of the utterances in each subset using the same statistical procedure and model formulas as used in Experiment 1 (see Section 3.2.6.2 for details).

The second set of analyses focused on the association between the participants' tendency to use specialized connectives (described as ORs) and their use of prosody in expressing subjective and objective causality. We predicted that there would be an interaction between OR and causality types on the prosody of the utterances; speakers who had a higher OR (thus a higher tendency to use *dus* exclusively as a specialized subjective causal connective) would use prosody to a lesser extent to distinguish between subjective and objective causality, compared to speakers who had a lower OR (thus a higher tendency to use *dus* as a general causal connective). The analysis involved the

[8] Only 442 (152 + 290) pairs were involved instead of 480 pairs, because 38 utterances did not have matching utterances to form a pair due to the incorrect use of connectives or lack of fluency.

entire data set (i.e., the *Dus* set and the *Dus & Daardoor* set in combination). As in Experiment 1, we built a series of linear mixed-effect models descending in complexity. The factors involved in model construction included the constant effects of `gender` (contrast-coded as -0.5 and +0.5 for female and male, respectively), `subjectivity` (contrast-coded as -0.5 and +0.5 for objective causality and subjective causality, respectively), `OR` (a numerical variable indicating how strongly a participant preferred to use *daardoor* to express objective causality), the two-way interactions between each two of these constant effects (`OR:gender`, `gender:subjectivity`, and `OR:subjectivity`), the three-way interaction among them (`gender: subjectivity: OR`), as well as varying effects of `subject` and `item` with random intercepts and fixed slopes. The prior used for each effect was based on the findings of Chapter 2.

Table 4

Models used to evaluate the association between the participants' preference for specialized connectives (represented by OR) and their use of prosody

Model	Formula
m1	`~ gender + OR + subjectivity + OR:subjectivity + gender:subjectivity + gender:OR + gender:OR:subjectivity + (1|subject) + (1|item)`
m2	`~ gender + OR + subjectivity + OR:subjectivity + gender:subjectivity + gender:OR + (1|subject) + (1|item)`
m3	`~ gender + OR + subjectivity + OR:subjectivity + gender:subjectivity + (1|subject) + (1|item)`
m4	`~ gender + OR + subjectivity + OR:subjectivity + (1|subject) + (1|item)`
m5	`~ gender + OR + subjectivity + (1|subject) + (1|item)`
m6	`~ gender + OR + (1|subject) + (1|item)`
m7	`~ gender + (1|subject) + (1|item)`
m8	`~ 1 + (1|subject) + (1|item)`

As in Experiment 1, the presence or absence of each constant effect was evaluated using Bayes factors by comparing models with and without an effect.

Take the effect of main interest, i.e., the interaction between the participants' OR and subjectivity (`OR: subjectivity`), as an example. It was evaluated by comparing the model containing the interaction effect (`m4` in Table 4) with the model not containing the effect (`m5` in Table 4).

In the result sections that followed, we first reported the results of the first set of analyses testing the relationship between the use of specialized causal connectives and prosody. We first reported the results of the *Dus* set (consisting of utterances expressing subjective and objective causality using *dus*) and then the results of the *Daardoor & Dus* set (consisting of utterances expressing subjective and objective causality using *dus* and *daardoor*, respectively). Then, we reported the results of the second set of analyses on the association between the participants' preference for connectives (represented by OR) and their use of prosody in expressing subjective and objective causality. As in Experiment 1, we only reported the posterior probabilities estimated by the models incorporating the most informative priors (the priors with the smallest SD) in the main texts. The posterior estimations from the models with less informative priors were presented in the Appendix.

3.3.6 Results

3.3.6.1 The first set of analyses: the relationship between the use of specialized causal connectives and prosody

3.3.6.1.1 The effect of subjectivity on the prosody of utterances in the *Dus* set

Table 5 summarizes the Bayes factor and posterior distribution of the effect of `subjectivity` on each acoustic measurement of the utterances in the *Dus* set (where *dus* was used to express both subjective and objective utterances in a pair). The results showed very strong evidence that subjectivity had an effect on the *f0 maximum in the second clauses* (BF_{10} larger than 10). The model with the most informative prior for the parameter of interest gave an estimate of -0.80 st with 95% CrI [-1.32 st, -0.27 st], suggesting that *the f0 maximum in the second clause* was lower by almost a semitone in the subjective condition relative to the objective condition. In addition, we found very weak evidence (BF_{10} was between 1.25 and 2.26) for `subjectivity` affecting the *f0 minimum in the second clause* (Estimate= -0.46 st, 95%CrI [-0.86 st, -0.04 st]). However, the Bayes factors were close to 1 when calculated with less informative priors,

suggesting that the model with the effect of `subjectivity` was not more likely than the model without this effect. In other words, it means that there seems that `subjectivity` has no effect on the *f0 minimum in the second clause*. For the *f0 minimum in the first clause* and the *normalized duration of the connective*, the Bayes factors for the effect of `subjectivity` were slightly above 1 when the prior was the most informative, suggesting that the two models were very similar to each other in terms of likelihood. However, with less informative priors (see Appendix), the Bayes factors descended below 1, suggesting no support for the effect of `subjectivity`. As for all other measurements, namely, *the f0 maximum in the first clause*, *the articulation rate of the two clauses*, and *the duration of the pause preceding the connective*, the results clearly showed that there was no evidence in our data in favor of an effect of `subjectivity` on any of these measurements, as suggested by the very small Bayes factors (between 0 and 1) evaluating the effect on each of these measurements.

Table 5

Statistical summary of the effect of `subjectivity` on each acoustic measurement of the utterances in the Dus set. Reported in the table are the prior (the most informative of the three priors used) used to calculate the Bayes factor evaluating the effect of `subjectivity`, the Bayes factor, the mean and 95% credibility interval of the posterior distribution of the model parameter corresponding to the constant effect of `subjectivity`.

Acoustic measurement	**Prior**	**BF_{10}**	**Posterior**		
			Estimate	**Lower**	**Upper**
c1f0Maxst	Normal(0, 1)	0.29	0.17	-0.29	0.62
c1f0Minst	Normal(0, 1)	1.35	-0.51	-1.10	0.07
c2f0Maxst	**Normal(0, 1)**	**15.74**	**-0.80**	**-1.32**	**-0.27**
c2f0Minst	Normal(0, 1)	2.26	-0.46	-0.86	-0.04
c1AR	Normal(0, 1)	0.29	0.07	-0.53	0.67
c2AR	Normal(0, 1)	0.24	-0.01	-0.53	0.50
pauseDur	Normal(0, 0.1)	0.37	-0.02	-0.07	0.03
connectiveDur	Normal(0, 0.5)	1.20	0.23	-0.04	0.49

3.3.6.1.2 The effect of subjectivity on the prosody of the utterances in the *Daardoor & Dus* set

Using the same statistical procedures used to analyze the data from the *Dus* set, we evaluated the effect of `subjectivity` on each acoustic feature of the utterances in the *Daardoor & Dus* set (where the subjective item in a pair was expressed by *dus* and the objective item in the same pair by *daardoor*). The Bayes factor and posterior probability of the effect of `subjectivity` on each measurement were summarized in Table 6.

The results showed that for all f0-related and articulation rate measurements, Bayes factors evaluating the effect of `subjectivity` were close to zero, favoring the model not containing the effect, clearly indicating that `subjectivity` had no effect on these measurements.

For the two duration measurements, however, the evidence was not as clear. For the *duration of the pause preceding the connective*, as shown in Table 6, the Bayes factor was 1.23 supporting the model containing the effect of `subjectivity` when computed under a relatively strong prior, suggesting that the two models were not substantially different in terms of likelihood. However, as the prior became less strong, BF_{10} gradually approached zero, suggesting that there was no evidence to support the effect of `subjectivity`. Regarding the effect of `subjectivity` on the *standardized duration of the connectives*, the model with the most informative prior yielded an estimated posterior mean of -0.42 (in Z-score units) with 95% CrI [-0.78, -0.06] (also in Z-score units). However, as Table 6 shows, the Bayes factor evaluating this effect was between 1 and 3, showing very weak support for the presence of the effect.

Table 6

Statistical summaries of the effect of `subjectivity` on each acoustic measurement of the utterances in the Daardoor & Dus set. Reported in the table are the prior (the most informative of the three priors used) used to calculate the Bayes factor evaluating the effect of `subjectivity`, the Bayes factor, the mean and 95% credibility interval of the posterior distribution of the model parameter corresponding to the constant effect of `subjectivity`.

Acoustic measurement	**Prior**	**BF_{10}**	**Posterior**		
			Estimate	**Lower**	**Upper**

Acoustic measurement	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
c1f0Maxst	Normal(0, 1)	0.47	-0.26	-0.66	0.14
c1f0Minst	Normal(0, 1)	0.36	-0.22	-0.60	0.17
c2f0Maxst	Normal(0, 1)	0.25	-0.03	-0.54	0.48
c2f0Minst	Normal(0, 1)	0.35	-0.20	-0.49	0.10
c1AR	Normal(0, 1)	0.34	0.16	-0.46	0.78
c2AR	Normal(0, 1)	0.31	-0.17	-0.69	0.35
pauseDur	Normal(0, 0.3)	1.23	-0.05	-0.10	-0.01
connectiveDur	**Normal(0, 0.5)**	**2.44**	**-0.42**	**-0.78**	**-0.06**

3.3.6.2 The second set of analyses: The interaction between OR and subjectivity on the prosody of ALL utterances obtained

The second set of analyses concerned the association between speakers' tendency to use specialized causal connectives (represented by OR) and their use of prosody in expressing subjective and objective causality. Table 7 summarizes the Bayes factor, the prior used to calculate the Bayes factor, and the posterior distribution of the interaction effect between `OR` and `subjectivity` on each acoustic measurement estimated by the model with the most informative prior. The table shows that for all four f0-related measurements and the two duration measurements, Bayes factors evaluating the interaction effect between `OR` and `subjectivity` were close to zero, clearly suggesting that there was no evidence of such an interaction effect in our data. In other words, the difference between utterances expressing subjective and objective causality on these acoustic dimensions did not vary with `OR`. As for whether there was an interaction effect between `subjectivity` and `OR` on *articulation rates*, the current evidence was less conclusive. Table 7 shows that for the *articulation rate in C1*, the BF_{10} evaluating the interaction effect was 1.22 in favor of the model containing the interaction effect when computed under the most informative prior with a *SD* of 0.1. With less informative priors (priors with *SD* of 0.3 and 0.5), the value of BF_{10} decreased to 0.1 (see the Appendix), suggesting that the model without the interaction effect was more likely than the model with the effect. Thus, we concluded that there was no interaction between `OR` and `subjectivity` on the *articulation rate in the first clause*. With respect to the

articulation rate in C2, the interaction effect was estimated at a value of -0.05 with a 95% CrI [-0.09, -0.01]. Since the 95% CrI did not include zero as a plausible value, the result could suggest that there is an interaction between `subjectivity` and `OR` on the *articulation rate in the second clause*. However, the Bayes factors evaluating this interaction effect were between 2.23 and 0.50, showing very weak to no support for the model containing the effect.

Table 7

Statistical summaries of the interaction effect `OR:subjectivity` on each acoustic measurement of all obtained utterances. Reported in the table are the prior (the most informative of the three priors used) used to calculate the Bayes factor evaluating the interaction effect, the Bayes factor, the mean and 95% credibility interval of the posterior distribution of the model parameter corresponding to the interaction effect.

Acoustic measurement	**Prior**	**BF_{10}**	**Posterior**		
			Estimate	**Lower**	**Upper**
c1f0Maxst	Normal(0, 1)	0.06	-0.03	-0.15	0.10
c1f0Minst	Normal(0, 1)	0.06	0.02	-0.10	0.13
c2f0Maxst	Normal(0, 1)	0.07	-0.03	-0.16	0.09
c2f0Minst	Normal(0, 1)	0.08	0.05	-0.06	0.16
c1AR	Normal(0, 0.1)	1.22	-0.04	-0.08	0.00
c2AR	**Normal(0, 0.1)**	**2.23**	**-0.05**	**-0.09**	**-0.01**
pauseDur	Normal(0, 1)	0.08	-0.00	-0.02	0.02
connectiveDur	Normal(0, 1)	0.83	-0.05	-0.16	0.06

3.3.7 Interim summary

The main goal of Experiment 2 was to test the trade-off relationship between the use of specialized causal connectives and prosody in expressing subjective and objective causality. Our prediction was that prosody would be used to a lesser extent when these two types of causality were expressed by specialized causal connectives than when they were expressed by a common causal connective. This prediction was tested in Dutch, where the causal connective *dus* can be used either as a specialized subjective causal connective or a general causal connective. Using the same dialogue task used in Experiment 1, we elicited

utterances conveying these two types of causality from the participants. We partitioned the obtained utterances into two subsets based on the connective(s) used in each pair of utterances. We evaluated the effect of subjectivity on the prosodic characteristics of the utterances in these two subsets separately. We found that for the utterances in the *Dus* set (where *dus* was used for both subjective and objective utterances in a pair), there was very strong evidence that subjectivity affected the f0 maximum in the second clause: utterances expressing subjective causality had a lower f0 maximum (by about -0.8 semitones) in the second clause than utterances expressing objective causality. For utterances in the *Daardoor & Dus* set (where the objective item in a pair was expressed by *daardoor* and the subjective item by *dus*), in contrast, there was no strong evidence in our data supporting the effect of subjectivity on prosody, and only some very weak to inconclusive evidence of an effect of subjectivity on the normalized duration of the connective. Taken together, these results indicate that prosody plays a bigger role in expressing subjective and objective causality when the two types of causality are not lexically specified by causal connectives (as in the *Dus* set) than when they are lexically distinguished by causal connectives (as in the *Daardoor & Dus* set). Thus, this finding supports a trade-off relationship between the use of prosody and the use of specialized causal connectives in expressing subjectivity in causality, in accordance with Haan's (2001) Functional Hypothesis.

Experiment 2 also explored whether the participants' preferences for specialized connectives influenced their use of prosody to express subjectivity in causality. Our data showed that our speakers varied considerably in their degrees of adherence to *dus*'s prototypical usage as a subjective causal connective, consistent with the speculation of previous studies (Pander Maat & Degand, 2001; Stukker et al., 2009). Specifically, some speakers used *dus* only for subjective causality, sticking to its prototypical use; other speakers used it as a general causal connective, not only for all subjective items but also for all objective items; still others fell somewhere between these two extremes, using *dus* to express all subjective items and some objective items. We will discuss possible reasons for this large variation in the use of *dus* in the next section. Given the individual variation in the use of *dus*, we predicted that speakers with different propensities for using it as a specialized causal connective might differ

in their use of prosody to express objective versus subjective causality: speakers with a high tendency to use *dus* as a specialized subjective causal connective (thereby marking the distinction between the two types of causality) would use prosody to a lesser extent when expressing these two types of causality, compared to speakers with a low tendency to use *dus* as a specialized subjective connective (thereby obscuring the distinction between subjective and objective causality). To assess this prediction, we represented each speaker's preference for connectives using an odds ratio (OR) and evaluated the interaction between OR and subjectivity on the prosodic characteristics of the utterances. However, the results did not show any evidence supporting the predicted interaction effect on any of the acoustic measurements, with the possible exception of the articulation rate in the second clause, for which the evidence for the interaction was very weak at best.

3.4 General discussion

The primary goal of this chapter was to explore the extent to which prosody was used to express subjective and objective causality in the presence of specialized causal connectives. Based on the Functional Hypothesis (Haan, 2001), we hypothesized a trade-off relationship between the use of specialized causal connective words and different prosodic patterns in expressing subjective and objective causality. Specifically, we predicted that using specialized causal connectives to express these two types of causality would reduce or eliminate the need to use prosody to distinguish between them. This hypothesis was tested in two languages: Mandarin Chinese and Dutch, where specialized causal connectives were commonly used to express subjective and objective causality (in contrast to English, where general causal connectives, such as *so*, were used more frequently). Our prediction for the use of prosody in expressing causality in Mandarin was that because subjective and objective causality in Mandarin can be clearly distinguished by specialized causal connectives (*kejian* 'so' and *yushi* 'so', respectively), prosody would be used to a lesser extent in expressing subjective and objective causality in Mandarin than in languages that prefer to use general causal connectives, such as English. Taking a Bayesian statistical approach, we found clear evidence that subjectivity had no effect on most of the acoustic-phonetic properties examined (with Bayes factors ≤ 1, Table 3) and

some very weak to inconclusive evidence for subjectivity affecting the f0 in the second clause and the pause duration between two clauses. With respect to the use of causal connectives in Dutch, previous studies have shown that the causal connective *dus* was specialized in the subjective causal category but can also be used to express causality in the objective category. In light of this, our prediction for the use of prosody in expressing the two types of causality in Dutch was that utterances expressing subjective and objective causality using *dus* and *daardoor* respectively (the *Daardoor & Dus* set) would contain fewer prosodic differences compared to utterances expressing these two types of causality using *dus* (the *Dus* set). We found strong evidence in favor of an effect of subjectivity on the f0 maximum in the utterances in the *Dus* set (Table 5) and no evidence for an effect of subjectivity on most of the acoustic-phonetic properties under study (with $BF_{10} \leq 1$, Table 6) or only very weak evidence in favor of an effect of subjectivity on two prosodic properties (with $BF_{10} < 3$, Table 6) of the utterances in the *Daardoor & Dus* set.

In addition to testing the trade-off relationship at the utterance level, we explored whether such a trade-off existed at the participant level, i.e., between participants' preferences for specialized causal connectives and their use of prosody. We expected that speakers who had a higher tendency to use *dus* as a specialized subjective causal connective (who therefore tended to use *daardoor* to express objective causality) would use prosody to a lesser extent to distinguish between subjective and objective causality, compared to participants who had a higher tendency to use *dus* as a general causal connective. Our data first confirmed that there was indeed individual variation in the use of *dus* – our speakers varied considerably in the extent to which they used *dus* as a specialized causal connective. Several factors may contribute to the observed individual variation. We know that, in general, language users' biological and social attributes such as age, sex, occupation, or social class can affect their linguistic choices (Biber & Conrad, 2009; Hymes, 1974). More specifically, people's linguistic experience influences their language performance, for example, in terms of coherence comprehension (Scholman, Demberg, & Sanders, 2020). Future research can explore the extent to which these factors explain the variation in the use of *dus* among Dutch speakers. As to whether speakers' preferences for specialized connectives have an effect on their use of prosody

when expressing subjective and objective prosody, the supporting evidence in our data is very weak or even absent, making it difficult to draw definitive conclusions about this issue. One possible reason for this inconclusive result is that our sample size (30 speakers, 30 utterances each) may not be large enough for the model to accurately estimate the rather complicated interaction effect. Future studies could increase the sample size by recording more participants and using a larger number of items, and reassess this hypothesis.

3.4.1 A trade-off relationship between specialized causal connectives and prosody

The utterances used in the two experiments in this chapter had similar semantic meanings to the utterances used in Experiment 2 in Chapter 2 (concerning the use of prosody in expressing subjectivity in causality in English). Moreover, the method used in the current two experiments to elicit the utterances was also identical to that used in Experiment 2 in Chapter 2. Therefore, it is possible to compare the findings of these three experiments. A common finding of Experiments 1 and 2 in this chapter is that utterances expressing subjective and objective causality using specialized causal connectives (i.e., *kejian* and *yushi* in Mandarin, and *dus* and *daardoor* in Dutch) contain fewer prosodic differences, with weaker evidence (as indicated by the very small Bayes factors), compared to utterances expressing subjective and objective causality using a general causal connective (such as *so* in English), as shown in Experiment 2 in Chapter 2. Given that the utterances used the three experiments are comparable in many aspects (such as semantic contents and syntactic complexity), expect for the presence or absence of specialized causal connectives, we attribute the lack of prosodic distinctions in the Mandarin and Dutch data to the presence of specialized causal connectives – the presence of specialized causal connectives makes the type of causality explicit, providing listeners with sufficient information about which type of causality needs to be constructed, thus reducing the need to distinguish between the two types of causality by means of prosody. This view that using lexical devices cancels or reduces the need to use prosodic markers to express the same meaning or function is shared by other researchers. For example, Snedeker and Trueswell (2003), referring to Lieberman (1963), argued that "*Speakers do not bother with prosodic cues if other cues are present to disambiguate structure*." Braun and Chen (2010) proposed that if speakers can

resolve the scope ambiguity of the adverb *now* by means of word order, then they might not use prosody at all, or to a lesser extent. Smith (2004) argued that the need for a speaker to use prosodic devices to indicate the organization of the text would be eliminated by the presence of the explicit markers of discourse structure.

Another interesting finding of the Dutch experiment was that when subjective causality and objective causality were expressed by a common causal connective (namely, *dus*), evidence strongly suggested that there were prosodic differences between them. This finding confirms our prediction and also is consistent with the findings of Experiment 2 in Chapter 2, which found that in English, subjective and objective causality expressed by the same connective are clearly different in prosody. These results suggest that both Dutch and English speakers use prosody to distinguish between subjective and objective causality when these two types of causality are *not* expressed by specialized causal connectives. However, it is important to note that the prosodic means used to distinguish between subjective and objective causality are different in Dutch than in English. In Dutch, we found that subjective causality had a lower f0 minimum in the second clause than objective causality, while in English, the difference is not in the f0 minimum but in the f0 maximum in the second clause, which is higher in subjective causality than in objective causality as reported in Chapter 2. Moreover, in English, the connective *so* has a longer duration and a more concave f0 contour in subjective causality than in objective causality. In Dutch, we also examined the duration of the connective *dus,* but we found no such difference. These findings suggest that although both Dutch and English speakers use f0 to distinguish between subjective and objective causality in the absence of specialized causal connectives, there is a difference in the way they use this cue, showing cross-linguistic differences.

Taken together, the findings of the current study and the findings of Chapter 2 demonstrate that prosody is used in a less salient way to express subjectivity in causality when specialized causal connectives are present than when they are absent. This evidence thus adds to much existing evidence (see the introduction for a brief review) to support the trade-off hypothesis postulated in many speech production models, including the Functional Hypothesis (Haan, 2001) and the Smooth Signal Redundancy Hypothesis (Aylett & Turk, 2004) and the Uniform

Information Density Hypothesis (Levy & Jaeger, 2007). The following perhaps more crucial question is: why do the trade-offs occur in language use? The explanation shared by several researchers is that speakers strive for efficient communication, which, in a broad sense, means that speakers tend to deploy various communicative resources economically as long as the messages they wish to convey can be interpreted successfully. This view, or some form of it, to the best of our knowledge, can be traced back to Passy (1891) and later postulated by Zipf (1935) as the Principle of least effort, according to which human behaviors follow a tendency to strive for the maximum outcome with the minimum effort. The principle of efficient communication is also embedded in Grice's four maxims of conversion, particularly the maxim of quantity (Grice, 1975), which holds that speakers in communication ought to provide a sufficient amount of information for listeners to decode their messages. From this perspective, using specialized causal connectives to express subjective and objective causality provides listeners with ample information about the type of causality the speaker intends to convey, thereby rendering the use of other cues superfluous. Using a general causal connective to express subjective and objective causality, however, does not provide listeners with information about which type of causality should be constructed, thus requiring the speaker to resort to other means to supplement the lacking information. The view of efficient communication is also shared by the hyperspeech-and-hypospeech principle (H&H) in Lindblom (1990), which argues that speakers adjust phonetic properties of their speech to balance between articulatory economy and perceptual clarity and has become the cornerstone of many more recent accounts of speech production, including ideal speaker framework (Kurumada & Jaeger, 2015) and Relevance Theory (Wilson & Wharton, 2006).

3.4.2 Future work

This chapter investigated the role of prosody in expressing subjective and objective causality in the presence of specialized causal connectives. The experimental setting we used is reminiscent of everyday conversations between interlocutors with comparable cognitive and language abilities. We found evidence for a trade-off relationship between the use of specialized causal connectives and prosody: utterances expressing subjective and objective causality using specialized causal connectives show fewer prosodic differences

than utterances expressing subjective and objective causality using a general causal connective. However, two crucial questions follow. One is to what extent the trade-off between morphosyntactic and prosodic cues applies to other types of communication contexts. We speculate based on previous research that several factors may break the balance between the use of, on the one hand, prosodic cues and, on the other hand, the use of specialized causal connectives as well as other lexical cues for the two types of causality. There might be circumstances in which speakers use lexical cues and prosodic cues in an additive way (i.e., not trading one for the other) or use neither cue. Among various potential factors, the most promising ones are the type of communication context and the identity and cognitive ability of addressees, which are known factors that affect prosody (Buxó-Lugo, Toscano, & Watson, 2018; Kraljic & Brennan, 2005). We will elaborate on the potential influence of these two factors in the final chapter. The second question to be investigated, which is also raised in Chapter 2 (concerning the use of prosody in expressing subjective and objective causality in English in the presence of a general causal connective), is whether the prosodic differences between utterances expressing subjective and objective causality using the general causal connective *dus* have any perceptual relevance for listeners: whether the prosodic features allow listeners to make predictions about the upcoming context. This issue will be investigated for English in the next chapter.

3.5 Conclusions

This chapter sheds new light on whether prosody plays a role in expressing subjective and objective causality, a long-standing issue in the field of causality research. It provides cross-linguistic evidence for a trade-off relationship between the use of lexical cues (i.e., specialized causal connectives) and the use of prosodic patterns in expressing these two types of causality in a dialogue setting. The evidence shows that the prosodic differences between these two types of causality tend to be less salient in the presence of specialized causal connectives (*kejian* and *yushi* in Mandarin, *dus* and *daardoor* in Dutch) than in the presence of a general causal connective (*dus* in Dutch).

Chapter 4

The role of prosody in interpreting causality in English discourse

Previous studies have well established that some causal connectives encode information about the semantic-pragmatic distinction between different types of causal relations (CAUSE-CONSEQUENCE versus CLAIM-ARGUMENT relations) and these "specialized" causal connectives help listeners establish different types of causality. Research has also shown that utterances expressing a CLAIM-ARGUMENT relation have different prosodic characteristics than utterances expressing a CAUSE-CONSEQUENCE relation. What remains unknown is whether the prosodic characteristics of utterances expressing causality can help listeners determine the type of causality expressed in the utterance. This study investigates this issue, focusing on the effect of the prosody of the causal connective *so* in English on listeners' interpretation of the type of causality. We found that the odds of listeners choosing subjective continuations over objective continuations increased when the connective *so* ending the sound clip was pronounced with subjective prosodic features, namely, prolonged duration and a concave f0 contour. This finding suggests that the prosody of the connective *so* encodes information about types of causality and guides listeners in interpreting causal relations. In addition, it is worth noting that there is individual variation among listeners in their interpretations of prosodic information related to subjective-objective causality contrast in our data.

4.1 Introduction

Establishing connections between discourse units is a prerequisite for understanding discourse. According to Rhetorical Structure Theory (Mann & Thompson, 1988), there are many different types of discourse relations (or, in the authors' term, rhetorical relations) such as *concession*, *contrast*, and *cause*. Among these relations, *causality* is regarded as fundamental to human cognition (Kuperberg, Paczynski, & Ditman, 2011; Sanders, Spooren, & Noordman, 1992).

According to discourse literature, human minds distinguish between at least two types of causality. One is referred to as subjective causality and the other as objective causality (Pander Maat & Degand, 2001; Sanders & Sweetser, 2009; Stukker et al., 2008), among other terms including *pragmatic* versus *semantic* (Sanders et al., 1992; van Dijk, 1979), *internal* versus *external* (Halliday & Hasan, 1976), *diagnostic* versus *simple-causal* (Traxler, Bybee, et al., 1997), and *presentational* versus *subject matter* causality (Mann & Thompson, 1988). The main difference between these two types of causality lies in the way in which causality is constructed. Subjective causality is established by the speaker's or author's deductive reasoning, involving mental products such as opinions, inferences, or evaluations of events taking place in the physical world (Knott, 2001), as in (1a), in which the conclusion "*The neighbors must be at home"* is inferred from the factual statement in the first clause. In contrast, objective causality concerns causal connections between actual events in the real world (Pander Maat & Sanders, 2000), such as the causal connection between below-zero temperatures and a frozen pond in (1b).

(1a) Their car is in the driveway. The neighbors must be at home.

(1b) The temperature has been below zero for weeks. The pond is frozen.

The division between subjective and objective causality in human cognition is supported by evidence from language development and processing (see Sanders & Evers-Vermeul, 2019, for a detailed review). For example, studies of child language acquisition have shown that the acquisition of these two types of

causality takes place at different ages, with objective causality being acquired earlier than subjective causality (Evers-Vermeul & Sanders, 2011; van Veen, 2011). Processing studies have found that these two types of causality have different processing patterns: subjective causality requires more cognitive resources to process than objective causality (Noordman & de Blijzer, 2000; Traxler, Bybee, et al., 1997; Traxler, Sanford, Aked, & Moxey, 1997).

Many studies have shown that these two types of causality can be distinguished at the lexical level by various types of coherence markers (also known as discourse markers or lexical markers of coherence and discourse structure; see Taboada, 2006). For instance, cue phrases such as *I think* and *in my opinion* are markers of subjective causality applicable to (1a). In contrast, phrases such as *for that reason* and *that's why* signal objective causality, suitable for (1b) (Pander Maat & Sanders, 2006). Some causal connectives can also distinguish between subjective and objective causality. For example, causal connectives that explicitly mar objective causality are *daardoor* 'so' in Dutch (Stukker et al., 2008), *yushi* 'so' in Mandarin (Li, Evers-Vermeul, & Sanders, 2013), *parce que* 'because' in French (Zufferey, 2012), and *weil* 'because' in German (Stukker & Sanders, 2012), and those that mark subjective causality in these languages are *dus* 'so' in Dutch, *kejian* 'so' in Mandarin, *car* and *puisque* 'because' in French, and *denn* 'because' in German.

These specialized causal connectives thus specify the type of causality the addresser intends to convey. A large body of evidence has shown that these causal connectives function as processing instructions in processing causality, guiding the addressees as to which type of causality should be established. For example, Canestrelli et al. (2013) found that in Dutch, the subjective causal connective *want* 'because', causes a processing delay in the words immediately following it, whereas the objective causal connective *omda* 'because', has no such effect. As another example, Li, Mak, Evers-Vermeul, & Sanders (2017) found that in Mandarin Chinese, subjective (in the authors' term, epistemic) causal relations marked with subjective causal connective *kejian* 'so' result in shorter reading time compared to those marked by an underspecified causal connective *suoyi* 'so'. These findings suggest that subjective causal connectives such as *want* and *kejian* prompt the addressees to establish a subjective representation of the upcoming content. Furthermore, research has shown that

specialized causal connectives allow addressees to make predictions about the upcoming context. For example, Wei, Mak, Evers-Vermeul, & Sanders (2019) found that after hearing a subjective causal connective, addressees' eye gaze fixates on an image depicting a person being interviewed by an interviewer, suggesting that the addressees expect the causality being communicated to involve a subject's reasoning.

However, not all causal connectives can distinguish between subjective and objective causality. A typical example is the English connective *so*, which is a general causal connective that can be used to express both subjective and objective causality (Andersson, 2016; Taboada, 2006) and fits both (1a) and (1b). Unlike specialized causal connectives such as *kejian* and *yushi* in Mandarin, general causal connectives, such as *so* in English, express a causal relation without marking its type. As a result, readers can only determine which type of causality should be established by referring to contextual information, world knowledge, and other lexical cues.

In speech communication, information is conveyed not only through lexical channels but also through non-lexical ones. As one of the non-lexical means of communication, prosody, referring to the acoustic variations in speech (Warren, 1999), carries a variety of meanings and functions in speech (for extensive reviews, see Cole, 2015; Cutler, Dahan, & Van Donselaar, 1997; Hirschberg, Beňuš, Gravano, & Levitan, 2020; Wagner & Watson, 2010). For example, prosody signals syntactic structures (e.g., Schafer, Speer, Warren, & White, 2000), marks discourse and rhetorical structure (e.g., den Ouden, Noordman, & Terken, 2009; Hirschberg & Grosz, 1992; Swerts, 1997; Tyler, 2013), marks focus and information status (Brown, 1983 ; Büring, 2011; Nooteboom & Terken, 1982), conveys pragmatic meanings such as uncertainty, irony, and sarcasm (e.g., Chen & Boves, 2018; Dijkstra, Krahmer, & Swerts, 2006; see Mitchell & Ross, 2013 for an extensive review), helps interlocutors with conversational turn-taking (Schaffer, 1983), and reveals speakers' social-indexical identities such as region, gender, and ethnicity. Furthermore, research also shows that prosodic information contributes to speech processing (see Cole, 2015; Hirschberg et al., 2020 for reviews). For example, prosody has been found to help listeners resolve syntactic ambiguity (e.g., Schafer et al., 2000; Snedeker & Trueswell, 2003), interpret focus or information status (e.g., Terken &

Nooteboom, 1987), and resolve referential ambiguity (e.g., Chen, Den Os, & De Ruiter, 2007; Dahan & Tanenhaus, 2005; Ito & Speer, 2008; Watson, Tanenhaus, & Gunlogson, 2008; Weber, Braun, & Crocker, 2006), establish the structure of a discourse (Herman, 2000), grasp illocutionary force and affective meaning (e.g., impoliteness: Culpeper, 2011; sarcasm: Chen & Boves, 2018), take turns in dialogues, and detect the function of polyfunctional words or word combinations such as *yes* and *I think* in a discourse (Didirková et al., 2019; Gravano, Hirschberg, & Běnuš, 2012).

However, in contrast to the above studies, to date, little is known about whether prosodic information contributes to the processing of subjective and objective causality. The need to elucidate this question has recently become even more pressing because Experiment 2 in Chapter 2 showed that prosody plays an active role in expressing subjective and objective causality in English in the absence of morphosyntactic cues for these two types of causality. Specifically, it was found in Experiment 2 in Chapter 2 that subjective causality in forward order (ARGUMENT-CLAIM) expressed by the general causal connective *so* has a higher pitch in the second clause, longer duration, and a unique f0 contour for the connective *so*, compared to objective causality (CAUSE-CONSEQUENCE). Based on this finding, the current study sets out to investigate whether the prosodic differences between subjective and objective causality are sufficient for listeners to distinguish between these two types of causality in the absence of lexical markers.

Previous research on the use of prosody to process information has also found that while at the group level listeners make use of prosodic information to understand utterances, there is substantial variation at the individual level, with some listeners being more successful than others in decoding the information conveyed by prosody. Such individual differences have been reported in the perception of prosodic information related to information structure (Bishop, 2012) including focus types (Breen, Fedorenko, Wagner, & Gibson, 2010) and prosodic phrase boundaries (Cole, Mo, & Baek, 2010), and in the interpretation of irony (Rivière, Klein, & Champagne-Lavau, 2018) and sarcasm (Peters, Wilson, Boiteau, Gelormini-Lezama, & Almor, 2016). In the current study, we explored whether listeners differ in the interpretation of prosodic information related to the contrast between subjective and objective causality.

To summarize, this chapter investigated whether prosody has an effect on the processing of subjective and objective causality in English and whether the effect of prosody differs between listeners. We conducted a perception experiment online, using an forced-choice discourse completion task similar to the task employed by Didirková et al. (2019). In our task, the participants heard short audio clips narrating real-world events ending with the connective *so* (e.g., "*Jim got his nose pierced so"*), with the critical word *so* being realized in two different types of prosody: one found in utterances conveying subjective causality (henceforth "subjective prosody") and the other in utterances conveying objective causality (henceforth "objective prosody"). After listening to each stimulus, the participants were tasked with choosing one continuation for the stimulus they heard from two options provided on the screen. One was an opinion or inference about the event described in the stimulus (hereafter referred to as "subjective continuation"), forming a subjective causal relationship with the stimulus; the other was the consequence of the event stated in the stimulus (hereafter "objective continuation"), thus forming an objective causal relationship with the stimulus. If the prosodic realization of the connective *so* encodes information about the type of causality the addresser intended to convey, listeners are expected to opt more often for subjective continuations when hearing *so* pronounced with subjective prosody than when hearing *so* pronounced with objective prosody. Given that the perception and interpretation of prosodic information typically varies between individuals (Bishop, 2012; Breen et al., 2010), we suspect that the effects of the prosody of the connective *so* might differ between participants.

4.2 Method

4.2.1 Participants

Fifty-five participants (27 females and 28 males) participated in the experiment. The participants were recruited from Prolific (www.prolific.co), an online crowdsourcing platform. A set of screening criteria was set up on Prolific to reach eligible participants. Those eligible to participate in the study were native speakers of American English between the ages of 25–35, raised in a monolingual family, and had obtained a bachelor's degree. The participants

received a small participation fee.

4.2.2 Materials

The materials used in this experiment were adopted from Chapter 2, which explored the acoustic differences between utterances expressing subjective and objective forward causality in the absence of specialized causal connectives. There were 15 pairs of target items, each pair consisting of two items, one expressing objective and the other subjective causality (see (2a) and (2b)). For each pair of items, the first clause (shown in the square brackets with the subscript "event" in (2a) and (2b)) were identical, telling a real-world event (hereafter referred to as the "event" clause), such as "*Jim got his nose pierced"* in (2a) and (2b). The second clauses were different, shown in square brackets with the subscript "continuation" in (2a) and (2b). For the objective item in a pair, the second clause stated an actual consequence of the event stated in the first clause, e.g., "*He bled a little"* as in (2a), thus forming objective forward causality with the first clause. For the subjective item in the same pair, the second clause expressed an opinion or evaluation of the event stated in the first clause, e.g., "*He wants attention"* as in (2b), thus establishing subjective forward causality with the first clause. In addition to the target items, 20 fillers were adopted from Chapter 2 to hide the research goal from the participants. All filler items expressed concessive relations with *but* (see (3)) and had a sentence structure similar to the target items.

(2a) [Jim got his nose pierced] $_{\text{event}}$ so [he bled a little] $_{\text{continuation1}}$.

(2b) [Jim got his nose pierced]$_{\text{event}}$ so [he wants attention] $_{\text{continuation2}}$.

(3) [John worked very hard] $_{\text{event}}$ but [he failed his exams].

4.2.3 Acoustic manipulations

In the current experiment, the "event" clause and the subsequent connective in each item (e.g., "*Jim got his nose pierced so"*) were presented to the participants in audio form. Each "event" in the target condition was presented twice, with the subsequent connective *so* having two types of prosody, subjective versus objective prosody, resulting in 30 target stimuli. These audio stimuli were created on the basis of utterances collected in Experiment 2 in Chapter 2. Those utterances were suitable as stimuli for the current study because they were

elicited from a naturalistic conversation setting where participants chatted with an interlocutor, producing sentences such as (2a) and (2b) as responses to questions posed by the interlocutor. A total of 15 native speakers of American English had participated in Experiment 2 in Chapter 2. To select the speaker for the current study, four judges evaluated the speech samples produced by each speaker independently in terms of voice quality (creakiness), fluency (pauses within a clause), and articulation rate (number of syllables produced per second). Ideally, speakers suitable for the current study should have a non-creaky voice, speak fluently, and not speak too fast or too slowly. The speaker who performed best in all of these respects, as unanimously agreed by the judges, is a male aged 23 (at the time of participation), whose utterances were used as the basis for the stimuli in the current study.

To ensure that the prosody of each utterance produced by this speaker matched the type of causality expressed in the utterance, a series of acoustic manipulations were applied to the utterances. The manipulations were based completely on the findings of Experiment 2 in Chapter 2 and involved only the prosody of the connective *so*, not the prosody of the "event" clause, because it was found in Experiment 2 in Chapter 2 that the prosodic differences between subjective and objective causality lie in the connective *so* and the second clause (not involved in the current experiment), not in the first clause (the "event" clause). It was reported in Chapter 2 that the connective *so* had a longer duration (mean difference: 50 milliseconds (ms), 95% CrI (95% credible interval, the central portion of the posterior distribution that contained 95% of the plausible values) [30 ms, 70 ms]) when expressing subjective causality than when expressing objective causality. Based on the estimated mean difference and intercept reported in Chapter 2, we derived a mean duration of 285 ms for the connective *so* in the subjective condition and 235 ms in the objective condition. In addition to the durational difference, Chapter 2 also reported a difference in the f0 contour for the connective *so* between subjective and objective causality. In Chapter 2, the f0 contours of the connective *so* had been modeled using Functional Principal Component Analysis (FPCA) (Gubian, Torreira, & Boves, 2015). This method converts each contour into a mathematical function of time (see Equation 1), which consists of the average contour of all contours in a data set ($\mu(t)$) and three Principal Component contours (*FPC1(t), FPC2(t)*, and

FPC3(t)), each FPC being associated with a weight (*s1, s2,* and *s3*) that indicated the extent to which each FPC should be applied to the mean contour in order to reconstruct the original contour with a reasonable balance between overfitting and under-fitting.

$$F0(t) \approx \mu(t) + s1 \cdot FPC1(t) + s2 \cdot FPC2(t) + s3 \cdot FPC3(t) \quad (1)$$

It was found in Chapter 2 (see Section 2.3.5.2) that the weight of FPC2 was 0.85 units larger (95% CrI [0.24, 1.46]) and the weight of FPC3 was 0.09 units smaller (95% CrI [-0.19, 0.00] for contours in the subjective condition than those in the objective condition. In descriptive terms, these estimates suggest that the f0 contour of the connective *so* was more concave and had a lower intercept with the y-axis in subjective causality than in objective causality, as shown in Figure 1 (compare the dotted contours). Based on the model estimations reported in Chapter 2, we derived that the mean weight of FPC2 was +0.335 units for subjective contours and -0.515 units for objective contours, and the mean weight of FPC3 was -0.065 units for subjective contours and +0.025 units for objective contours. These values were used to create a typical contour for the connective *so* for each type of causality.

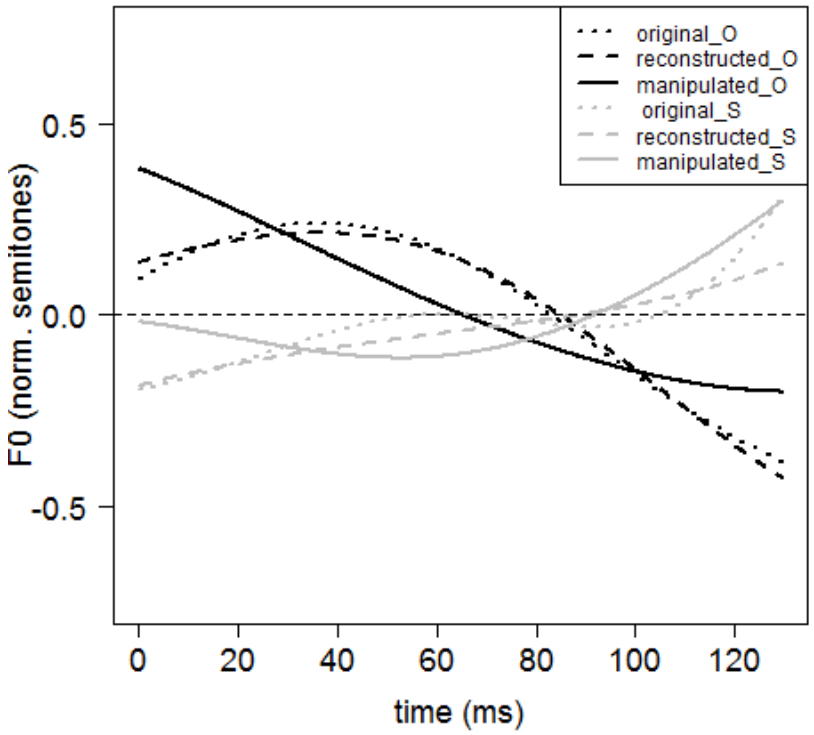


Figure 1. The f0 contours of the vowel /əʊ/ of the connective *so* in the two stimuli in Pair 5 (black lines: in the objective condition; grey lines: in the subjective condition) in their original forms (dotted lines), after being modeled by FPCA (dashed lines), and after being manipulated (solid lines).

Acoustic manipulations were carried out with Praat (Boersma & Weenink, 2018) (data extraction, duration manipulation, and speech synthesis) and R (R Core Team, 2017) (f0 contour restyling using FPCA (code is available at https://osf.io/g8e6x/). First, the first clause (the "event" clause) and the subsequent connective *so* were extracted from each utterance as a new audio file, resulting in 30 sound clips. Second, using an accurate autocorrelation method described in Boersma (1993), f0 points (in Hz) were extracted from each sound

clip in steps of 5 milliseconds (f0 floor: 75 Hz; f0 ceiling: 300 Hz). Third, the f0 points within the span of the connective *so* were saved separately for the acoustic manipulation, resulting in a total of 30 f0 contours (see the dotted lines in Figure 1 for two of these contours). Fourth, the f0 contours of the connective *so* were modeled using FPCA with the duration normalized, resulting in 30 mathematical functions (one for each contour) (dashed lines in Figure 1). Fifth, the weights of FPC2 and FPC3, i.e., *s2* and *s3*, in each obtained function were modified. For the f0 contours in the subjective causality condition, *s2* was changed from its original value to +0.335 and *s3* to -0.065; for the f0 contours in the objective causality condition, *s2* was changed to -0.515 and *s3* to 0.025 (see Figure 1 for the resulting contours (solid lines)). Sixth, the value of *F0(t)* in each newly obtained function was solved, with the values of *t* being multiples of 5 ms. This yielded a new series of values of *F0(t)*, i.e., a new f0 contour for the connective *so*. Seventh, the new f0 contours for the connective *so* were used to replace the original contours for the connective in the contours obtained in Step 2 to obtain a new f0 contour for each stimulus. Eighth, the new f0 contours were resynthesized into speech using the PSOLA synthesizer in Praat. Ninth, the duration of the connective *so* in each synthesized audio file was modified. This was achieved by first defining a new duration tier and then resynthesizing the speech using the new tier utilizing PSOLA in Praat. For stimuli with subjective prosody, the duration was changed to 285 ms; for stimuli with objective causality, it was changed to 235 ms. Considering that the original relative duration between the consonant /s/ and the vowel /əʊ/ varied between stimuli, to avoid disproportional changes in the duration of the two phonemes, the duration ratio was fixed at 1:1. Tenth, the silent interval between the first clause and *so* in each stimulus was removed to exclude its potential effect on the interpretation of subjective and objective causality. Lastly, the authors of this study evaluated the naturalness of the utterances perceptually. The evaluation showed that all stimuli were natural in terms of prosody. Table 1 summarizes the acoustic specifications of the resulting two types of prosody. The stimuli are available at https://osf.io/g8e6x/.

Table 1
The acoustic details of the connective so in each prosodic condition

Prosodic version	The shape of the f0 contour for the connective	Duration of the connective
subjective	μ(t) + s1 * PC1 + (+0.335) * PC2+ (-0.065) * PC3	285 ms
objective	μ(t) + s1 * PC1 + (-0.515) * PC2+ (+0.025) * PC3	235 ms

Filler stimuli were prepared based on the speech samples produced by the same speaker. The part of each original utterance containing the first clause and the connective *but* (e.g., "*John worked very hard but"* in (3)) was extracted using Praat, resulting in 20 filler stimuli. No acoustic manipulation was performed on the filler stimuli.

4.2.4 Task

The stimuli (30 targets and 20 fillers) were presented to the participants using an online forced-choice discourse completion task set up with the online survey tool Qualtrics (www.qualtrics.com/). In the task, the stimuli were presented to the participants in a randomized order on a trial-by-trial basis over headphones. On each target trial (trials involving target stimuli), a stimulus, e.g., "*Jim got his nose pierced so"*, was first played automatically to the participants. One second after the stimulus was played, two possible continuations of the stimulus appeared on the screen in a textual form, one unveiling the consequence (e.g., "*He bled a little"*) of the event announced in the stimulus, the other expressing an opinion/deduction/inference (e.g., "*He wants attention"*) about the event (see Figure 2 for a graphic description of the timeline of a trial). The participants' task was to choose the continuation that they thought best continued the stimulus they had just heard. The play button remained on the screen. The participants were allowed to click on it as many times as they wanted to listen to the stimuli before making a choice.

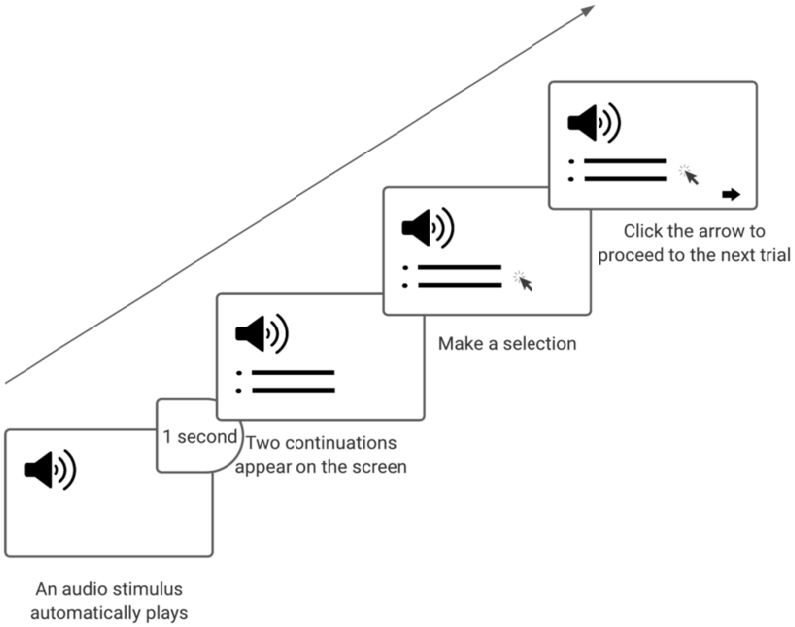


Figure 2. A graphic description of the timeline of a trial

The filler stimuli were presented to the participants in the same way as the target stimuli. On each filler trial, a filler stimulus (e.g., "*John worked very hard but"*) was played first. Then two continuations were shown on the screen, only one of which satisfied the concessive relation required by the connective *but,* and the other sentence had no semantic relevance to the stimulus. Take the stimulus "*John worked very hard but"* as an example. The two continuations shown on the screen were (A) "*He failed his exams"* and (B) "*The plane landed on time*." Option A was the only correct choice, whereas Option B was completely out of context (the order of the correct and incorrect options was randomized in the experiment). Considering that the correct continuation was obvious, the filler stimuli were also used as attention checks. If a participant selected incorrect continuations in 10% or more of the filler stimuli, they would be judged as having failed the task and their responses would be excluded from further analyses.

4.2.5 Procedure

The experiment had been approved by the Ethics assessment committee of Humanities at Utrecht University before it was conducted. The experiment was conducted online via the crowdsourcing platform Prolific (www.prolific.co). Prolific users who met the screening criteria (see Section 4.2.1 for details) received an invitation via email. Users who accepted the invitation first completed a Captcha test, which was used to filter out bot users (identified by Prolific). Those who passed the Captcha test read an information letter on the screen containing relevant information about the study including the task, data storage, and approval policies. After reading the letter, users had the opportunity to decide whether they wanted to participate in the experiment. Users who did not wish to proceed could simply click "No" on the screen to withdraw from the survey. The users who agreed to participate were asked to provide their Prolific ID (which was to be used to identify participants when we notified them of the decision on their submission). The participants then read instructions (see Appendix F), which explained the task and instructed them to wear headphones to listen to stimuli and complete the task in a quiet room. After that, the survey started. The entire experiment took approximately 15 minutes to complete. The participants were remunerated 2.5 euros for their participation through Prolific.

4.2.6 Statistical analysis

We first examined the participants' responses to the filler questions. We found that of the 55 participants who submitted their responses, 38 participants answered the filler questions with 100% accuracy, 2 participants had an accuracy rate higher than 90%, 3 participants had an accuracy rate between 70% and 89%, 8 participants had an accuracy rate between 50% and 69%, and 4 participants had an accuracy rate lower than 50%. Based on the assessment criteria set before the task, we excluded participants with accuracy rates below 90% from further analyses, resulting in a sample size of 40 participants.

To estimate the effect of the prosody of the connective *so* on the participants' choice of continuation, we fitted a series of Bayesian logistic regression models in `R` (version 3.6.3, R Core Team, 2020) using the `brms` package (Bürkner, 2017), a wrapper package for the probabilistic programming language `Stan` (Carpenter et al., 2017). The outcome variable in our models was a dichotomous variable indicating participants' choice of continuation (subjective continuation = 1,

objective continuation = 0). The predictor variable was the prosody of the connective *so* (`prosody`), which had two levels: subjective and objective, coded as 1 and 0, respectively. The grouping variables were `participant` and `pair` (verbally identical but acoustically different stimuli were considered a pair). We added these variables into models in an incremental manner (see Table 2), starting with an intercept model (`m0`) containing only the grouping variables `participant` and `pair`, to `m1` containing the predictor variable `prosody`, to `m2` containing a varying slope for the effect of `prosody` by `participant` (`1+prosody|participant`) allowing for by-participant adjustments to the effect of `prosody`, and finally, to `m3` containing a varying slope for `prosody` by `pair` (`1+prosody|pair`) allowing for by-pair adjustments to the effect of `prosody`.

To evaluate each model term, we computed the Bayes factors for each model term using the function `bayes_factor (m1, m0)` in `brms`, with `m1` and `m0` in the bracket referring to models containing and not containing the model term being evaluated, respectively. For example, to assess the effect of `prosody` on the participants' choice of continuation, `m1` and `m0` in Table 2 were compared, which were the models with and without the constant effect term `prosody`, respectively. The resulting Bayes factors, referred to as BF_{10} (with the subscripts 1 and 0 referring to `m1` and `m0`, respectively), indicate the extent to which the evidence supports `m1` over `m0`, akin to the ratio of likelihoods of the two models (Lee & Wagenmakers, 2014; Nicenboim & Vasishth, 2016), with larger BF_{10} values indicating more robust support for `m1`. The conventional interpretations of BF_{10} are as follows: BF_{10} greater than 10, 3–10, and 1–3, respectively, indicate strong, weak, and very weak support for `m1`; BF_{10} smaller than 0.1 indicates that the evidence favors `m0` (Jeffreys, 1998).

Table 2

Models formulas

Model	Formula
`m0`	`~ 1 + (1|participant) + (1|pair)`
`m1`	`~ prosody + (1|participant) + (1|pair)`
`m2`	`~ prosody + (1+prosody|participant) + (1|pair)`
`m3`	`~ prosody + (1+prosody |participant) + (1+prosody|pair)`

It is worth noting that Bayes factors are under the influence of the prior incorporated in models (Vasishth, Nicenboim, Beckman, Li, & Kong, 2018), that is, the assumption held by the model before the data comes in. This could create potential difficulties in interpreting BF_{10}. To circumvent this issue, it is common practice to compute Bayes factors under different priors (Vasishth et al., 2018). We took this approach in the study, calculating Bayes factors for each effect of interest using three different priors. The priors for the parameters in the model were normal distributions (`normal (0, SD)`) with standard deviations (`SD`) of `1.5`, `1`, and `0.5`, which were chosen by examining the prior predictive distributions generated by the intercept model incorporating priors (`normal (0, SD)` with `SD` of `10`, `1.5`, `1`, `0.5`, and `0.25`. As shown in Figure 3, models incorporating priors with `SD`s of `1.5`, `1`, and `0.5` produced reasonable prior predictive distributions. In descriptive terms, the models did not have strong beliefs about which continuation the participants would choose before seeing the actual data. In contrast, these model incorporating the `normal (0, 10)` prior, a conventional flat prior commonly used in linear regression models, produced very unrealistic data; before seeing the data, the model assumed that the participants either never or always chose the subjective continuation. Since this was a very extreme assumption, the `normal (0, 10)` prior was not adopted. The reason that the `normal (0, 10)` prior does not behave as a flat prior in the current case as it does in linear regression models is that the parameter values in logistic models are in the log-odds space, which are hard to interpret. In order to make the model parameters interpretable, we need to convert them to the outcome probability space using an `inverse-link` function (in this case, the function is `inv-logit`, as the link function we used is `logit`) (McElreath, 2016). The resulting values will have a probability mass that is piled up near zero and one as shown in Figure 3. The models were fitted using four chains, 10,000 iterations, 2,000 of which were in the warming up phase, and the `Bernoulli` family with the `logit link` function, which maps a parameter that is defined as a probability mass onto a linear model that can take on any real value. To assess model convergence, we verified that there were no divergent transitions and the `Rhat` value for each model coefficient was close to one. We also ensured that the number of `ESS` (effective sample size) exceeded 90% of the

post-warmup samples, following Nicenboim et al. (2020).

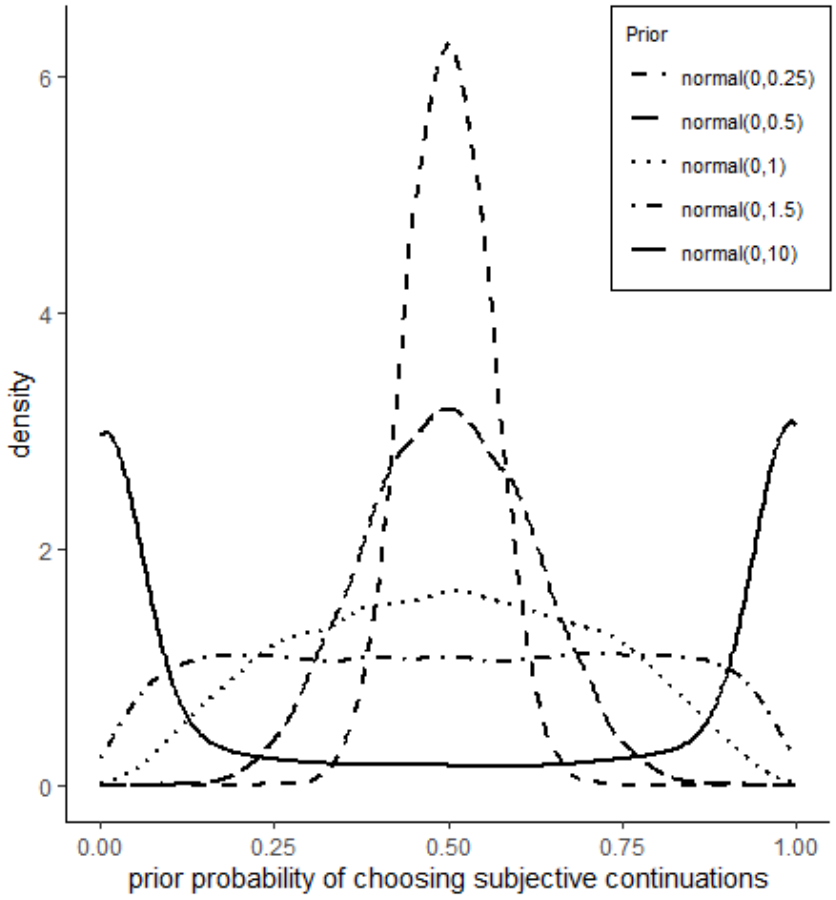


Figure 3. Prior predictive distributions generated by `m0`, the intercept model, under different priors.

As mentioned earlier, the parameters of logistic models were on the log-odds space. In particular, the coefficient for the constant effect `prosody` describes a difference in the log odds for two units who differ by 1 in the predictor. Clearly, this interpretation is not straightforward. For a more intuitive interpretation, this parameter was exponentiated using the function `exp()`, which resulted in the

ratio of the odds of choosing subjective continuations after listening to stimuli with subjective prosody to the odds of choosing subjective continuations after listening to stimuli with objective prosody.

In the following result sections, we focus on the estimates of two models. We first report `m0` with a focus on its intercept, which represents the baseline of the participants' choice of continuation, and then `m3`, which has the most complete random parts. The summaries of `m1` and `m2` are provided in the Appendix. For `m3`, we report the estimated mean and 95% credible interval (`95% CrI`, the Q2.5-Q97.5 interval of the posterior distribution) for each model term of interest. We also report the Bayes factors evaluating the effects of interest as well as the priors used to compute the Bayes factors. Unless otherwise stated, the posterior distributions reported in the main text were all estimated by the model with the least informative prior `normal (0, 1.5)`.

4.3 Results

First, the intercept model (`m0`) showed that the posterior distribution of the intercept was centered at -1.06 with a 95% CrI [-1.34, -0.77]. Considering that the estimated 95% CrI did not include zero, we can be certain that the estimated mean was not zero. Since this model did not contain any predictor variables, the intercept represented the baseline log odds of the participants choosing subjective continuations. By exponentiating the log odds, we obtained the odds of participants choosing subjective continuations, which is 0.34 with a 95% CrI [0.26, 0.46]. With this information, we further derived the odds of participants choosing objective continuations, which is 2.94 (1/0.34), higher than the odds of participants choosing subjective continuations, which was 0.34. This suggests that the participants had a strong baseline tendency to choose objective continuations for the stimuli they heard.

Table 3 summarizes the most complex model (`m3` in Table 2), the model that contains the constant effect `prosody` and by-participant and by-pair random slopes of `prosody`. As shown in the table, the model coefficient for `prosody` is estimated at 0.39 (95% CrI [0.09, 0.69]). Table 4 shows that the Bayes factors for the constant effect `prosody` were between 3 and 7, showing weak support for this effect. Solving for the exponential of these estimates yielded an odds ratio of 1.48 (95% CrI [1.10, 1.99]) for the prosody effect, meaning that across

participants and across pairs, the odds of participants choosing subjective continuations in the subjective prosody condition were 1.48 times the odds of participants choosing subjective continuations in the objective prosody condition.

Table 3

Summaries of the most complex Bayesian mixed-effects model (`m3`) with the least informative priors (normal (0, 1.5)). The model contains the constant effect `prosody` and a varying slope of `prosody` by `participant` and `pair`. Reported in the table are the estimated mean and the lower and upper bounds of the 95% credibility interval of the posterior distribution of each model parameter of interest, namely, the random effect terms `sd(prosodyS)` by `participant` and `pair`, the `intercept`, and the constant effect `prosody`.

Parameter	Posterior		
	Estimate	Lower	Upper
~Pair sd(prosodyS)	0.42	0.12	0.83
~Participant sd(prosodyS)	0.51	0.21	0.87
Intercept	-1.19	-1.47	-0.90
ProsodyS	0.39	0.09	0.69

Table 4

The Bayes factors evaluating each model term, computed using three different priors.

parameter	Prior	BF10
~Pair	Normal(0, 1.5)	5.34
sd(prosodyS)	Normal(0, 1)	7.60
	Normal(0, 0.5)	11.4
~Participant	Normal(0, 1.5)	32.7
sd(prosodyS)	Normal(0, 1)	45.1
	Normal(0, 0.5)	61.7
ProsodyS	Normal(0, 1.5)	3.02

	Normal(0, 1)	4.25
	Normal(0, 0.5)	6.75

Table 4 also shows that the BF_{10} evaluating the by-participant varying slopes for `prosody` (`(1+prosody|participant)`) exceeded ten under all incorporated priors, indicating that including this varying slope term was meaningful. Also, Table 3 shows that the lower and upper bounds of the 95% CrI of this random slope term were 0.21 and 0.87, respectively, both clearly away from zero, emphasizing the relevance of including this random slope term in the model. The model showed that the posterior mean of the standard deviation of prosody (`sd(prosody)`) was 0.51, and thus the variance was 0.51^2=0.26, which was quite large. Figure 4 shows the posterior distribution of the slope for prosody per participant. It can be observed from the figure that there was a significant variation in the participants' responses to prosody, with some participants responding more strongly to the prosodic manipulations than others. Fourteen of the participants, e.g., participants 26, 28, and 33, were clearly affected by prosody, with their 95% CrIs far from zero, while for the other participants, the effect of prosody was less lucid as the 95% CrI of these participants contained zero.

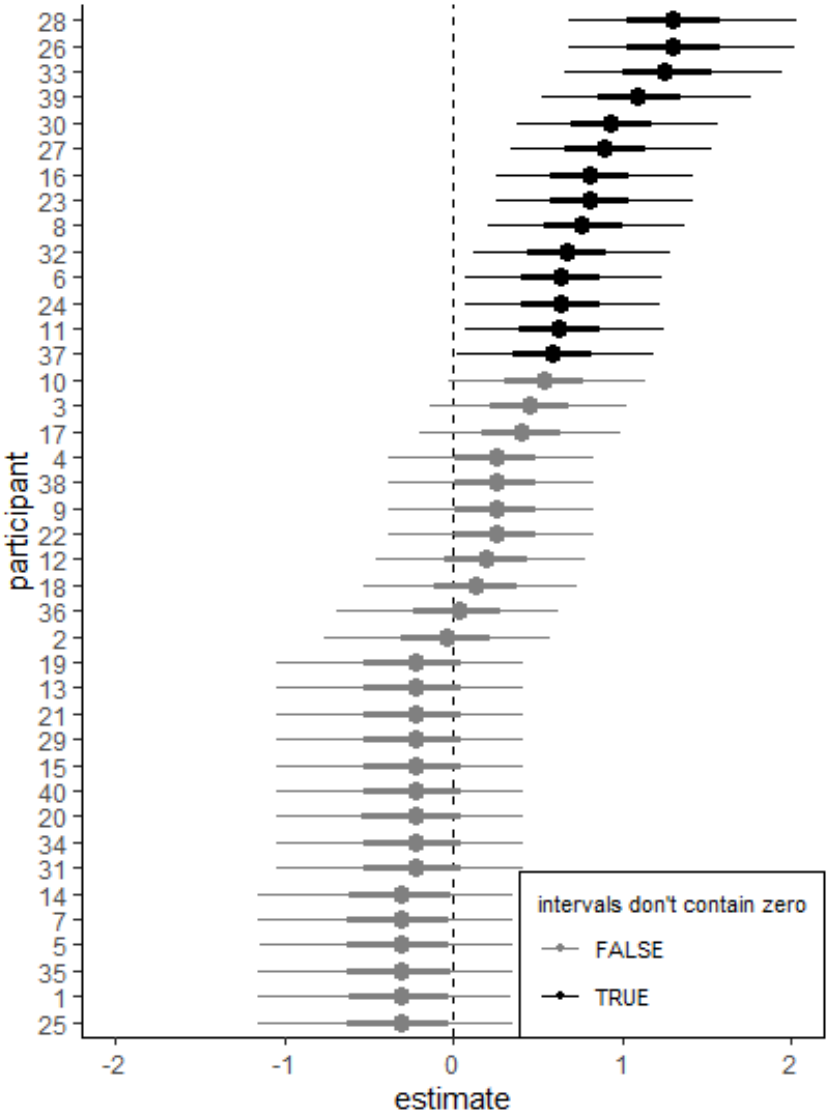


Figure 4: The posterior distribution of the slope for prosody for each participant, averaged over the levels of pair. The black dots are the posterior means. The thin and thick horizontal lines are the percentile-based 95% and 50% posterior intervals, respectively. Each line represents a participant with the participant's ID

denoted on the y-axis.

In addition to the variance in the slope of prosody for participants, our data also supported the inclusion of the random slope of prosody for pairs. As shown in Table 3, the Bayes factors evaluating by-pair random slopes of prosody ranged from 5 and 11, favoring the model containing the random slopes under the three incorporated priors. Also, the lower and upper bounds of the 95% CrI were clearly away from zero, confirming that including this random slope term was necessary. According to the model, the variance of the random slope of prosody by pair was 0.42^2=0.17, which was not negligible.

4.4 Discussion

The current study investigated the effects of prosody on the participants' interpretation of subjective versus objective causality in English. Specifically, we explored whether the prosodic make-up of the connective word *so* allowed listeners to make predictions about upcoming context. To this end, we conducted a perception experiment online involving a forced-choice discourse completion task, where participants first listened to audio stimuli announcing real-world events ending with the connective *so* with prosodic characteristics featuring either subjective prosody or objective prosody. After listening to each stimulus, the participants were asked to choose a continuation for each stimulus from two choices shown on the screen, one continuation establishing subjective causality with the stimulus and the other objective causality. If the prosody of the connective is sufficient for listeners to establish subjective versus objective causality, then the participants should be able to correctly anticipate the upcoming causality after hearing the connective. Specifically, they should choose subjective continuations more often after hearing the stimulus presented with subjective prosody than after hearing it presented with objective prosody and vice versa. Furthermore, given the commonly observed individual differences in the perception and interpretation of prosodic cues, we expected that listeners would differ in terms of how they interpreted the prosody of the connective *so*. Several interesting findings emerged from our data. First, we found a general bias towards objective continuations regardless of prosody. Second, we found that, despite this bias, the prosody of *so* indeed has an effect on

the listeners' interpretation of causality. The connective with subjective prosodic features, that is, prolonged duration and a concave f0 contour, yielded higher odds of choosing subjective continuations. Third, as expected, we also found considerable variation between the participants in terms of how they reacted to the effect of prosody, with some participants reacting more strongly to the prosodic features of the connective than others. In addition, we found that the effect of prosody varied between stimuli. In what follows, we discuss these findings in turn and then we suggest directions for future research.

The finding that the participants had a strong bias toward choosing objective continuations suggests that they prefer to construct objective causality rather than subjective causality. One possible explanation for this bias is that objective causality is easier to construct because it is less complicated in nature, involving only factual situations; subjective causality, on the other hand, is more challenging to construct because it involves establishing a meta-representation of other persons' mental processes (Canestrelli et al., 2013; Noordman & de Blijzer, 2000; Sanders et al., 1992; Traxler, Sanford, et al., 1997). This presumed difference in conceptual complexity between subjective and objective causality is supported by evidence from language acquisition and processing. Studies have shown that objective causality is acquired earlier by children and requires less time to process than subjective causality (Evers-Vermeul & Sanders, 2011). The preference for constructing objective causality may also have been caused by the design of the task. The continuations, which were adopted from Chapter 2, were provided directly to the participants on the computer screen. Although in Chapter 2, these items were judged as typical examples of each type of causality by native speakers, the participants in the current study may have been reluctant to accept the judgments or evaluations involved in certain subjective continuations as their own judgments, and may have opted instead for the objective continuations. Future studies could invite participants to provide their own continuations for the audio stimuli they heard, and annotators to categorize the obtained annotations. However, this procedure would increase the workload of the researchers and could introduce considerable variation in participants' responses.

The most crucial finding of the current study is that although the participants had a baseline tendency to construct objective causality, the prosody of the connective *so* had an effect on participants' choice of continuation. When

the connective *so* was produced with subjective prosody—prolonged duration and a concave f0 contour, the odds of choosing subjective continuations were 1.48 times greater than the odds of choosing subjective continuations when *so* was produced with objective causality. This finding has two implications. First, it suggests that the prosody of the connective *so* indeed encodes the types of causality. With a prolonged duration and a concave f0 contour, the connective *so* signals subjective causality, i.e., the involvement of a speaker, signaling to listeners that the causal relationship between the previous clause and the upcoming clause is established by the cognitive reasoning of the speaker (as opposed to existing in reality). Second, the finding indicates that native English speakers make use of this prosodic information in interpreting causality; they make predictions about the upcoming context based on the prosodic characteristics of the connective *so*. This finding improves our understanding of the function of so-called "general causal connectives" such as *so* in processing subjective and objective causality. Previous research has generally found that in reading comprehension, readers cannot determine the type of causality that the author (or character) intends to convey based on the connective *so* but have to wait for more contextual information to become available, as evidenced by longer reading time for words near the end of sentences. This finding should not be surprising because, in written language, these general causal connectives are presented only in their morphological forms, which do not change across different types of causality and thus do not distinguish one type of causality from the other. The present study extends this finding by showing that in listening comprehension, where those connectives are presented not only morphologically but also prosodically, the prosody of the connective *so* allows listeners to make predictions about the nature of the upcoming context (factual versus inferential). Thus, it seems logical to conclude that in spoken language, connectives such as *so* may not always be general causal connectives that do not distinguish between subjective and objective causality as deemed by previous research. Instead, the prosodic features of these connectives can encode subjective versus objective causality, signaling to the addressees the type of causality the addresser intends to convey—whether that clause contains the speaker's opinion/conclusion or the factual consequence of the event they just heard. Similar effects of prosody have been reported in studies on the meaning of morphologically underspecified

words such as *okay* in English and *alors* 'then/well' in French. For example, Gravano et al. (2012) find that word-final pitch patterns and word-level intensity distinguish various functions of the affirmative cue word *okay*. Van Zyl & Hanekom (2013) show that listeners are able to identify the speaker's compliance versus reluctance to an interlocutor's proposal based on prosodic features of this affirmative cue word. Didirková et al. (2019) provide evidence that the prosodic realization of the French discourse marker *alors* 'then/well' helps listeners identify the word's specific function in discourse. Together with these studies, the current study suggests that prosody plays an important role in speech communication by complementing the information provided through the morphological level, emphasizing the necessity to take prosody into account when studying the pragmatics of causal connectives as well as other coherence markers.

Note, however, that our data show that the effects of the prosody of the connective *so* varied across listeners. Individual differences have been found in the interpretation of semantic, syntactic, and discourse information (e.g., Afflerbach, 2015; Fuchs, Pape, Petrone, & Perrier, 2015; Kidd, Donnelly, & Christiansen, 2018; Scholman, Demberg, & Sanders, 2020) and in the perception of prosodic information related to information on these linguistic levels. For example, it has been found that listeners vary in the perception of prosodic cues related to information structure (Bishop, 2012), such as focus types (Breen et al., 2010) and prosodic phrase boundaries (Cole et al., 2010), and in the interpretation of irony (Rivière et al., 2018) and sarcasm (Peters et al., 2016). Several studies have attempted to identify the causes of listener variability. They have found various factors that could result in listener variability, including listeners' cognitive resources such as working memory (Petrone, D'Alessandro, & Falk, 2021; Scholman et al., 2020), fatigue level (Deliens et al., 2015), attention, linguistic experience, autistic traits (Bishop, 2012), and also environmental factors such as noises. Among these factors, listeners' sensitivity to acoustic contrasts might have contributed to the individual variations in our data. A person's sensitivity to acoustic cues plays a role at the early stage of the perception process, allowing a person to discriminate between sounds. After all, if a person cannot perceive acoustic distinctions, they certainly would not be able to utilize the information to establish representations of categories and further

apply this category knowledge to decode incoming sounds. Previous research has shown that people who are naturally sensitive to tunes or have received musical training have an advantage over others in discriminating sound differences and show an advantage in learning and identifying linguistic timing information (Sadakata & Sekiyama, 2011). Future research may explore the extent to which musicality accounts for the individual variation in the current study. In addition to listeners' sensitivity to acoustic cues, given the fact that the current experiment was conducted online, the listener variability revealed in our data may also be caused by variables in the testing environment. While online surveys have several advantages, such as allowing for testing a large number of participants simultaneously and recruiting participants without geographical restrictions, this approach has several limitations. First, it is not possible to exert human supervision, i.e., the supervision by an experimenter, on the testing processes. Hence, it is hard to know how committed participants are to the task. Second, there is no way to control the environment in which participants complete a task, and many factors such as poor internet connection or environmental noises could have compromised the sound quality of stimuli. This is particularly problematic for listening experiments, especially those testing subtle acoustic contrasts, such as the subtle contrast between subjective and objective causality tested in the current study. The aforementioned factors might have contributed to the listener variability found in the current study. Future studies can verify this by testing participants in a lab setting.

There is yet another possible reason for the listener variability found in the current study. It might be that the prosodic contrasts in our stimuli are not salient enough for each participant to perceive. It is likely to be the case because the acoustic contrasts implemented in the current study are based on the findings of Experiment 2 in Chapter 2, in which utterances conveying subjective versus objective causality were elicited from the speakers in a lab setting based on provided scripts. Although we do not think that the findings of Chapter 2 deviate from how prosody is actually used in natural conversations to distinguish between subjective and objective causality (for a defense of lab speech, see Xu, 2010), given that the study design of Experiment 2 in Chapter 2 involves a script that is not available in natural conversations and exempts the participants from speech planning, we think that it is likely that the prosodic contrasts between

subjective and objective causality found in Chapter 2 are smaller compared to those produced in natural conversations. To evaluate this possibility, follow-up research is needed, implementing prosodic contrasts produced by people in a less restrictive conversational environment. Having said that, we are aware of the opposite possibility that the prosodic contrast found in lab settings might be more prominent than those in natural speech because the experimental conditions of interest are made salient by controlling for many other potentially confounding factors. At the moment, we cannot determine the validity of this explanation—another reason to conduct further research on the use of prosody in expressing subjective and objective causality using a less restricted study design.

In addition to the variations between participants, we also found that the effects of prosody varied between stimuli. For some stimulus pairs, the prosody of the connective did affect the participants' choice of continuation, while for others, the effect did not seem to be present – the participant preferred objective continuations in both prosodic conditions. In our view, two factors might have contributed to the variations across stimuli. One is the semantic content of the provided continuations. From the participants' perspective, some subjective continuations might be more difficult to resonate with than objective continuations. The other factor is the sentiment involved in the subjective continuations. Some subjective continuations involved negative sentiments, expressing negative evaluations of people or events, such as *"He is an idiot"*, "*She is scatterbrained"*, etc. (for the full list of stimuli, see Appendix G). This type of subjective continuation accounts for 7 of the 15 subjective continuations (the rest involve positive comments). The participants may feel reluctant to accept those negative comments as their own and opt for the objective continuations instead. Future research needs to examine this possibility in a more nuanced way.

To our knowledge, this study is the first to investigate the effect of prosody on inferring subjective and objective causality. We provided the very first evidence that the prosodic characteristics of the connective *so* had an influence on the listener's expectations about the coming type of causality. However, several questions remain to be solved by future research. The first question is which prosodic feature of the connective *so*, duration or the concave f0 contour, actually leads listeners to expect subjective causality. Are they both essential for

so to have a subjective profile, or is one of them sufficient? In terms of helping listeners disambiguate between subordinated and coordinated discourse, Tyler (2014) finds that f0 contributes more than duration. In identifying the speaker's compliance versus reluctance to an interlocutor's proposal, van Zyl & Hanekom (2013) find that increased duration outperforms other acoustic measurements, including f0, intensity, and voice quality, to be the strongest predictor of perceived speaker reluctance. These findings suggest that although prosody is commonly used to distinguish between meanings or functions, the most effective prosodic cues vary across cases. Future research needs to determine which prosodic dimension is most closely related to the contrast between subjective and objective causality. The second question calling for an investigation is the effect of prosody on the online processing of subjective and objective causality. Online processing differs from offline processing in several ways. First, while offline tasks such as the task involved in the current study test listeners' conscious evaluation of the meaning, online tasks such as eye-tracking assess the participants' intuitive perception. In addition, online processing places higher demands on a cognitive ability such as working memory than offline processing because, in online tasks, experimental prompts unfold in real-time, and it is not possible to go back to previous segments and reflect, unlike in offline tasks such as the task involved in the current experiment. Previous studies have found a significant difference between online and offline tasks in participants' performance in language processing. For example, learners better detect non-native uses of connectives (Zufferey, Mak, Degand, & Sanders, 2015) and overt pronouns (Roberts, Gullberg, & Indefrey, 2008) in an offline task than in an online task. Moreover, an online task also allows for a better understanding of the exact time course of the effect of prosody – how fast listeners update their discourse models with the expectations generated by the prosodic information embedded in the connective *so*. Future studies can tap into these questions through eye-tracking or similar techniques.

4.5 Conclusion

The causal connective *so* has long been regarded as a general causal connective that does not distinguish between different types of causality. Through a forced-choice discourse completion task, this study provides evidence that the

prosody of the connective *so* allows listeners to make predictions about the type of the causality the speaker intends to convey. This finding suggests that the prosody of the connective *so* encodes the type of causality. This finding thus extends our previous knowledge of the connective *so*, showing that while the morphological form of this connective cannot distinguish between subjective and objective causality, the prosody of this connective can (at least for some listeners). In light of this, our study re-emphasizes the need to take prosody into account when studying the pragmatics of causal connectives.

Chapter 5

Discussion and Conclusions

Human minds systematically distinguish at least two types of causal relations. One is objective causality, which describes a CAUSE-CONSEQUENCE (or, CONSEQUENCE-CAUSE) relation between actual events taking place in the real world, as in "*The temperature was below zero for weeks, so the lake was frozen."* The other is subjective causality, which is the relationship between a person's claim and his/her argument for that claim, as in "*Their car is not there, so they are not at home.*" How these two types of causality are communicated in languages has been an active area of research. Discourse studies have shown that, in some languages, but not all, these two types of causality may be conveyed by lexical markers and that those lexical markers assist readers or listeners in processing these two types of causality. However, lexical information is not the only source of information in spoken language; information is also conveyed through non-lexical channels such as prosody. Yet, to date, our understanding of whether and how prosody communicates subjectivity in causality remains very limited except for a few impressionist accounts. This dissertation aimed to fill this gap. Approaching this issue in two steps, we first tested the hypothesis of a functional trade-off between lexical and prosodic cues in expressing subjective and objective causality, and then we investigated the effect of prosodic information on listeners' interpretation of these two types of causality. In this chapter, we consolidate the main findings of the previous chapters, discuss their implications, and propose research topics for future studies.

5.1 Overview of main findings

5.1.1 The role of prosody in expressing subjective and objective causality

The first question this dissertation aimed to explore was whether and how prosody expressed subjective and objective causality. Based on the Functional Hypothesis (Haan, 2001), we hypothesized that there is a trade-off relationship between the use of lexical cues and prosodic cues in expressing subjective and objective causality. Specifically, we predicted that prosody should be used to distinguish between subjective and objective causality to a greater extent in the absence of lexical cues for these two types of causality (e.g., specialized causal connectives) than in the presence of these lexical cues. This hypothesis was

evaluated in Chapters 2 and 3, which examined the use of prosody in expressing subjective and objective causality in the absence and presence of specialized causal connectives, respectively. The research question addressed in Chapter 2 was:

RQ1: Are there prosodic differences between subjective and objective causality in the *absence* of specialized causal connectives?

We expected to see prosodic differences between subjective and objective causality in the absence of specialized causal connective. To evaluate this prediction, we examined the prosodic realizations of English subjective and objective causality, which, according to previous studies, were often expressed using a general causal connective (*because* or *so*). Because the *antecedens P* and *consequens Q* in a causal relation can be presented in two orders: forward causal order ($P \rightarrow Q$) or backward causal order ($Q \leftarrow P$), these two orders of causality were investigated in two separate experiments. To obtain utterances expressing subjective or objective causality in each order, we gave participants a dialogue task to complete in each experiment. In the task, the participants conversed with an interlocutor about information on PowerPoint slides. The interlocutor asked three questions about each slide, and the participants answered those questions by using the sentence fragments on the slides. The second question asked by the interlocutor elicited a target utterance – an utterance expressing subjective or objective causality. Various acoustic measurements were extracted from the target utterances, including not only conventional static acoustic measurements such as f0-related measurements and duration, but also features describing the trajectories of f0 movement. The presence or absence of subjectivity on each measurement was evaluated statistically with Bayes factors, which quantify the likelihood of causality types affecting a measurement.

Results of Experiments 1 and 2 were in line with our prediction, showing that there are systematic prosodic differences between subjective and objective causality in English. Specifically, we found that utterances expressing subjective causality had a larger f0 range (in the case of backward subjective causality, a higher f0 maximum and a lower f0 minimum; in the case of forward subjective causality, a higher f0 maximum) than utterances expressing objective causality.

This finding is consistent with previous research on the prosody of stance-expressing utterances that simple sentences or phrases expressing opinions exhibit a larger f0 range than those stating facts (Morency et al., 2011). In addition to the difference in the range of f0, we also found that the f0 contour of the connective *so* was more concave in subjective causality than in objective causality. Furthermore, subjective causality had a longer duration than objective causality at the conjunction of the two clauses. For backward subjective causality, the lengthening takes place at the silent interval following the first clause and preceding the connective *because*; for forward subjective causality, the lengthening occurs at the connective *so*, both the consonant and the vowel. These findings suggest that the *P* and *Q* involved in subjective causality were more remotely connected than those involved in objective causality. Given that a longer silent interval between phrases and a prolonged consonant at the initial position of a phrase may lead to the perception of a prosodic boundary, our findings suggest that *P* and *Q* in subjective causality are more likely to be produced as two separate intonational units than the *P* and *Q* in objective causality.

From Chapter 2, we learned that prosody plays an active role in expressing subjective and objective causality when the two types of causality are not expressed with specialized causal connectives. This raises the question of whether prosody still plays a role when specialized causal connectives are in use. For this question, the hypothesis proposed by the Functional Hypothesis (Haan, 2001) was that using specialized causal connectives would reduce or eliminate the need to use prosody to distinguish between subjective and objective causality, because specialized causal connectives already specify the types of causality. This hypothesis was tested in Chapter 3, of which the research question was:

RQ2: Are there prosodic differences between subjective and objective causality in the *presence* of specialized causal connectives?

This question was explored by examining the prosodic realizations of subjective and objective causality in two languages that often use specialized causal connectives to express subjective or objective causality: Mandarin Chinese and Dutch. For Mandarin Chinese, we hypothesized that the prosodic differences

between the two types of causality were not as prominent as those found in English. For Dutch, however, whether prosody would express subjective and objective causality seemed more complicated because, although, in theory, the causal connective *dus* 'so' has a strong subjective profile, in actual language use, it can be used not only as a specialized causal connective, but also as a general causal connective expressing both types of causality. In light of this, we hypothesized that Dutch utterances expressing subjective and objective causality exhibited less prosodic distinctions when expressed by specialized causal connectives than when expressed by a general causal connective. To explore these hypotheses, we conducted two production experiments involving the same dialogue task as also used in Chapter 2.

The results for Mandarin Chinese were consistent with our prediction, showing that causality types had a limited effect on the prosodic realizations of utterances expressing the two types of causality. In other words, utterances that express subjective and objective causality with specialized causal connectives (i.e., *kejian* and *yushi*, respectively) are not drastically different in terms of prosody, at least not in the prosodic dimensions examined in the study.

The Dutch results first showed that the use of *dus*, a subjective but also general causal connective, differed between participants. Some participants strictly adhered to its prototypical usage, using it exclusively for subjective causality; others ignored its prototypical usage and instead used it as a general causal connective; still others fell between these two extremes, using *dus* both as a specialized causal connective and as a general one. By partitioning the utterances we collected according to the causal connective(s) used in each pair of utterances, we found that only when *dus* was used as a general causal connective did the two types of causality differ clearly in prosody. When *dus* was used exclusively as a specialized causal connective to express subjective causality (thus *daardoor* was used to express objective causality), the evidence for causality types affecting prosody became weaker. Thus our prediction was borne out.

The individual differences in the use of causal connectives emerged from our data prompted us to ask whether the participants' preferences for the connectives affect the use of prosody in expressing subjectivity in causality, thus RQ3.

RQ3: Do participants' personal preferences for specialized causal connectives affect their use of prosody to express subjective and objective causality?

This question was addressed in two steps. First, we used an odds ratio (OR) to describe each participant's use of the two connectives in expressing the two types of causality. The odds ratio indicates the extent to which a participant used *daardoor* to express objective causality – the greater a participant' s OR, the more often he/she used *daardoor* (and therefore the less often he/she used *dus*) to express objective causality. We then evaluated an interaction effect between participants' ORs and causality types on the prosody of utterances. We hypothesized that the extent to which the participants used *dus* as a specialized causal connective would influence the extent to which they used prosody to distinguish between subjective and objective causality. Our prediction was that speakers with a higher tendency to use *dus* exclusively as a specialized subjective causal connective (i.e., speakers who more often use *daardoor* to express objective causality) would use prosody to a lesser extent to differentiate subjective causality from objective causality, compared to speakers with a higher tendency to use *dus* as a general causal connective. The results showed that the evidence for this hypothesis was between very weak and absent in our data. Thus, it is difficult to draw a clear conclusion. As discussed in Chapter 4, this may be because the sample size of this study was not large enough to estimate the interaction effect.

5.1.2 The role of prosody in comprehending subjective and objective causality

Chapters 2 and 3 explored the role of prosody in expressing subjective and objective causality. Chapter 2 demonstrated that prosody was actively involved in expressing these two types of causality when lexical markers for these two types of causality (i.e., specialized causal connectives) were not in use. For causality in a forward causal order (Experiment 2 in Chapter 2), the evidence showed that the connective *so* had a longer duration in subjective causality than in objective causality. Also, the f0 contour of the connective was more concave in subjective causality than in objective causality. The question that followed is:

Can the prosodic information help listeners to process subjective and objective causality? Ample evidence has shown that prosody conveys information at various linguistic levels and listeners rapidly integrate prosodic information in establishing sentence and discourse representation (see Chapter 1 for a review). However, regarding the processing of subjective and objective causality, much research has focused on the effects of lexical information such as coherence markers, discourse contexts, and genres, with the effects of prosody almost completely unexplored. Chapter 4 was devoted to filling this gap.

The literature on the effect of prosody on speech processing shows that there are two main ways prosody can contribute to speech comprehension. One is that certain prosodic features such as heightened f0 attract listeners' attention and lead to better comprehension. The other is that prosody can encode information related to meanings or functions, directly contributing to the decoding and establishment of those meanings or functions. In Chapter 4, we explored the second possibility, investigating whether the prosody of the connective *so* encodes information about subjective and objective causality. The research question we aimed to answer in Chapter 4 is:

RQ4: Can listeners predict the type of causality the speaker intends to convey based on the prosody of an utterance?

To address this question, we devised a forced-choice discourse completion task, in which the participants first listened to sentence fragments introducing world events followed by the connective *so* (e.g., "*Jim got his nose pierced. So…*") and then completed each fragment by choosing a continuation for it from two options provided on the screen. Each fragment was presented to the participants twice, with the connective *so* having either "subjective prosody" or "objective prosody", which was created based on the findings of Experiment 2 in Chapter 2. To recap, the duration of the connective *so* was 50 milliseconds longer in the subjective-prosody version than in the objective-causality version. In addition, the f0 contour of the connective *so* was more concave (with the weight of FPC2 being 0.85 units larger) in the subjective-prosody version than in the objective-prosody version. After each stimulus, two possible continuations appeared on the screen, both of which formed a causal relation with the

stimulus, one unveiling the actual consequence of the event announced in the stimulus, forming an objective causal relation with the fragment, and the other continuation commenting on the event announced in the audio, thus forming a subjective causal relation with the event. The idea was that if the prosody of the connective *so* encoded information about types of causality, then it should help participants predict the type of causality the speakers intend to convey. More specifically, if the connective *so* with "subjective prosodic features", i.e., an extended duration and a concave f0 contour, encodes subjective causality, then the participants should form an expectation of subjective causality after hearing it. Thus, in theory, the participants should choose subjective continuations more often when they heard *so* with subjective prosodic features than when they heard *so* with objective prosodic features.

Several interesting findings emerged. First, we found that the participants had a baseline preference for objective continuations. In addition, we found that the prosody of the connective *so* indeed affected the participants' choices of continuations. With the connective *so* having a prolonged duration and a concave f0 contour, the odds of choosing subjective continuations increased, suggesting that these prosodic features triggered the expectation of subjective causality. Furthermore, our data also showed considerable variation among participants in terms of how they reacted to the effect of prosody. Some participants reacted more to the prosodic features of the connective than the others did. Also, there appeared to be variation among stimuli.

5.2 General discussion

5.2.1 Prosody reflects the cognitive distinction between subjective and objective causality

Numerous studies have provided evidence for the cognitive reality of the division between subjective and objective causality from different perspectives including language acquisition, production, and processing (see Sanders & Evers-Vermeul, 2019, for an extensive review). From the perspective of language acquisition, studies have shown that these two types of causality are acquired at different ages rather than at the same age with objective causality acquired earlier than subjective causality (Spooren & Sanders, 2008;

Evers-Vermeul & Sanders, 2011; van Veen, 2011). From the perspective of language processing, studies have shown that these two types of causality are associated with different processing patterns; subjective causality on average takes longer time to process than objective causality. The division between subjective and objective causality is also substantiated by the existence of specialized causal connectives in many languages, such as the subjective causal connective *kejian* and the objective causal connective *yushi* in Mandarin Chinese (see Chapter 1 and Stukker & Sanders, 2012, for reviews). These findings corroborate that the division between subjective and objective causality exists in human cognition, exerting an internal impact on how causality is acquired, processed, and expressed. The current research adds to existing evidence by showing that the conceptual distinction between subjective and objective causality is also reflected on prosody, one of the non-lexical aspects of language, confirming the assumption of Sanders & Evers-Vermeul (2019). Together, current and previous research demonstrates that the cognitive division between subjective and objective causality has implications for linguistic representations at multiple levels, not only at the lexical level, but also at the non-lexical level.

5.2.2 The source of the prosodic differences between subjective and objective causality

Chapter 2 found several prosodic differences between lexically implicit subjective and objective causality. Specifically, utterances expressing subjective causality exhibit a larger f0 range and longer duration compared to utterances expressing objective causality. An ensuing question is: What is the source of the found prosodic differences? This, however, is not an easy question to answer. There are two opposing views on this issue. One is held by theories including the cooperation principle (Grice, 1975), audience design (Blokpoel et al., 2012; Clark & Carlson, 1982), common ground theory (Clark & Marshall, 1981; Clark & Brennan, 1991), and perspective-taking, which generally attribute prosodic variation to the perceptual needs of the listener, arguing that prosodic variation in speech is communicative and purposefully tailored by the speaker for the benefits of the listener. This way, listeners can decode prosodic information in speech with minimal effort (Achim, Achim, & Fossard, 2017; Yoon & Brown-Schmidt, 2018; Brennan & Hanna, 2009; Clark, 1996). In our case, the

prosodic distinctions between subjective and objective causality align with the listener's perceptual needs in processing these two types of causality. The heightened f0 in utterances expressing subjective causality can attract the listener's attention and facilitate comprehension (Bugental & Lin, 1997; see Scherer, 2003 for a review). Not only the expanded f0 range but also the extended duration of the utterance expressing subjective causality benefits the processing of subjective causality. The extended duration of an utterance allows the listener extra time to allocate cognitive resources.

Opposing the listener's account is the speaker's account, which holds that the listener-oriented way of planning speech costs too many cognitive resources to be applied efficiently in everyday speech (e.g., Bard et al., 2000; Brown & Dell, 1987; Horton & Keysar, 1996). Thus, speakers are likely to prioritize their production needs over the perceptual needs of their listeners and will only adapt to the needs of their listeners if they have sufficient time or cognitive resources to do so. Therefore, prosodic variations in speech are more likely to reflect the speaker's physiological and mental state during speech planning and recovery rather than being tailored to the audience (Wagner & Watson, 2010). Models and theories sharing this view include listener adaptation (Dell & Brown, 1991), perspective monitoring and adjustment model (Epley, Keysar, Van Boven, & Gilovich, 2004; Horton & Keysar, 1996; Keysar, Barr, Balin, & Brauner, 2000; Keysar, Barr, & Horton, 1998), and dual process model (Bard et al., 2000; Roßnagel, 2000). According to these theories, the prosodic characteristics of utterances expressing subjective causality are the manifestations of speakers' production needs, not necessarily for communicative purposes. Compared to objective causality, subjective causality is more complex and hence more difficult to construct and comprehend. Thus, it is possible that when constructing subjective causality, speakers develop certain physiological states such as becoming more cognitively engaged, which leads to changes in their articulatory performance such as the higher f0 shown in our data. As for the extended duration for subjective causality, it might result from speech planning given that subjective causality takes more time to construct than objective causality.

There is yet a third view, which promotes a "symbiotic relationship" between speakers and listeners, jointly exerting influences on the prosody in speech (Cutler, 1987). Theories or accounts that adopt this view include the

biological account – or more specifically, the frequency account – of f0 variation (Ohala, 1983; Gussenhoven, 2008) and the arousal account, neither of which distinguishes the effects of the speaker and listener on prosody. The arousal account, in particular, argues that an increase in the f0 range indicates a higher level of speaker arousal on the one hand, and helps to engage the listener and promotes comprehension on the other (for a review, see Juslin & Laukka, 2003; Scherer, 2003).

As to which account explains the prosodic differences between subjective and objective causality found in the current study, the current experimental design does not allow for a definitive answer as the current study was not designed to address this issue. It is likely that the preparation time the participants had before answering the experimenter's questions may have reduced the potential cognitive stress the participants may have felt in constructing subjective causality, thus rendering speakers' internal states less prominent than listeners' perceptual need in affecting the prosodic realizations of subjective and objective causality. However, it is equally likely that the preparation/waiting time might have imposed task-related anxiety on the speakers, affecting their articulatory performance, as anecdotal evidence suggests that people's anxiety levels increase while waiting to speak during a self-introduction round. A new experimental design is required to separate the effects of these two sources. That said, we are skeptical about the separability of the two sources for two reasons. First, speaking is to communicate (Jakobson, Waugh, & Taylor, 1987)—the listeners will always be present, if not in person, then in the speaker's imagination. Second, as discussed in the first and second paragraphs of this section, the two sources have the same effect on prosody, leading to the same acoustic characteristics in speech, i.e., an expanded f0 range and a longer duration. It is therefore impossible to single out the effect that affected prosody based on the prosodic characteristics of the utterances.

5.2.3 A functional trade-off relationship between specialized causal connectives and prosody in expressing subjective and objective causality

This dissertation addresses a long-standing issue about the expression of subjective and objective causality: Does prosody play a role in expressing subjective and objective causality? Based on the Functional Hypothesis (Haan,

2001), we hypothesized that there would be a trade-off relationship between the use of lexical markers for these two types of causality, e.g., specialized causal connectives, and the use of prosody. We predicted that using explicit lexical markers for these two types of causality would reduce or even eliminate the need to use prosody to distinguish between them. To test our hypothesis, we conducted four production experiments involving languages with varying degrees of preference for using specialized causal connectives to express subjective and objective causality, including a language that does not prefer specialized causal connectives, i.e., English (Chapter 2), a language that strongly prefers specialized causal connectives, i.e., Mandarin Chinese (Chapter 3), and a language that has specialized causal connectives, but often uses them not as specialized causal connectives but as a general causal connective, i.e., Dutch (Chapter 3). To make the results of these experiments comparable, we kept the semantic content of items consistent across the experiments and we used the same dialogue task and the same experimental setting to elicit those items in these experiments.

Our data showed that there were systematic prosodic differences between utterances expressing subjective and objective causality using a general causal connective (*because* or *so* in English and *dus* in Dutch) (Chapters 2 and 3). In contrast, for utterances expressing subjective and objective causality using specialized causal connectives (*kejian* and *yushi* in Mandarin Chinese and *dus* and *daardoor* in Dutch), there is little or no evidence for prosody being involved in distinguishing them (Chapter 3). Taken together, these findings suggest that prosody is more likely to be used to express subjective and objective causality in the absence of specialized causal connectives (as in English) than in the presence of specialized causal connectives (as in Mandarin Chinese). Speakers tend not to use both lexical and non-lexical cues to express subjective and objective causality, at least in the communication context involved in the current experiments. This finding thus adds to the growing body of evidence (see Chapter 1 for a brief review) supporting the trade-off relationship between the use of lexical and prosodic cues proposed explicitly or implicitly in various models or theories of communication, e.g., the Functional Hypothesis (Haan, 2001). This finding is also compatible with a more general form of trade-off, i.e., the trade-off between linguistic coding and the predictability of information, as

described in various other speech models including the Smooth Signal Redundancy Hypothesis and the Uniform Information Density (UID) hypothesis (Aylett & Turk, 2004; Levy & Jaeger, 2007) and probabilistic reduction hypothesis, which generally hold that there is an inverse relationship between the amount of linguistic coding needed and how readily the information intended can be derived from context. In the case of expressing subjective and objective causality, specialized causal connectives (e.g., *kejian* and *yushi* in Mandarin Chinese and *dus* and *daardoor* in Dutch) specify the type of causality, guiding addressees' expectations of the upcoming context, making the type of causality easily predictable, thus rendering the use of prosodic cues unnecessary. In contrast, general causal connectives (e.g., *so* and *because* in English) do not distinguish between different types of causality, thus leaving the type of causality unspecified, forcing addressees to resort to other information to determine the type of causality, creating difficulties in processing. Therefore, for the sake of communication efficiency, it is necessary for the speaker to provide other cues for the type of causality under communication, e.g., prosodic cues.

However, perhaps a more crucial question about the trade-offs is why, in many cases, speakers deploy communicative resources in such a strategic rather than exhaustive way. The most widely accepted explanation is that of efficient communication. Based on the idea that the purpose of speaking is to be understood (Jakobson et al., 1987), this explanation prescribes that speakers need to balance two opposing forces in communication: their inherent impulse to conserve articulatory effort and the quality of information transmission. To save articulatory and cognitive effort, speakers may wish to use fewer cues. However, this would leave the burden of decoding information to the listeners and would likely result in unsuccessful information transmission. To allow listeners to decode messages with minimal effort, in contrast, speakers should make their messages extremely explicit by including multiple cues. However, this requires too much cognitive and articulatory effort on the part of speakers, which is undesirable from their perspective. To resolve the conflict between production ease and robust information transfer, the ideal solution is to balance the two by deploying communicative resources in an economical, i.e., trade-off, manner without compromising the amount of information the listeners need to know or

costing the speakers too much effort. This view, or some form of it, to the best of our knowledge, can be traced back to Passy (1890) and later postulated by Zipf (1935) as Principle of Least Effort, according to which human behaviors follow a tendency to strive for the maximum outcome with the minimum effort. The principle of efficient communication also underlies Grice's four maxims of conversion, and in particular, the maxim of quantity (Grice, 1975). From the perspective of this maxim, using specialized causal connectives to express subjective and objective causality has provided listeners with ample information about the type of causality the speaker intends to convey, thereby rendering the use of other cues superfluous. In contrast, using a general causal connective to express subjective and objective causality does not provide listeners with sufficient information about which type of causality should be constructed. Thus, the speaker is expected to supply this information by other means. Otherwise, the listener would not have sufficient cues to determine the type of causality the speaker intends to convey. The view of efficient communication is also implied in Hyperspeech-and-Hypospeech principle (H&H) by Lindblom (1989), who argued that speakers adjust the phonetic properties of their speech to balance between articulatory economy and perceptual clarity. In recent years, the assumption of efficient communication has become the cornerstone of many recent accounts of speech production, including the ideal speaker framework (Kurumada & Jaeger, 2015) and Relevance Theory (Wilson & Sperber, 2005).

Note, however, that, at this stage, with the data at hand, we can only conclude that the trade-off relationship between the use of specialized causal connectives and prosody applies only to the specific communicative context involved in our experiments, i.e., casual chats between interlocutors of the same generation and with similar cognitive and language abilities. It is difficult to know to what extent such a trade-off relationship can be generalized without looking into other types of communicative contexts. Although there is no definitive answer to this question, we speculate based on previous research that several factors may potentially impact the trade-off relationship between the use of prosodic cues and the use of specialized causal connectives, or for that matter, the use of lexical cues for causality types. In some circumstances, speakers may use lexical cues and prosodic cues in an additive way (i.e., without weighing between them), while in other cases they might use neither. We will discuss in

more detail below some of the factors that may influence the trade-off relationship between the use of lexical and prosodic cues.

The first factor that can potentially influence the trade-off relationship is the communication environment. Previous studies have found that speech produced in noisy environments contains more prosodic variation than speech produced in quiet environments (Lombard, 1911). Moreover, speech produced in tasks involving interaction with listeners contains more prosodic cues than speech produced in tasks where listeners are absent (Buxó-Lugo, Toscano, & Watson, 2018; Kraljic & Brennan, 2005). These findings suggest that the level of interaction posed by communicative contexts can influence the amount of communicative resources deployed by the speaker. It may be the case that speakers would use both lexical and prosodic cues to express subjective and objective causality when engaged in communications with high communicative demands such as addressing public audiences or speaking in noisy environments. Conversely, speakers might use neither cue when engaged in communication with low communicative demands, for example, when informally conversing with people familiar to the speaker.

The second variable that could affect the trade-off relationship is the identity or cognitive ability of the addressee. Studies comparing the prosodic characteristics of speech directed at different audiences have established that speech orienting subjects with high communicative demands, such as infants, non-native speakers (especially those with underdeveloped language proficiency), and people with hearing impairments, contains exaggerated prosody characterized by a higher pitch, a larger pitch range, and a slower speaking rate, compared to speech directed at adult native speakers (Biersack, Kempe, & Knapton, 2005; Fernald & Mazzie, 1991; see Soderstrom, 2007 for a review). Research has also shown that speech with exaggerated prosody positively affects language acquisition (Kitamura, Thanavishuth, Burnham, & Luksaneeyanawin, 2001; see Han, De Jong, & Kager, 2019 for a review). For example, it has been found that speech with exaggerated prosodic characteristics facilitates word learning (Graf Estes & Hurley, 2013; Ma, Golinkoff, Houston, & Hirsh-Pasek, 2011). For less-skilled readers or readers with little domain knowledge of the textual topic under discussion, studies have shown that these readers benefit more from coherence markers in texts than more skilled readers

or readers with expert knowledge of the textual topic (Linderholm et al., 2000; Kamalski, Sanders, & Lentz, 2008) (but see van Silfhout, Evers-Vermeul, & Sanders, 2015), which found that readers with high language proficiency also benefit from coherence markers in texts). These two lines of studies independently suggest that for audiences with less developed cognitive or language skills, providing them with more prosodic cues or lexical markers can help them with language comprehension. On this basis, it seems logical to deduct that when addressing such audiences, making both cues available to them would further enhance language comprehension. Conversely, the speaker probably would use fewer cues when addressing audiences with expert knowledge of the subject under discussion.

5.2.4 The role of prosody in processing subjective and objective causality

The second issue this dissertation aimed to shed light on is the role of prosody in processing subjective and objective causality. According to prosody literature, there are at least two ways prosody can contribute to speech processing. One is by attracting listeners' attention and the other is by directly implying meanings or functions. In this dissertation, we explored the second direction, investigating whether the prosodic realizations of the "general" connective *so* encode information about subjective and objective causality. Our data yielded several interesting findings. Most importantly, the participants chose subjective continuations (i.e., opinions or inferences) for the audio stimuli they heard (presenting real events followed by the connective *so*) more often when the connective *so* in the stimuli was pronounced with subjective prosody than when it was pronounced with objective prosody. This finding indicates that the prosody of the connective *so* encodes information about the type of causality. The extended duration and the concave f0 contour (see Figure 1 in Chapter 4 for the illustration) features subjectivity, endowing the connective *so* with a subjective profile, signaling to the listener that the causality the speaker intends to convey involves subjectivity. This finding is important because it expands our understanding of "general causal connectives" by showing that while in written language the causal connective *so* functions as a general causal connective that does not distinguish between subjective and objective causality, in spoken language the different prosodic realizations of the connective *so* allows it to

have different functions. Our finding thus reinforces the fact that while written communication relies primarily on lexicon and grammar, spoken communication involves other communicative dimensions such prosody, which opens up an additional channel for speakers to express meanings and functions. This message is relevant to the research of subjective and objective causality because previous studies have mainly dealt with lexical devices, leaving the role of prosody largely unattended. In Section 5.4, we propose future studies in this direction.

5.3 Limitations

To our knowledge, this dissertation is the first to use an experimental approach to investigate the role of prosody in expressing subjectivity in causality. It used a dialogue task to elicit pre-scripted utterances expressing different types of causality. The advantage of this method is that it allows us to control for various factors that might influence the prosody of utterances, such as syntactic structure, sentence length, and emotion, so that we can reasonably attribute the differences in prosody to the distinction between subjective and objective causality. However, the task has a few limitations that prevent us from gaining a comprehensive understanding of the issue at stake. First, the utterances elicited from the task were pre-scripted, and the participants had enough time (10 seconds) to process the relationship between the two sentence fragments they had to produce in response to the questions posed by the interlocutor. In simple terms, this means that participants already knew how to answer the questions before they heard them. Therefore, it is invalid to test the difference in reaction time before producing utterances expressing subjective and objective causality. However, previous research has suggested that there might be differences in the amount of time needed to construct subjective and objective causality. Subjective causality is conceptually more complex and, therefore, more difficult to construct. Thus, the time required to construct subjective causality may be longer than the time required to construct objective causality. This may be reflected in the prosody of speech as a longer response time before producing utterances expressing subjective causality than utterances expressing objective causality.

Second, although the causality expressed in each target utterance was confirmed as valid by native speakers before being embedded in the task, it is

possible that some participants might have constructed a different type of causality than we expected, as often happens in causality interpretation. To circumvent this issue, follow-up studies are recommended to verify that the causal relations constructed by the participants are of the same types as those designed. This can be achieved by asking a validation question after each target item. This issue also concerns Chapter 4, in which we explored the effect of prosody on the interpretation of causality by asking participants to choose a continuation for each stimulus they heard from two options provided on the screen. Future studies may want to ask participants to provide their own continuations, rather than providing continuations to them. This, however, would introduce a great deal of variation in responses and create more workload in determining the type of causality between the continuation provided by the participants and the preceding sentence.

Another limitation of the current research concerns the coverage of subjective causality. As mentioned in Chapter 1, the current research only dealt with subjective causality in the epistemic domain and not that in the speech act domain, because subjective causality in the speech act domain is relatively rare and it can be classified into several subtypes (Xiao et al., 2021; Li et al., 2013) that might differ in prosody. But this is not to say subjective causality in the speech act domain is not important. On the contrary, according to pragmatic theories, speech acts – the speaker's communicative intentions – are crucial in communication as they motivate communication, driving the recipient's behavior (Austin, 1962; Searle, 1969). Hence, it is necessary to understand how subjective causality involving different speech acts are (de)coded in communication (Sanders & Spooren, 1999). There have been studies on prosodic differences between different speech acts expressed by single words (Hellbernd & Sammler, 2016). However, little is known about whether and how subjective causality expressing different speech acts differs in prosody. To this end, researchers first need to identify the types of speech acts included in subjective causality. There are preliminary proposals in this regard. For example, it has been found that subjective causality can express offering, promising, and commanding. However, the list is far from complete. More work is needed before we can investigate the role of prosody in conveying speech acts in subjective causality.

5.4 Topics for future research

This dissertation investigated how prosody, an essential component of spoken language, communicates different types of causality. Taking an experimental approach, it presents initial evidence that there is a trade-off relationship between the use of prosody and specialized causal connectives in expressing subjective and objective causality. In addition, the prosody of the causal connective *so* encodes information about causality types. However, given that *subjectivity* is a complicated concept involving many dimensions and that many variables in natural conversations can influence prosody, we see the current study as a first step towards a comprehensive understanding of the role of prosody in communicating subjectivity in causality and that many questions remain to be addressed. In each of the previous chapters, we have posed some questions that immediately arise from the findings of each chapter. In this section, we propose additional questions for future research.

5.4.1 A universal phenomenon?

In this dissertation, we present initial evidence for the trade-off relationship between the use of lexical cues and the use of prosody in expressing subjective and objective causality. We found that utterances expressing subjective and objective causality with a general causal connective (i.e., *so* in English and *dus* in Dutch) are more likely to show prosodic differences between them compared to utterances expressing subjective and objective causality using specialized causal connectives (i.e., *kejian* and *yushi* in Mandarin, and *dus* and *daardoor* in Dutch). One plausible explanation for this finding may be that speakers economize communicative resources when expressing subjective and objective causality. The remaining question is: To what extent is this phenomenon common in languages worldwide? Is it always the case that languages that prefer a general causal connective are more likely to use prosody to distinguish between subjective and objective causality than languages that favor specialized causal connectives? Do certain typological features possessed by a language affect the use of prosody in expressing subjective and objective causality? This question can be addressed by replicating the study in other languages that prefer specialized causal connectives but are typologically distinct from Mandarin Chinese, such as German (Stukker & Sanders, 2012) and French (Zufferey,

2012), and in other languages that prefer to use a general connective but are typologically different from English, such as Spanish (Santana, Spooren, Nieuwenhuijsen, & Sanders, 2021).

Suppose there is a trade-off relationship between the use of lexical cues and the use of prosody in terms of expressing subjectivity in causality. In that case, we should expect to see a trade-off not only between prosody and specialized causal connectives, but also between prosody and other lexical cues for subjective and objective causality such as cue phrases (e.g., *I think* and *I believe*). The trade-off between the use of prosody and discourse markers in expressing meanings and functions has been identified in the literature. For example, in expressing politeness in Mandarin Chinese, there is a trade-off relationship between the use of prosody and the use of the discourse marker *en*, which can express politeness (He, Tang, Gryllia, & Chen, 2022). Future studies need to assess the extent to which such stance markers or other subjectivity-related lexical markers reduce or eliminate the need to use prosody to signal the subjectivity in causality.

5.4.2 Other factors that may affect the prosody of subjective and objective causality

In this dissertation, we have provided initial evidence that subjective causality and objective causality expressed by a general causal connective differ in prosody. However, the subjectivity (or, in equivalent terms, stance) involved in establishing subjective causality is a rather complex notion that can vary in several dimensions such as strength, type, and polarity. For example, there are strong or weak opinions, positive or negative attitudes, absolute or partial agreement, and different degrees of certainty towards propositions. More interestingly, extensive research has shown that subjectivity differing in each dimension exhibits different prosodic characteristics. It is found that utterances expressing strong stances (e.g., "*Oh my god! I can't have that happen on my watch!*") exhibit a higher f0 and intensity than those expressing weak stances (e.g., "*Okay*") (Freeman, 2019; Levow & Wright, 2017), and that sentences expressing a positive stance (e.g., "*Yes! Perfect*") have longer vowel duration, higher pitch, and lower intensity than sentences expressing a negative stance (e.g., "*No. I don't think so*") (Freeman, 2019; Mairesse, Polifroni, & Di Fabbrizio, 2012; Levow & Wright, 2017). Taking a computational approach, Morency,

Mihalcea, & Doshi (2011) reported a satisfactory accuracy rate in using prosodic features to classify opinions with different polarities (positive/negative/neutral), suggesting a robust association between prosody and the polarity in utterances.

Utterances expressing subjective causality can involve stance of different polarity and intensity. For example, the stance expressed in (3) is neutral in terms of polarity, whereas that expressed in (1) and (2) is positive and that expressed in (4) is negative. The stance involved in (1) and (2) differs in strength, with the stance expressed in (1) being stronger than that expressed in (2), as indicated by the stance word *absolutely*.

(1) She gave her own piano concert when she was four, so she is absolutely a genius.
(2) She gave her own piano concert when she was four, so she is a genius.
(3) She gave her own piano concert when she was four, so she might practice it every day.
(4) She gave her own piano concert when she was four, so she must have sacrificed playing time for practice.

Given this, the question that needs to be explored is: Does the prosody of subjective causality vary with the polarity and intensity of the stance involved? Does subjective causality involving positive stance, e.g., (1) and (2), have different prosodic realizations than subjective causality involving neutral stance, e.g., (3)? Also, does subjective causality involving stronger stance such as (1) have different prosody characteristics than subjective causality involving weaker stance, e.g., (2)? These questions are crucial for a comprehensive understanding of the role of prosody in expressing subjective and objective causality. Follow-up studies are needed.

Another factor that might have a potential influence on the prosody of subjective and objective causality is the degree of causal relatedness, that is, how closely two propositions are causally related. The literature often distinguishes three degrees of causal relatedness: highly related (e.g., "*Joey's brother punched him again and again. The next day his body was covered in bruises*"), intermediately related (e.g., "*Joey's brother became furiously angry with him.*

The next day his body was covered in bruises"), and weakly or not causally related (e.g., "*Joey went to a neighbor's house to play. The next day his body was covered in bruises*") (Myers, Shinjo, & Duffy, 1987). It is found in the literature that the level of causal relatedness directly relates to the expectedness of a causal relation, which affects the linguistic marking of a causal relation, with weakly-related causal relations being less expected and more often linguistically marked than strongly-related causal relations (Asr & Demberg, 2012). According to the Uniform Information Density hypothesis (Levy & Jaeger, 2007), the degree of expectedness of information affects the prosodic marking of the information; information with low expectedness is more prosodically distinctive than information that is highly predictable from the context. This leads to the hypothesis that subjective causality and objective causality with different degrees of expectedness might be different in terms of prosody. Subjective causality with stronger relatedness might be less marked in terms of prosody than subjective causality with weaker causal relatedness. The same prediction can be made for objective causality. Future research could evaluate these predictions.

5.4.3 Speaker variability

In the field of speech production research, while most studies have focused on the general pattern of speakers' use of prosody to express a certain meaning or function, a growing number of studies have recently turned their attention to individual variability in the way prosody encodes meanings or functions (see Cole, 2015 for a review). To date, the finding is that although speakers generally use prosody to serve communicative goals, there is substantial individual variation in the prosodic features that speakers use. For example, regarding encoding syntactic structure, Schafer, Speer, Warren, & White (2000) have found differences in the pitch contours (i.e., different pitch accent, phrase accent, and boundary tone combinations) used by speakers to disambiguate between sentences with early and late closure ambiguity. About encoding discourse structure, Caspers (2003) has found that speakers do not always mark the end of a discourse unit using prosodic features. Swerts & Geluykens (1994) have found that Dutch speakers vary in the f0 features they use to mark the beginning and the end of a topic, and in the f0 trajectory they adopt during a topic. Den Ouden, Noordman, & Terken (2009) has demonstrated that speakers differ in their use of

prosody to mark the hierarchical structure of discourse; some speakers prefer to vary pause duration and maximum f0, while others alter loudness and vowel length.

Speaker variability is also relevant to the current study. The question that concerns us is: Are there speaker-dependent prosodic cues to express the differences between subjective and objective causality? To answer this question, we need to scrutinize the prosodic features used by individual speakers, looking for prosodic choices unique to a speaker. If speaker-specific prosodic cues emerge, the question that follows is: How do listeners make sense of those speaker-dependent prosodic cues? Or, do those speaker-dependent cues also encode information about the type of causality? Previous studies show that in perceiving prosodic prominence and boundaries in spontaneous conversations, listeners can adapt to individual speakers' prosodic traits and interpret prosodic cues by taking those personal traits into account (Cole et al., 2010). Moreover, the result of Chapter 5 indicates that there is also individual variability among listeners in interpreting the prosodic cues for subjective and objective causality. Some listeners react more to the prosodic cues than others. Individual differences are also observed among readers in processing lexical information, including in the processing of syntactic structure (see Kidd, Donnelly, & Christiansen, 2018 for a review) and in establishing the global and local representation of a text (Scholman et al., 2020). Research is needed to further explore and explain speaker variability in producing prosodic cues for subjective and objective causality and listener variability in perceiving speaker-specific prosodic cues for subjective and objective causality.

5.4.4 Incorporating prosody into the processing mechanism underlying the construction of subjective and objective causality

In this dissertation, we show that prosody plays an active role in distinguishing between subjective and objective causality when lexical markers for these two types of causality, i.e., specialized causal connectives, are not used. We also present evidence that the prosodic information contained by the connective *so* encodes information about subjective and objective causality in a forward causal order. The remaining task is to incorporate the effects of prosody into models of subjective and objective causality processing. To date, studies on the mechanisms underlying the construction of subjective and objective causality

have focused exclusively on how lexical information such as coherence markers and contexts contribute to this process. Researchers have found that the process of constructing subjective and objective causality takes place incrementally (Cozijn, Commandeur, Vonk, & Noordman, 2011; Traxler, Bybee, et al., 1997) – the integration of text segments starts right after the connective that provides processing instructions (Cozijn et al., 2011; Canestrelli, Mak, & Sanders, 2013), rather than being delayed until the end of a sentence. What needs to be investigated is the mechanism of processing prosodic information related to subjective and objective causality. Research has repeatedly shown that acoustic information is transient and is used for comprehension and interpretation promptly or at least must be converted to a more abstract representation before it is used to interpret spoken messages. Based on this, we predict that prosodic cues of subjective and objective causality would be processed and integrated right after the occurrence of the connective. Research on this issue will further our understanding of the mechanisms underlying the processing of subjective and objective causal relations.

5.5 Conclusion

Compared to written language, spoken language involves more dimensions in that information is conveyed through multiple and equally important channels (Borod, 1993). Yet, studies on the expression of causality, a fundamental concept in our cognition, have largely focused on lexical devices, with very limited attention being paid to the role of prosody. This dissertation aimed to fill this gap. To the best of our knowledge, this is the first experimental examination of the role of prosody in communicating two types of causality: subjective and objective causality. It contributes to our understanding of how subjectivity in causality is communicated in speech by showing that the use of prosody is in a trade-off relationship with the use of lexical cues in expressing subjective and objective causality and that listeners use prosodic cues to interpret the types of causality. With these findings, this dissertation sets the stage for further discussions on this topic, which will further advance our knowledge of how people communicate subjectivity in causality in language.

Appendix A Chapter 2 Instructions

The following instructions were given to the participants prior to the task in Experiment 1. The instructions given in Experiment 2 are identical to the one given in Experiment 1, except that the two optional connectives are *so* and *but*.

> You are going to read some slides. After each slide, you will get three questions from your conversation partner. Please formulate your answers in the following way.
>
> Use the first sentence to answer the first question. Use the second and third sentences to answer the second question. Combine these two sentences with either *because* or *however*. Use the last sentence to answer the last question. Please read everything on the slides carefully. Do not change or add words. Do not alter the order of sentences. Please produce your answers naturally.

Appendix B Chapter 2 Statistical summaries

This appendix complements Sections 2.3. and 3.3 with statistical results for the effects of subjectivity, gender and the interaction between subjectivity and gender on each measurement. Listed in each table are the priors used to calculate Bayes factors evaluating the presence or absence of each effect, the resulting Bayes factors, as well as the mean and 95% credibility interval of the posterior distribution of each effect. Tables are titled by the name of the dependent variable.

B.1. Experiment 1

Table 1

Pause duration

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 0.1)	0.27	0.01	-0.04	0.06
	Normal(0, 0.3)	0.09	0.01	-0.04	0.06
	Normal(0, 0.5)	0.05	0.01	-0.04	0.06
subjectivity	Normal(0, 0.05)	41.86	0.05	0.02	0.08
	Normal(0, 0.1)	29.63	0.05	0.02	0.08
	Normal(0, 0.2)	16.60	0.05	0.02	0.08
gender	Normal(0, 0.1)	0.47	0.01	-0.08	0.10
	Normal(0, 0.3)	0.17	0.01	-0.10	0.12
	Normal(0, 0.5)	0.10	0.01	-0.10	0.12

Table 2

Connective duration

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 0.1)	0.14	-0.00	-0.03	0.02
	Normal(0, 0.3)	0.04	-0.00	-0.03	0.02
	Normal(0, 0.5)	0.02	-0.00	-0.03	0.02
subjectivity	Normal(0, 0.1)	0.07	-0.00	-0.02	0.01
	Normal(0, 0.3)	0.02	-0.00	-0.02	0.01

	Normal(0, 0.5)	0.01	-0.00	-0.02	0.01
gender	Normal(0, 0.1)	0.68	0.04	-0.03	0.11
	Normal(0, 0.3)	0.25	0.05	-0.03	0.12
	Normal(0, 0.5)	0.15	0.05	-0.03	0.12

Table 3

F0 contours of the connective because

a. FPC1

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 5)	0.56	-1.74	-5.20	1.78
	Normal(0, 10)	0.31	-1.90	-5.67	1.83
	Normal(0, 15)	0.21	-1.94	-5.64	1.80
subjectivity	Normal(0, 1)	0.66	-0.17	-1.46	1.12
	Normal(0, 1.5)	0.50	-0.22	-1.70	1.28
	Normal(0, 2)	0.40	-0.24	-1.82	1.36
gender	Normal(0, 5)	1.03	2.85	-2.33	7.68
	Normal(0, 10)	0.63	3.52	-2.14	9.07
	Normal(0, 15)	0.47	3.67	-2.28	9.52

b. FPC2

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 5)	0.54	1.53	-0.83	3.87
	Normal(0, 10)	0.29	1.61	-0.77	4.03
	Normal(0, 15)	0.19	1.61	-0.82	4.05
subjectivity	Normal(0, 1)	1.06	-0.58	-1.51	0.37
	Normal(0, 1.5)	0.82	-0.67	-1.67	0.35
	Normal(0, 2)	0.65	-0.70	-1.72	0.32
gender	Normal(0, 5)	0.40	-0.27	-4.40	3.87
	Normal(0, 10)	0.21	-0.32	-4.82	4.23
	Normal(0, 15)	0.14	-0.34	-4.91	4.21

c. FPC3

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper

gender: subjectivity	Normal(0, 5)	0.20	0.23	-1.70	2.17
	Normal(0, 10)	0.10	0.24	-1.73	2.22
	Normal(0, 15)	0.06	0.24	-1.74	2.23
subjectivity	Normal(0, 1)	0.67	-0.40	-1.12	0.33
	Normal(0, 1.5)	0.47	-0.43	-1.19	0.32
	Normal(0, 2)	0.38	-0.44	-1.21	0.33
gender	Normal(0, 5)	0.21	-0.31	-2.47	1.86
	Normal(0, 10)	0.11	-0.33	-2.53	1.84
	Normal(0, 15)	0.07	-0.32	-2.50	1.90

Table 4

F0

a. C1f0Maxst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal (0, 1)	0.43	0.23	-0.54	1.00
	Normal (0, 1.5)	0.33	0.24	-0.57	1.05
	Normal (0, 2)	0.24	0.25	-0.57	1.07
subjectivity	Normal(0, 0.5)	6.96	0.57	0.13	1.00
	Normal(0, 1)	6.21	0.59	0.15	1.03
	Normal(0, 1.5)	4.69	0.59	0.15	1.04
gender	Normal(0, 15)	39.84	-11.14	-17.32	-4.83
	Normal(0, 20)	33.29	-11.37	-17.50	-5.09
	Normal(0, 25)	28.05	-11.48	-17.68	-5.16

b. C1f0Minst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal (0, 1)	0.72	0.42	-0.39	1.24
	Normal (0, 1.5)	0.52	0.47	-0.37	1.32
	Normal (0, 2)	0.42	0.49	-0.37	1.36
subjectivity	Normal(0, 0.5)	12.84	-0.67	-1.12	-0.21
	Normal(0, 1)	9.72	-0.69	-1.15	-0.24
	Normal(0, 1.5)	7.85	-0.70	-1.16	-0.22
gender	Normal(0, 15)	>>100	-11.50	-15.04	-7.83

	Normal(0, 20)	>>100	-11.58	-15.16	-7.91
	Normal(0, 25)	>>100	-11.62	-15.21	-8.01

c. C2f0Maxst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal (0, 1)	0.48	0.22	-0.61	1.04
	Normal (0, 1.5)	0.35	0.24	-0.63	1.11
	Normal (0, 2)	0.26	0.25	-0.63	1.13
subjectivity	Normal(0, 1)	0.35	0.17	-0.40	0.74
	Normal(0, 1.5)	0.23	0.18	-0.41	0.77
	Normal(0, 2)	0.17	0.18	-0.41	0.78
gender	Normal(0, 15)	>>100	-11.76	-16.61	-6.73
	Normal(0, 20)	>>100	-11.92	-16.79	-6.83
	Normal(0, 25)	>>100	-11.98	-16.91	-6.99

d. C2f0Minst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal (0, 1)	0.79	0.47	-0.59	1.54
	Normal (0, 1.5)	0.61	0.56	-0.59	1.69
	Normal (0, 2)	0.49	0.59	-0.60	1.80
subjectivity	Normal(0, 1)	0.83	-0.44	-1.10	0.23
	Normal(0, 1.5)	0.62	-0.47	-1.14	0.22
	Normal(0, 2)	0.47	-0.48	-1.18	0.21
gender	Normal(0, 15)	>>100	-11.49	-14.96	-7.91

Table 5

Articulation rate

a. C1AR

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal (0, 0.1)	0.79	0.00	-0.16	0.16
	Normal (0, 0.3)	0.41	-0.01	-0.26	0.24
	Normal (0, 0.5)	0.27	-0.01	-0.28	0.26
subjectivity	Normal(0, 1)	0.35	0.20	-0.37	0.77

	Normal(0, 1.5)	0.24	0.21	-0.36	0.78
	Normal(0, 2)	0.18	0.21	-0.34	0.79
gender	Normal(0, 1)	0.40	0.12	-0.66	0.90
	Normal(0, 1.5)	0.28	0.13	-0.72	0.98
	Normal(0, 2)	0.22	0.14	-0.74	1.02

b. C2 AR

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal (0, 0.1)	0.84	-0.03	-0.19	0.13
	Normal (0, 0.3)	0.50	-0.08	-0.32	0.17
	Normal (0, 0.5)	0.33	-0.08	-0.35	0.18
subjectivity	Normal(0, 1)	0.24	-0.02	-0.53	0.49
	Normal(0, 1.5)	0.17	-0.02	-0.55	0.50
	Normal(0, 2)	0.13	-0.02	-0.55	0.51
gender	Normal(0, 15)	0.44	-0.06	-1.04	0.92
	Normal(0, 20)	0.34	-0.08	-1.11	0.97
	Normal(0, 25)	0.25	-0.07	-1.16	1.02

Table 6

F0 contours of the first clause

a. FPC1

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal (0, 5)	0.86	0.98	-7.28	9.09
	Normal (0, 10)	0.63	2.18	-9.45	13.82
	Normal (0, 15)	0.49	2.79	-10.19	15.86
subjectivity	Normal(0, 1)	1.03	-0.29	-2.21	1.64
	Normal(0, 1.5)	1.07	-0.62	-3.44	2.24
	Normal(0, 2)	1.11	-1.05	-4.69	2.64
gender	Normal(0, 15)	0.96	-0.05	-9.38	9.59
	Normal(0, 20)	0.89	0.21	-17.14	17.47
	Normal(0, 25)	0.76	-0.01	-22.98	23.04

b. FPC2

Constant effect	Prior	BF_{10}	Posterior

			Estimate	Lower	Upper
gender: subjectivity	Normal (0, 5)	0.98	2.38	-5.60	10.33
	Normal (0, 10)	0.81	4.87	-6.63	16.34
	Normal (0, 15)	0.66	5.91	-6.78	18.51
subjectivity	Normal(0, 1)	1.02	-0.23	-2.18	1.70
	Normal(0, 1.5)	1.03	-0.50	-3.35	2.34
	Normal(0, 2)	1.07	-0.84	-4.57	2.87
gender	Normal(0, 15)	0.96	2.09	-6.14	10.28
	Normal(0, 20)	0.77	4.25	-7.79	15.93
	Normal(0, 25)	0.61	5.30	-8.18	18.68

c. FPC3

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal (0, 5)	0.80	0.06	-7.56	7.74
	Normal (0, 10)	0.52	0.15	-10.23	10.56
	Normal (0, 15)	0.38	0.17	-11.06	11.56
subjectivity	Normal(0, 1)	0.95	-0.06	-1.96	1.80
	Normal(0, 1.5)	0.93	-0.11	-2.77	2.55
	Normal(0, 2)	0.86	-0.20	-3.60	3.19
gender	Normal(0, 15)	0.90	1.28	-7.41	9.96
	Normal(0, 20)	0.74	2.90	-10.84	16.55
	Normal(0, 25)	0.61	3.87	-12.56	20.18

B.2. Experiment 2

Table 7

Pause duration

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 0.1)	0.17	0.01	-0.03	0.04
	Normal(0, 0.3)	0.05	0.01	-0.03	0.04
	Normal(0, 0.5)	0.03	0.01	-0.03	0.04
subjectivity	Normal(0, 0.1)	0.13	-0.01	-0.02	0.01
	Normal(0, 0.3)	0.04	-0.01	-0.02	0.01
	Normal(0, 0.5)	0.02	-0.01	-0.02	0.01

gender	Normal(0, 0.1)	0.42	0.02	-0.03	0.08
	Normal(0, 0.3)	0.14	0.03	-0.03	0.08
	Normal(0, 0.5)	0.08	0.03	-0.03	0.08

Table 8

Connective duration

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 0.1)	0.16	0.00	-0.03	0.03
	Normal(0, 0.3)	0.05	0.00	-0.03	0.03
	Normal(0, 0.5)	0.03	0.00	-0.03	0.03
subjectivity	Normal(0, 0.1)	>>100	0.05	0.03	0.06
	Normal(0, 0.3)	>>100	0.05	0.03	0.07
	Normal(0, 0.5)	>>100	0.05	0.03	0.07
gender	Normal(0, 0.1)	0.58	0.03	-0.06	0.12
	Normal(0, 0.3)	0.23	0.04	-0.07	0.14
	Normal(0, 0.5)	0.13	0.04	-0.07	0.15

Table 9

F0 contours of the connective so

a. FPC1

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 5)	0.12	-0.07	-1.34	1.20
	Normal(0, 10)	0.06	-0.07	-1.33	1.20
	Normal(0, 15)	0.04	-0.07	-1.34	1.21
subjectivity	Normal(0, 1)	0.37	-0.09	-0.84	0.67
	Normal(0, 1.5)	0.26	-0.09	-0.89	0.70
	Normal(0, 2)	0.19	-0.10	-0.90	0.69
gender	Normal(0, 5)	2.46	1.54	0.26	2.79
	Normal(0, 10)	1.28	1.57	0.30	2.82
	Normal(0, 15)	0.86	1.57	0.30	2.82

b. FPC2

Constant effect	Prior	BF_{10}	Posterior

			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 5)	0.13	0.26	-0.89	1.43
	Normal(0, 10)	0.06	0.26	-0.92	1.44
	Normal(0, 15)	0.04	0.26	-0.91	1.45
subjectivity	Normal(0, 1)	9.41	0.79	0.20	1.37
	Normal(0, 1.5)	7.59	0.83	0.23	1.44
	Normal(0, 2)	6.24	0.85	0.24	1.46
gender	Normal(0, 5)	0.20	-0.53	-2.11	1.05
	Normal(0, 10)	0.10	-0.56	-2.16	1.03
	Normal(0, 15)	0.06	-0.54	-2.11	1.04

c. FPC3

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 5)	0.004	-0.00	-0.18	0.17
	Normal(0, 10)	0.002	-0.00	-0.18	0.17
	Normal(0, 15)	0.001	-0.00	-0.18	0.17
subjectivity	Normal(0, 0.1)	2.06	-0.08	-0.16	0.01
	Normal(0, 0.3)	1.00	-0.09	-0.19	0.01
	Normal(0, 0.5)	0.64	-0.09	-0.19	0.00
gender	Normal(0, 5)	0.04	-0.12	-0.39	0.15
	Normal(0, 10)	0.02	-0.12	-0.40	0.15
	Normal(0, 15)	0.01	-0.12	-0.39	0.15

Table 10

F0

a. C1f0Maxst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 1)	0.27	-0.05	-0.56	0.46
	Normal(0, 1.5)	0.18	-0.05	-0.57	0.48
	Normal(0, 2)	0.14	-0.05	-0.58	0.47
subjectivity	Normal(0, 1)	0.46	0.22	-0.08	0.53
	Normal(0, 1.5)	0.32	0.23	-0.08	0.53
	Normal(0, 2)	0.22	0.23	-0.08	0.53

gender	Normal(0, 15)	>>100	-10.20	-12.77	-7.52
	Normal(0, 20)	>>100	-10.25	-12.93	-7.64
	Normal(0, 25)	>>100	-10.28	-12.88	-7.66

b. C1f0Minst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 1)	0.27	-0.04	-0.57	0.48
	Normal(0, 1.5)	0.18	-0.04	-0.58	0.49
	Normal(0, 2)	0.14	-0.04	-0.57	0.49
subjectivity	Normal(0, 1)	0.21	0.06	-0.34	0.46
	Normal(0, 1.5)	0.13	0.06	-0.35	0.47
	Normal(0, 2)	0.10	0.06	-0.35	0.47
gender	Normal(0, 15)	>>100	-12.28	-14.11	-10.46
	Normal(0, 20)	>>100	-12.31	-14.07	-10.52
	Normal(0, 25)	>>100	-12.33	-14.12	-10.51

c. C2f0Maxst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 1)	1.41	0.57	-0.09	1.23
	Normal(0, 1.5)	1.08	0.61	-0.07	1.29
	Normal(0, 2)	0.81	0.62	-0.07	1.31
subjectivity	Normal(0, 1)	19.72	0.69	0.24	1.12
	Normal(0, 1.5)	15.37	0.71	0.26	1.14
	Normal(0, 2)	12.46	0.71	0.27	1.16
gender	Normal(0, 15)	>>100	-10.49	-12.19	-8.78
	Normal(0, 20)	>>100	-10.50	-12.21	-8.77
	Normal(0, 25)	>>100	-10.50	-12.21	-8.80

d. C2f0Minst

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 1)	0.30	0.07	-0.50	0.65
	Normal(0, 1.5)	0.20	0.08	-0.50	0.66
	Normal(0, 2)	0.15	0.08	-0.52	0.67
subjectivity	Normal(0, 1)	0.63	-0.28	-0.65	0.09

	Normal(0, 1.5)	0.41	-0.29	-0.66	0.09
	Normal(0, 2)	0.32	-0.29	-0.67	0.09
gender	Normal(0, 15)	>>100	-11.96	-14.36	-9.47
	Normal(0, 20)	>>100	-11.98	-14.39	-9.53
	Normal(0, 25)	>>100	-12.03	-14.51	-9.55

Table 11

Articulation rate

a. C1AR

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 0.1)	0.80	0.03	-0.11	0.17
	Normal(0, 0.3)	0.40	0.06	-0.14	0.25
	Normal(0, 0.5)	0.23	0.06	-0.14	0.26
subjectivity	Normal(0, 1)	0.30	0.00	-0.56	0.58
	Normal(0, 1.5)	0.19	0.00	-0.60	0.59
	Normal(0, 2)	0.14	0.00	-0.60	0.62
gender	Normal(0, 1)	0.44	0.26	-0.43	0.92
	Normal(0, 1.5)	0.30	0.27	-0.40	0.97
	Normal(0, 2)	0.23	0.28	-0.43	0.98

b. C2AR

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 0.1)	1.11	-0.07	-0.22	0.08
	Normal(0, 0.3)	0.80	-0.14	-0.34	0.06
	Normal(0, 0.5)	0.52	-0.14	-0.35	0.07
subjectivity	Normal(0, 1)	0.35	-0.20	-0.68	0.31
	Normal(0, 1.5)	0.24	-0.20	-0.72	0.32
	Normal(0, 2)	0.18	-0.20	-0.72	0.32
gender	Normal(0, 1)	0.41	0.19	-0.60	0.97
	Normal(0, 1.5)	0.30	0.21	-0.63	1.03
	Normal(0, 2)	0.22	0.22	-0.63	1.06

Table 12

F0 contours of the first clause

a. FPC1

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 5)	0.79	-0.76	-8.17	6.68
	Normal(0, 10)	0.52	-1.32	-11.40	8.86
	Normal(0, 15)	0.37	-1.56	-12.37	9.38
subjectivity	Normal(0, 1)	0.97	-0.11	-1.99	1.75
	Normal(0, 1.5)	0.95	-0.22	-2.95	2.55
	Normal(0, 2)	0.90	-0.36	-3.78	3.14
gender	Normal(0, 5)	1.08	-2.24	-11.37	6.90
	Normal(0, 10)	1.10	-6.42	-21.75	9.23
	Normal(0, 15)	1.10	-9.69	-28.51	9.83

b. FPC2

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 20)	0.29	3.33	-5.69	12.39
	Normal(0, 30)	0.20	3.40	-5.92	12.71
	Normal(0, 50)	0.12	3.49	-6.02	13.04
subjectivity	Normal(0, 5)	0.71	-0.20	-7.23	6.86
	Normal(0, 10)	0.46	-0.33	-9.76	8.80
	Normal(0, 15)	0.33	-0.24	-10.24	9.72
gender	Normal(0, 20)	3.11	-13.84	-26.44	-0.57
	Normal(0, 30)	2.55	-14.87	-28.31	-1.31
	Normal(0, 50)	1.65	-15.27	-28.80	-1.56

c. FPC3

Constant effect	Prior	BF_{10}	Posterior		
			Estimate	Lower	Upper
gender: subjectivity	Normal(0, 20)	1.42	-8.59	-17.37	0.15
	Normal(0, 30)	1.03	-8.84	-17.56	0.13
	Normal(0, 50)	0.62	-8.97	-17.86	0.02
subjectivity	Normal(0, 5)	0.70	1.99	-3.14	7.13
	Normal(0, 10)	0.41	2.52	-3.23	8.20
	Normal(0, 15)	0.29	2.63	-3.18	8.49

gender	Normal(0, 10)	0.50	0.17	-10.07	10.34
	Normal(0, 15)	0.36	0.24	-10.71	11.45
	Normal(0, 20)	0.28	0.14	-11.32	11.77

Appendix C Chapter 2 Items

C.1. Experimental items used in Experiment 1 (a: objective causality; b: subjective causality; contexts in italic; target sentences in bold):

1.

a. *You and Jim are friends. You two just talked on the phone. Now you know some information about him.*
Jim bled a lot because he got his nose pierced.

b. *You and Jim go to the same school, but you don't really know him. You have the following impression of him.*
Jim wants attention because he got his nose pierced.

2.

a. *You are Alan's mentor. He came to you and told you something about himself. Now you know some information about him.*
Alan went to AA meetings because he had a drinking problem.

b. *You and Alan used to be friends, but you haven't talked for a long time. You don't know for sure but you think something went wrong with him.*
Alan can't get his life together because he had a drinking problem.

3.

a. *Tom is your classmate. He just messaged you about the accident he just had. Now you know some information about him.*
Tom broke his arm because he tripped over his shoelaces.

b. *Tom is your classmate. You don't know him very well, but you are not very fond of him. You hold the following opinion about him.*
Tom is an idiot because he tripped over his shoelaces.

4.

a. *Susan is your colleague. You just met her in the hallway. She told you what just*

happened to her. Now you know that she had a pretty bad day.
Susan lost her money because she left her wallet on the bus.

b. *Susan is your colleague. You don't know her very well, but you have some personal opinions about her.*
Susan is scatterbrained because she left her wallet on the bus.

5.
a. *You came across an old friend, Tom. You two talked for a while. Now you know some information about him.*
Tom moved out of his villa because he was bankrupt.

b. *Tom is a businessman. You don't know him personally, but you read from the news that he was bankrupt. You have some comments on this.*
Tom knows nothing about business because he was bankrupt.

6.
a. *You were in a meeting with your boss. He told you he made some decision about your colleague, Jack. Now you know the following some information.*
Jack was fired because he was late for work every day.

b. *You were in a meeting with your boss. You were asked to comment on your colleague, Jack. You know he is always late for work, but you don't really know why. Here is your own guess.*
Jack is not a morning person because he is late for work every day.

7.
a. *Marie is your colleague. You and Marie went boating together. An accident happened to Marie. Here is what you saw with your own eyes.*
Marie fell into the water because the boat spun around on the current.

b. *You and your colleagues went boating together. There is one colleague, Marie, that you don't know very well, but you have something to say about her rowing skills.*

Marie is an inexperienced rower because the boat spun around on the current.

8.

a. *You and Heidi are good friends. She participated in an art festival. You were there with her. Here is what you saw with your own eyes.*

Heidi was thrilled because she won the first prize at the art festival.

b. *Heidi is your friend. She won the first prize at the art festival. You have some comments on her success.*

Heidi is talented because she won first prize at the art festival.

9.

a. *Hans is your friend. You just talked with him. He told you what happened to him lately.*

Hans bought a new house because he had won the lottery.

b. *Hans is your friend. You think he is the luckiest person you ever know.*

Hans is lucky because he had won the lottery.

10.

a. *Ian is your friend. You just talked to him. He told you what he did after school yesterday.*

Ian went to basketball practice because he was chosen for the school team.

b. *Ian is your friend. He just told you that he was chosen for the school team of basketball. You have made some comment on his success.*

Ian is a talented basketball player because he was chosen for the school team.

11.

a. *Joshua is your friend. You two just talked on the phone. Now you know some information from him.*

Joshua's fingers hurt because he had played the guitar for hours.

b. *Joshua is your neighbor. He has been playing guitar for the whole afternoon. You don't know Joshua in person but you guess the following.*
Joshua has a great passion for music because he has played the guitar for hours.

12.
a. *Julia is your sister. You know that her old shelf is too small to fit all her books. She bought a new one.*
Julia bought a new shelf because she has a lot of books.

b. *Julia is your classmate. You know that she has a lot of books. You guess the following.*
Julia loves reading because she has a lot of books.

13.
a. *You got the card on the left from your friend. On it you can see the following things.*
The girl is laughing because the kite is flying.

b. *You got a card from a friend. It has a picture of a flying kite on it. You are asked to make predictions on what makes the kite fly. Here is what you came up with.*
The wind is blowing because the kite is flying.

14.
a. *Jonny is your friend. You two are very close. You know everything about him.*
Jonny works as a mover because he can lift a sofa easily.

b. *From the picture you can see a man. You have made some predictions based on what you saw. Here is what you came up with.*
The man is strong because he can lift a sofa easily.

15.
a. *From the picture on the left you learned the following information.*

The boy is covered with mud because he is playing in the mud.

b. *From the picture on the left you can see a boy playing in the mud. You come up with the following comments based on what you saw.*
The boy likes mud because he is playing in the mud.

C.2. Experimental items, Experiment 2 (a: objective causality; b: subjective causality; contexts in italic; target sentences in bold):
1.
a. *You and Jim are friends. You two just talked on the phone. Now you know some information about him.*
Jim got his nose pierced so he bled a lot.

b. *You and Jim go to the same school, but you don't really know him. You have the following impression of him.*
Jim got his nose pierced so he wants attention.

2.
a. *You are Alan's mentor. He came to you and told you something about himself. Now you know some information about him.*
Alan has a drinking problem so he goes to AA meetings.

b. *You and Alan used to be friends, but you haven't talked for a long time. You don't know for sure but you think something went wrong with him.*
Alan has a drinking problem so he has weak self-control.

3.
a. *Tom is your classmate. He just messaged you about the accident he just had. Now you know some information about him.*
Tom tripped over his shoelaces so he broke his arm.

b. *Tom is your classmate. You don't know him very well, but you are not very fond of him. You hold the following opinion about him.*
Tom tripped over his shoelaces so he is an idiot.

4.

a. *Susan is your colleague. You just met her in the hallway. She told you what just happened to her. Now you know that she had a pretty bad day.*
Susan left her wallet on the bus so she lost her money.

b. *Susan is your colleague. You don't know her very well, but you have some personal opinions about her.*
Susan left her wallet on the bus so she is scatterbrained.

5.

a. *You came across an old friend, Tom. You two talked for a while. Now you know some information about him.*
Tom went bankrupt so he had to move out of his villa.

b. *Tom is a businessman. You don't know him personally, but you read from the news that he was bankrupt. You have some comments on this.*
Tom went bankrupt so he knew nothing about business.

6.

a. *You were in a meeting with your boss. He told you he made some decision about your colleague, Jack. Now you know the following information.*
Jack was always late for work so he was fired.

b. *You were in a meeting with your boss. You were asked to comment on your colleague, Jack. You know he is always late for work, but you don't really know why. Here is your own guess.*
Jack is always late for work so he is not a morning person.

7.

a. *Marie is your colleague. You and Marie went boating together. An accident happened to Marie. Here is what you saw with your own eyes.*
The boat spun around on the current so Marie fell into the water.

b. *You and your colleagues went boating together. There is one colleague, Marie, that you don't know very well, but you have something to say about her rowing skills.*

The boat spun around on the current so Marie doesn't know much about rowing.

8.

a. *You and Heidi are good friends. She participated in an art festival. You were there with her. Here is what you saw with your own eyes.*

Heidi won the first prize at the art festival so she was happy.

b. *Heidi is your good friend. She won the first prize at the art festival. You have some comments on her success.*

Heidi won the first prize at the art festival so she is talented.

9.

a. *Hans is your friend. You just talked with him. He told you what happened to him lately.*

Hans won the lottery so he bought a new house.

b. Hans is your friend. You think he is the luckiest person you ever know.

Hans won the lottery so he is lucky.

10.

a. *Ian is your friend. You just talked to him. He told you what he did after school yesterday.*

Ian made the school team so he went to basketball practice.

b. *Ian is your friend. He just told you that he was chosen for the school team of basketball. You have made some comment on his success.*

Ian made the school team so he is a talented basketball player.

11.

a. *Joshua is your friend. You two just talked on the phone. Now you know some*

information from him.
Joshua played the guitar for hours so his fingers hurt.

b. *Joshua is your neighbor. He has been playing guitar for the whole afternoon. You don't know Joshua in person but you guess the following.*
Joshua played the guitar for hours so he has a great passion for music.

12.
a. *Julia is your sister. You just talked to her. Now you know the following information from her.*
Julia has so many books so she gave some away.

b. *Julia is your classmate. You know that she has a lot of books. You guess the following.*
Julia has so many books so she loves reading.

13.
a. *You got the card on the left from your friend. On it you can see the following things.*
The kite is flying so the girl is laughing.

b. *You got a card from a friend. There is a flying kite on it. You are asked to make predictions on what makes the kite fly. Here is what you came up with.*
The kite is flying so the wind is blowing.

14.
a. *Jonny is your friend. You two are very close. You know almost everything about him.*
Jonny can lift a sofa easily so he helped his friend move house.

b. *From the picture you can see a man. You have some comments about what you saw. Here is what you came up with.*
The man can lift a sofa easily so he is strong.

15.

a. *From the picture on the left you learn the following information.*
The boy is playing in the mud so he gets covered in it.

b. *From the picture on the left you can see a boy playing in the mud. You come up with the following comments based on what you saw.*
The boy is playing in the mud so he likes mud.

C.3. Filler items, Experiments 1 and 2 (note: the connectives were *however* in Experiment 1)

1f.

You met your colleague, Ben, during coffee break. You two talked for a while. Now you know what he went through last evening.
Ben locked himself out of his own house, but he managed to get in.

2f.

You and John are friends. He told you what he has gone through recently. Here is what he told you.
John worked very hard, but he failed his exams.

3f.

You just talked on the phone with your brother, Leo. Now you know something about his business trip to Paris.
Leo went to Paris, but he didn't visit the Eiffel Tower.

4f.

You met your colleague, Bill, in the hallway. You two talked for a while. He told you how he spent his weekend.
Bill is a big fan of basketball, but he missed the all-star game yesterday.

5f.

Jessica is your friend. You two chatted for a while. Jessica told you about how her life's been going recently. Now you know the following information.
The new "Star Wars" is nice, but Jessica hasn't watched it.

6f.
Alan is your roommate. You know him quite well. Here is something you know about him.
Alan was born in China, but he doesn't speak Mandarin.

7f.
You are Tim's boss. You two have been working together for years. You are quite familiar with him. Here is something that you know about him.
Tim is healthy as a horse, but he called in sick today.

8f.
You are taking a walk in the park. You saw your neighbor's kid, Mark, play with other kids on the ground. And then the following things happened.
Mark tripped over a rock and scratched his knee, but he did not cry.

9f.
You and your friend, Lisa, were chatting on the phone. Lisa mentioned her neighbor, Jane. Now you know something about Jane.
Jane and Lisa are neighbors, but they rarely see each other.

10f.
You came cross a friend, Lily. You two talked for a while. Now you know something about her trip to London.
Lily's flight departed later than scheduled, but the plane landed on time.

11f.
You and Sam are friends. You two chatted on the phone. He told you something about his assignment.
The math paper was difficult, but Sam finished it on his own.

12f.
You ran into an old friend, Rose. She told you about the dress she saw in the mall. Now you know the following information.

Rose liked the dress very much, but she decided not to buy it.

13f.
You and Dylan are friends. You two are catching up on the phone. You talked about his project. Now you know the following information.
Dylan had planned his project carefully, but the project didn't go very well.

14f.
Your colleague, David, just got back from his lunch. He told you how lucky he was in the café. Now you know the following information.
The café was crowded, but David found a table.

15f.
Sam works for you as your assistant. He updated you about the report he has been working on. Now you know about his progress.
The report was already proofread, but Sam found additional mistakes in it.

16f.
Andy is your brother. You two just talked on WhatsApp. Now you know about his trip in Budapest.
The weather was bad, but Andy had a good time.

17f.
You and Lisa are talking about your common friend, Alex. Lisa told you the following information about Alex.
Alex didn't feel very well, but she didn't go to see the doctor.

18f.
Benjamin is your officemate. You know him quite well. Here is something you know about him.
Benjamin has a car, but he doesn't drive it very often.

19f.
You and Becky are close friends. She told you about her job offer. Now you know

the following information.
The job is not well-paid, but Becky wants to take it.

20f.
Andy is your colleague. You have been working together for years. You know him quite well.
Andy is usually very punctual, but he was late for the meeting this morning.

Appendix D Chapter 3 Instructions

D.1 Experiment 1: Mandarin

你将看到一些幻灯片。有的幻灯片上描述的是实际发生的情况，有的则是你自己的一些猜测。
每张幻灯片后你将听到三个问题。请按照以下规则组织你的答案：
1、请用第一个方框中的句子回答第一个问题。
2、请用第二个和第三个方框中的句子回答第二个问题，并将这两个句子用“可见”、“于是”或者“但是”连接起来。
3、请用第四个方框中的句子回答第三个问题。
请仔细阅读每张幻灯片上的内容。
请不要改变句子的顺序，不要加字减字，。
请尽可能自然地说出你的答案，就像在和朋友聊天一样。

D.2. Experiment 2: Dutch

Je krijgt zo een aantal dia's te lezen. Op sommige dia's staan feiten en andere dia's vragen je om je mening over personen of gebeurtenissen. Op elke dia staan drie vragen. Formuleer je antwoord op de volgende manier:
Gebruik VAKJE 1 om Vraag 1 te beantwoorden.
Gebruik VAKJE 2 en VAKJE 3 om Vraag 2 te beantwoorden. Verbind deze vakjes met elkaar met 'daardoor‘of 'dus‘ of ‘maar’. Kies het meest passende verbindingswoord.
Gebruik VAKJE 4 om Vraag 3 te beantwoorden.
Lees de tekst zorgvuldig door.
U kunt de woordvolgorde in de VAKJE 3 wijzigen.
Probeer je antwoord zo natuurlijk mogelijk te laten klinken.

Appendix E Chapter 3 Items

E.1. Experiment 1 (a: objective causality; b: subjective causality; f: filler; contexts in italic; target sentences in bold):

1.

a. *你和张磊是同班同学。以下描述的内容是你自己亲眼看到的。*

张磊打了个鼻洞，于是他不停地跟别人炫耀。

You and Zhang Lei were in the same class. The following description is what you saw with your own eyes.

Zhang Lei had his nose pierced, so he kept showing it off to others.

b. *你和张磊同校，但是你跟他不熟。根据你平日里对他的观察，你对他有如下评价。*

张磊打了个鼻洞，可见他想吸引别人的注意。

You go to the same school as Zhang Lei, but you don't know him very well. Based on your own observations, you have the following comments about him.

Zhang Lei has his nose pierced, so he wants to attract other people's attention.

2.

a. *安仑是你的下属，他告诉你他遇到了一些状况。现在你知道了下面的信息。*

安仑酒后和人打架，于是他被拘留了几天。

An Lun works for you. He told you that he has run into some troubles. Now you know the following information.

An Lun was drunk and got into a fight, so he was detained for a few days.

b. *安仑是你的下属，他告诉你他遇到了一些事，你听后对他有了如下评价。*

安仑酒后和人打架，可见他自控能力不强。

An Lun works for you. He told you that he has run into some troubles. Based on what he said, you have the following comments.

An Lun was drunk and got into a fight, so he does not have strong self-control.

3.

a. *王明是你的同班同学。他给你发短信说自己出了点事故。现在你知道了下面的信息。*

王明自己把自己绊倒了，于是他赶紧从地上爬起来。

Wang Ming is a classmate of yours. He sends you a text message saying that he has had an accident. Now you know the following information.

Wang Ming tripped himself up, so he hurriedly got up from the ground.

b. *王明是你的同班同学。你跟他不太熟，你听说他最近出了点事，对此你对他有如下评价。*

王明自己把自己绊倒了，可见他是个笨蛋。

Wang Ming is a classmate of yours. You don't know him very well. You have heard that he has recently had an accident and you have the following to say about him.

Wang Ming tripped himself up, so he is an idiot.

4.

a.*李丽是你的同事。你俩刚刚在走廊里碰到，她跟你说了她今天的遭遇。现在你知道了下面的信息。*

李丽把钱包落在公交车上了，于是她刚刚去了失物招领处登记。

Li Li is a colleague of yours. You two just ran into each other in the corridor and she told you about her encounter today. Now you know the following information.

Li Li left her purse on the bus, so she went to the lost and found to register it.

b. *李丽是你的同事。你俩不太熟，你听说她把钱包落在公交车上了，你对她有如下评价。*

李丽把钱包落在公交车上了，可见她这个人丢三落四的。

Li Li is a colleague of yours. You don't know her very well. You heard that she left her wallet on the bus and you have the following comments about her.

Li Li left her purse on the bus, so she is scatterbrained.

5.

a. *你在路上碰到了老朋友张林。你俩聊了一会。现在你知道了以下信息。*

张林破产了，于是他把别墅卖了。

You ran into an old friend, Zhang Lin. You two talk for a while. Now you know the following information.

Zhang Lin has gone bankrupt, so he sold his villa.

b. *张林是个商人。你不认识他，你从新闻上看到他最近破产了，对此你对他有如下评价。*

张林破产了，可见他不太懂做生意。

Zhang Lin is a businessman. You do not know him and you have read on the news that he has recently gone bankrupt.

Zhang Lin has gone bankrupt, so he doesn't know much about business.

6.

a.*你跟你老板在开会。在会上，他宣布了一项关于你同事刘杰的决定。现在你知道了下面的信息。*

刘杰天天上班迟到，于是他被炒了。

You are in a meeting with your boss. At the meeting, he announces a decision about your colleague Liu Jie. Now you know the following information.

Liu Jie was late for work every day, so he was fired.

b.*你跟你老板开会，他让你评价评价你的同事刘杰。你知道刘杰天天上班迟到，对此你有如下评价。*

刘杰天天上班迟到，可见他这个人很懒散。

You are in a meeting with your boss and he asks you to evaluate your colleague Liu Jie. You know that Liu Jie is late for work every day and you have the following comments about this.

Liu Jie is late for work every day, so he is slack.

7.

a. *马丽是你的同事。你们一起去划船。马丽出了点意外。下面是你亲眼看到的。*

船翻了，于是马丽大声呼救。

Ma Li is your colleague. You went boating together. Ma Li had an accident. Here is what you saw.

The boat tipped over, so Ma Li called out for help.

b. *马丽是你的同事。你们一起去划船。你对马丽的划船技术有如下评价。*
船翻了，可见马丽的划船技术不行。
Ma Li is a colleague of yours. You went boating together. You have the following comments about Ma Li's rowing skills.
The boat tipped over, so Ma Li's rowing skills are not good.

8.
a. *何丽是你的好朋友。你们刚刚见过面。她告诉了你以下信息。*
何丽绘画大赛得了一等奖，于是别人请她去教小朋友画画。
He Li is a good friend of yours. You have just met. She has told you the following information.
He Li won first prize in a drawing competition, so someone asked her to teach children to draw.

b. *何丽是你的好朋友。她绘画大赛得了一等奖，对此你有如下评价。*
何丽绘画大赛得了一等奖，可见她很有天赋。
He Li is a good friend of yours. She won first prize in a drawing competition and you have the following to say about it.
He Li won first prize in the drawing competition, so she is very talented.

9.
a.*韩明是你的朋友。你俩刚在电话上聊了会儿。他跟你说了他的近况。现在你知道了下面的信息。*
韩明中彩票了，于是他买了一套大房子。
Han Ming is a friend of yours. You two have just had a chat on the phone. He told you about his recent experience. Now you know the following information.
Han Ming has won the lottery, so he has bought a big house.

b. *韩明是你的朋友。你俩刚在电话上聊了会儿。他跟你说了他的近况。你听后有如下想法。*
韩明中彩票了，可见他很幸运。
Han Ming is a friend of yours. You two have just been talking on the phone for a while. He told you about his recent experience. You have the following comment.

Han Ming has won the lottery, so he is very lucky.

10.

a. *李安是你的朋友。你们刚聊过天。他告诉你他昨天干什么了。现在你知道了下面的信息。*

李安被校篮球队选中了，于是教练安排他去参加训练。

Li An is a friend of yours. You have just had a chat. He told you what he did yesterday. Now you know the following information.

Li An was selected for the school's basketball team, so the coach asked him to attend training.

b. *李安是你的朋友。你们刚聊过天。他告诉你他入选了校篮球队。你对此事有如下评价。*

李安被校篮球队选中了，可见他非常有天赋。

Li An is a friend of yours. You have just had a chat. He tells you that he has been selected for the school basketball team. You have the following comments about this.

Li An was selected for the school's basketball team, so he is very talented.

11.

a. *乔华是你的朋友。你俩刚打电话聊过。现在你知道了下面的信息。*

乔华弹了一下午吉他，于是他决定休息一下。

Qiao Hua is a friend of yours. You two have just talked on the phone. Now you know the following information.

Qiao Hua has been playing the guitar all afternoon, so he decided to take a break.

b. *乔华是你的邻居，但你并不认识他。他弹了一下午吉他。你对此有如下评价。*

乔华弹了一下午吉他，可见他对音乐相当狂热。

Qiao Hua is your neighbour, but you don't know him. He has been playing the guitar all afternoon. You have the following comments about this.

Qiao Hua played the guitar all afternoon, so he is quite fanatical about music.

12.

a. *乔娜是你的妹妹。你们刚刚聊过。现在你知道了以下的信息。*

乔娜书太多了，于是她捐了一些出去。

Jona is your sister. You have just had a chat. Now you know the following information.

Jona had a lot of books, so she gave some away.

b. *乔娜是你的同学。你知道她有很多书。对此你有如下评价。*

乔娜书太多了，可见她很喜欢阅读。

Jona is a classmate of yours. You know that she has a lot of books. You have the following comments about this.

Jona has a lot of books, so she likes reading.

13.

a. *左侧这张卡片是你的朋友送给你的。从这张卡片上你可以看到以下信息：*

风筝飞起来了，于是女孩高兴得笑了。

The card on the left was given to you by your friend. From this card you can see the following information.

The kite is flying, so the girl is smiling.

b.*左侧这张卡片是你的朋友送给你的。卡片上风筝在飞。别人问你风筝是怎么飞起来的，以下是你的猜测。*

风筝飞起来了，可见起风了。

The card on the left was given to you by your friend. On the card is a picture of a flying kite. You are asked how the kite flies and here is your guess.

The kite is flying, so the wind is blowing.

14.

a. *张强是你的朋友，你对他很了解，你知道以下的事情。*

张强能轻松抬起沙发，于是朋友经常请他帮忙搬家。

Zhang Qiang is your friend and you know him well. You know the following thing.

Zhang Qiang can lift a sofa easily, so his friends often asks him to help them with moving.

b. *这张图上画着一个男人，根据图上的内容，你对他有如下的评价。*
这个男人能轻松抬起沙发，可见他力气很大。
This picture shows a man. Based on the picture, you have the following to say about him.
This man can lift the sofa easily, so he is very strong.

15.
a. *张言是你的朋友，你们经常聊天，他告诉了你如下信息。*
张言住的小区里有一家特别好的健身会所，于是他在那办了一张年卡。
Zhang Yan is a friend of yours and you often talk to each other. He tells you the following information.
There is a very nice gym in the neighbourhood where Zhang Yan lives, so he gets an annual card there.

b. *张言是你的同事，你没去过他家，不过你知道他家小区里有一家不错的健身会所，对此你自己有如下推论。*
张言住的小区里有一家特别好的健身会所，可见那个小区比较高端。
Zhang Yan is a colleague of yours and you have never been to his home, but you know that there is a good gym in his neighbourhood. Based on this, you made the following inference.
There is a very nice gym in the neighbourhood where Zhang Yan lives, so that neighbourhood is very high-end.

16f.
你碰到了你的同事李冰。你俩聊了一会。现在你知道了他昨晚的经历。
王冰把自己锁在屋子外面了，但是他想办法进去了。
You bump into your colleague Li Bing. You two talk for a while. Now you know what he went through last night.
Wang Bing had locked himself out of the house, but he managed to get in.

17f.
李强是你的朋友。他刚告诉了你他最近的经历。
李强学习很努力，但是他考试挂科了。

Li Qiang is a friend of yours. He has just told you about his recent experience.
Li Qiang studied hard, but he failed his exams.

18f.
李欧是你的弟弟。你俩刚打过电话。他跟你说了他去巴黎出差的事。
李欧去巴黎了，但是他没去看埃菲尔铁塔。
Li Ou is your brother. You two have just spoken on the phone. He told you about his business trip to Paris.
Leo went to Paris, but he didn't go to see the Eiffel Tower.

19f.
你碰见了你的同事王乐。你俩聊了一会儿。他告诉你他周末都干嘛了。
王乐是个篮球迷，但是他周末没看全明星赛。
You ran into your colleague Wang Le. You two talk for a while. He tells you what he did over the weekend.
Wang Le is a basketball fan, but he didn't watch the All-Star game over the weekend.

20f.
陈洁是你的朋友。你们俩聊了一会儿。她告诉了你如下的信息。
新上映的《星球大战》不错，但是陈洁没去看。
Chen Jie is a friend of yours. You two talked for a while. She told you the following information.
The new Star Wars movie is good, but Chen Jie didn't watch it.

21f.
艾伦是你的室友。你对他比较了解。以下信息是你知道的。
艾伦在中国出生，但是他不会说中文。
Alan is your roommate. You know him pretty well. You know the following information.
Alan was born in China, but he doesn't speak Chinese.

22f.
你是王力的老板。你对他比较了解。以下是一些你知道的信息。

王力身体一向不错，但是他今天请病假了。

You are Wang Li's boss. You know him well. Here is some information that you know.

Wang Li is always in good health, but he called in sick today.

23f.

你在公园散步,看到邻居家的孩子马乐在草地上玩，你目睹了如下情形。

马乐被石头绊倒了，但是他没哭。

You are walking in the park and you see the neighbor's child, Ma Le, playing on the lawn, and you have witnessed the following situation.

He tripped over a stone, but he didn't cry.

24f.

你和你的朋友张洁在聊天，她提到了她的邻居李梅，现在你知道了如下信息。

李梅和张洁住对门，但是她们很少碰见。

You are talking to your friend Zhang Jie and she mentions her neighbour Li Mei. Now you know the following information.

Li Mei and Zhang Jie live across the street from each other, but they rarely meet.

25f.

你遇到了你的朋友李丽，你们俩聊了一会儿，现在你知道李丽去伦敦出差了。

李丽的航班延误了一小时，但是飞机准点落地了。

You meet your friend Li Li and you talk for a while, and now you know that Li Li has gone to London on business.

Li Li's flight was delayed by an hour, but the plane landed on time.

26f.

你和张三是朋友。你们在电话上聊了会儿。张三提到了他的家庭作业。

数学作业很难，但是张三自己都做出来了。

You and Zhang San are friends. You talked on the phone for a while. Zhang San mentioned his homework.

The maths homework was difficult, but Zhang San did it all by himself.

27f.

你碰到了你的老朋友罗颖。她跟你说她刚才逛街看到一条特别喜欢的裙子。

罗颖非常喜欢那条裙子，但她决定不买了。

You bumped into your old friend Luo Ying. She told you that she saw a dress she particularly liked when she was shopping.

Luo Ying likes the dress very much, but she decides not to buy it.

28f.

你和张迪是朋友。你们俩在电话上聊了一会儿。他跟你讲了他的项目进展。现在你知道了如下信息。

张迪花了很多精力在他的项目上，但是项目的结果不是很好。

You are friends with Zhang Di. You two talked on the phone for a while. He told you about the progress of his project. Now you know the following information.

Zhang Di has put a lot of effort into his project, but the project is not going very well.

29f.

你同事戴威刚吃完中饭回来。他跟你讲了他在餐厅的经历。现在你知道了如下信息。

餐厅人很多，但是戴威等到一张桌子。

Your colleague Dai Wei has just returned from lunch. He told you about his experience at the restaurant. Now you know the following information.

The restaurant was crowded, but Davy got a table.

30f.

陈山是你的助理。你们最近在合写一份报告，以下是工作进展。

这份报告已经有人检查过了，但是陈山又发现了一些错误。

Chen Shan is your assistant. You have recently been working together on a report and the following is the progress of the work.

This report has already been checked, but Chen Shan has found some errors in it.

31f.

安迪是你的弟弟。你俩刚联系过。现在你知道他去布达佩斯玩了。

布达佩斯天气很糟糕，但是安迪玩得很开心。

Andy is your brother. You two have just been in touch. Now you know he has gone to Budapest for a trip.

The weather in Budapest was terrible, but Andy had a great time.

32f.

你刚和你的朋友李思打过电话，她告诉你如下信息。

李思感觉不太舒服，但是她没去医院。

You have just spoken to your friend Liz on the phone and she has told you the following information.

Lisi is not feeling well, but she didn't see the doctor.

33f.

王博是你的同事，你对他蛮了解。以下是一些你知道的信息。

王博有车，但是他不常开。

Wang Bo is a colleague of yours and you know him quite well. Here is some information that you know.

Wang Bo has a car, but he doesn't drive it very often.

34f.

你和刘蓓是好朋友。你俩聊了聊她的新工作。现在你知道了如下信息。

这份工作工资不高，但是刘蓓决定接受。

You and Liu Bei are good friends. You two talk about her new job. Now you know the following information.

The job doesn't pay much, but Liu Bei decides to take it.

35f.

安迪是你的同事。你们俩共事很久了，你对他比较了解。你知道下面的信息。

安迪一般很守时，但是他今天开会迟到了。

Andy is a colleague of yours. You have worked together for a long time and you

know him well. You know the following information.
Andy is usually very punctual, but he was late for a meeting today.

E.2. Items, Experiment 2 (a: objective causality; b: subjective causality; f: fillers: contexts in italic; target sentences in bold):

1.
a. *Jim en jij zijn vrienden. Jullie hebben elkaar net via de telefoon gesproken. Nu heb je de volgende informatie over hem.*
Jim heeft een neuspiercing laten zetten, daardoor bloedde hij erg.
You and Jim are friends. You have just spoken to each other on the phone. Now you have the following information about him.
Jim has had his nose pierced, so he bled a lot.

b. *Jim en jij gaan naar dezelfde school, maar je kent hem niet goed. Je hebt de volgende indruk van hem.*
Jim heeft een neuspiercing laten zetten, dus hij wil aandacht.
Jim and you go to the same school, but you don't know him very well. You have the following impression of him.
Jim has had his nose pierced, so he wants attention.

2.
a. *Je leest in de krant over een geval van ernstige vervuiling. Het volgende is gebeurd.*
De fabriek heeft het water vervuild, daardoor zijn veel vissen gestorven.
You read in the newspaper about a case of serious pollution. The following has happened.
The factory polluted the water, so many fish died.

b. Je las in de krant over ernstige watervervuiling. Je hebt de volgende opmerking op deze milieuramp.
De fabriek heeft het water vervuild, dus de directeur is een onverantwoordelijk persoon.
You read in the newspaper about serious water pollution. You have the following

comment on this environmental disaster.
The factory polluted the water, so the director is an irresponsible person.

3.
a. *Tom is je klasgenoot. Hij heeft jou net een bericht gestuurd dat hij een ongeluk heeft gehad.*
Tom is over zijn schoenveters gestruikeld, daardoor heeft hij zijn arm gebroken.
Tom is your classmate. He has just sent you a message that he had an accident.
Tom tripped over his shoelaces, so he broke his arm.

b. Tom is je klasgenoot. Je kent hem niet heel goed, maar je bent niet dol op hem. Je hebt de volgende mening over hem.
Tom is over zijn schoenveters gestruikeld, dus hij is een idioot.
Tom is your classmate. You don't know him very well, but you don't like him. You have the following opinion about him.
Tom tripped over his shoelaces, so he's an idiot.

4.
a. *Suzan is je collega. Je bent haar net tegengekomen op de gang. Ze vertelde je wat haar vandaag is overkomen. Nu weet je waarom ze haar lunch niet kon betalen.*
Suzan heeft haar portemonnee in de bus laten liggen, daardoor is ze al haar geld verloren.
Susan is your colleague. You just bumped into her in the corridor. She told you what happened to her today. Now you know why she couldn't pay for her lunch.
Susan left her wallet on the bus, so she lost all her money.

b. *Suzan is je collega. Je kent haar niet heel goed, maar je hebt wel een persoonlijke mening over haar.*
Suzan heeft haar portemonnee in de bus laten liggen, dus ze is een warhoofd.
Susan is your colleague. You don't know her very well, but you have a personal opinion about her.
Susan left her wallet on the bus, so she is a scatterbrain.

5.

a. *Je kwam je oude vriend Tom tegen. Jullie hebben een tijdje met elkaar gepraat. Nu heb je de volgende informatie over hem.*

Tom is failliet gegaan, daardoor raakte hij zijn bedrijf kwijt.

You bumped into your old friend Tom. You talked to each other for a while. Now you have the following information about him.

Tom went bankrupt, so he lost his business.

b. *Tom is een zakenman. Je kent hem niet persoonlijk, maar je las in de krant dat hij failliet is gegaan. Je hebt het volgende commentaar hierop.*

Tom is failliet gegaan, dus hij weet niets van zaken doen.

Tom is a businessman. You don't know him personally, but you read in the newspaper that he has gone bankrupt. You have the following comment on this.

Tom went bankrupt, so he knows nothing about business.

6.

a. *Je had een gesprek met je baas. Hij vertelde je waarom hij je collega Jan heeft moeten ontslaan. Nu heb je de volgende informatie over Jan.*

Jan was altijd te laat op zijn werk, daardoor mist hij de ochtendvergaderingen.

You had a conversation with your boss. He told you why he had to dismiss your colleague Jan. Now you have the following information about Jan.

Jan is always late for work, so he misses the morning meeting.

b. *Je had een gesprek met je baas. Hij vroeg jou om je mening over je collega Jan. Je weet dat hij altijd te laat op zijn werk is, maar je weet niet waarom. Dit is wat je denkt.*

Jan is altijd te laat op zijn werk, dus hij is geen ochtendmens.

You had a conversation with your boss. He asked you for your opinion about your colleague John. You know that he's always late for work, but you don't know why. This is what you think.

John is always late for work, so he is not a morning person.

7.

a. *Marie is jouw collega. Marie en jij gingen samen roeien. Marie kreeg een ongeluk. Dit is wat je met je eigen ogen hebt gezien.*
De boot sloeg om, daardoor viel Marie in het water.
Marie is your colleague. You and Marie went rowing together. Marie had an accident. This is what you saw with your own eyes.
The boat tipped over, so Marie fell into the water.

b. *Je collega's en jij gingen samen roeien. Je kent je collega Marie niet goed, maar je hebt wel iets over haar roeivaardigheden te zeggen.*
De boot sloeg om, dus Marie kan niet goed roeien.
You and your colleagues went rowing together. You don't know your colleague Marie very well, but you have something to say about her rowing skills.
The boat tipped over, so Marie is not good at rowing.

8.

a. *Jij en Heidi zijn goede vrienden. Zij heeft meegedaan aan een kunstfestival. Jij was daar samen met haar. Dit is was je met eigen ogen zag.*
Heidi won de eerste prijs in het plaatselijke kunstfestival, daardoor werd ze geselecteerd voor de landelijke expositie.
You and Heidi are good friends. She participated in an art festival. You were there with her. This is what you saw with your own eyes.
Heidi won the first prize in the local art festival, so she was selected for the national exhibition.

b. *Heidi is een goede vriendin van jou. Ze won de eerste prijs op het kunstfestival. Dit zijn jouw gedachten over haar succes.*
Heidi won de eerste prijs in het plaatselijke kunstfestival, dus ze is getalenteerd.
Heidi is a good friend of yours. She won the first prize in the art festival. These are your thoughts about her success.
Heidi won the first prize in the local art festival, so she is talented.

9.

a. *Hans is je vriend. Je hebt net met hem gesproken. Hij vertelde je wat hij de laatste tijd heeft meegemaakt.*
Hans heeft miljoenen in de loterij gewonnen, daardoor werd hij miljonair.
Hans is your friend. You have just been talking to him. He told you what he has been going through lately.
Hans won millions in the lottery, so he became a millionaire.

b. *Hans is je vriend. Je denkt dat er niemand is die meer geluk heeft dan hij.*
Hans heeft miljoenen in de loterij gewonnen, dus hij heeft geluk gehad.
Hans is your friend. You think that nobody is luckier than him.
Hans won millions in the lottery, so he was lucky.

10.
a. *Ivo is een vriend. Je hebt hem net gesproken. Hij vertelde waarom hij zijn opdrachten niet af had.*
Ivo is geselecteerd voor het schoolteam, daardoor moet hij nu 4 keer in de week trainen.
Ivo is your friend. You have just spoken to him. He told you why he didn't finish his assignments.
Ivo has been selected for the school team, so he now has to train 4 times a week.

b. *Ivo is je vriend. Hij heeft jou net verteld dat hij is geselecteerd voor het hockeyteam van je school. Jij maakte een paar opmerkingen over zijn succes.*
Ivo is geselecteerd voor het schoolteam, dus hij is een getalenteerde hockeyspeler.
Ivo is your friend. He just told you that he is selected for your school's hockey team. You made some remarks about his success.
Ivo has been selected for the school team, so he is a talented hockey player.

11.
a. *Joshua is jouw vriend. Je hebt hem net aan de telefoon gesproken. Nu heb je de volgende informatie over hem.*
Joshua heeft urenlang gitaar gespeeld, daardoor doen zijn vingers pijn.

Joshua is your friend. You just spoke to him on the phone. Now you have the following information about him.
Joshua played the guitar for hours, so his fingers hurt.

b. *Joshua is jouw buurman. Hij heeft de hele middag gitaar gespeeld. Je kent Joshua niet persoonlijk, maar je verwacht het volgende.*
Joshua heeft urenlang gitaar gespeeld, dus hij heeft een grote passie voor muziek.
Joshua is your neighbour. He played the guitar all afternoon. You don't know Joshua personally, but you expect the following.
Joshua has been playing the guitar for hours, so he has a great passion for music.

12.
a. *Julia is jouw zus. Je hebt haar net gesproken. Nu heb je de volgende informatie over haar.*
Julia heeft heel veel boeken,daardoor is haar boekenkast ingestort.
Julia is your sister. You have just spoken to her. Now you have the following information about her.
Julia has a lot of books, so her bookcase collapsed.

b. *Julia is jouw klasgenoot. Je weet dat ze veel boeken heeft. Je denkt het volgende.*
Julia heeft heel veel boeken, dus ze houdt van lezen.
Julia is your classmate. You know that she has a lot of books. You think the following.
Julia has lots of books, so she likes reading.

13.
a. *Je hebt de ansichtkaart links van je vriend gekregen . Op de kaart zie je de volgende dingen.*
De vlieger vliegt, daardoor valt er een schaduw op de grond.
You have received the postcard on the left from your friend. You can see the following things on the card.

The kite is flying, so a shadow falls on the ground.

b. *Je hebt een ansichtkaart van een vriend gekregen. Er staat een vliegende vlieger op. Uit deze afbeelding trek je de volgende conclusies?*
De vlieger vliegt, dus de wind waait.
You received a postcard from a friend. It shows a kite flying. You draw the following conclusions from this picture?
The kite is flying, so the wind is blowing.

14.
a. *Peter is jouw vriend. Je hebt hem net gesproken over de telefoon. Hij vertelde je dat hij gisteren een vriend heeft geholpen met verhuizen.*
Peter kan makkelijk een bank optillen, daardoor ging de verhuizing heel snel.
Peter is your friend. You just spoke to him on the phone. He told you that he helped a friend to move yesterday.
Peter can easily lift a sofa, so the move went very quickly.

b. *Op de foto zie je een man. Je hebt het volgende commentaar op wat je hebt gezien. Dit is wat je hebt bedacht.*
De man kan makkelijk een bank optillen, dus hij is sterk.
In the picture you see a man. You have the following comments about what you have seen. This is what you have thought.
The man can easily lift a sofa, so he is strong.

15.
a. *Op de foto links zie je de volgende informatie.*
De jongen speelt in de modder, daardoor is hij helemaal vies.
In the photo on the left you see the following information.
The boy is playing in the mud, so he gets very dirty.

b. *Op de foto links zie je een jongen spelen in de modder. Op basis van wat je hebt gezien, heb je het volgende commentaar.*
De jongen speelt in de modder, dus hij houdt ervan om vies te worden.

On the photo on the left you see a boy playing in the mud. Based on what you have seen, you have the following comment.
The boy is playing in the mud, so he likes getting dirty.

16f.
Tijdens de pauze ontmoette je je collega Ben. Jullie hebben een tijdje gepraat. Nu weet je wat hem gisteravond is overkomen.
Ben had zichzelf buitengesloten uit zijn eigen huis, maar hij is weer naar binnen gekomen.
During the break you met your colleague Ben. You talked for a while. Now you know what happened to him last night.
Ben had locked himself out of his own house, but he managed to get in.

17f.
Daan en jij zijn vrienden. Hij vertelde jou wat hij de afgelopen tijd heeft meegemaakt. Dit is wat hij vertelde.
Daan heeft hard gewerkt, maar hij is gezakt voor zijn examens.
Daan and you are friends. He told you what he has been going through lately. This is what he told you.
Daan has worked hard, but he failed his exams.

18f.
Je hebt net je broer Leo gesproken aan de telefoon. Nu weet je iets over zijn zakenreis naar Parijs.
Leo ging naar Parijs, maar hij heeft de Eiffeltoren niet bezocht.
You have just spoken to your brother Leo on the phone. Now you know something about his business trip to Paris.
Leo went to Paris, but he didn't visit the Eiffel Tower.

19f.
Je bent je collega Bram op de gang tegen gekomen. Jullie hebben een tijdje gepraat. Hij vertelde jou wat hij in het weekend heeft gedaan.
Bram is een grote fan van basketbal, maar hij heeft de all-star game van gisteren gemist.

You met your colleague Bram in the corridor. You talked for a while. He told you what he did over the weekend.
Bram is a big fan of basketball, but he missed yesterday's all-star game.

20f.
Jessica is je vriendin. Jullie hebben een tijdje gekletst. Jessica vertelde je hoe het de laatse tijd met haar gaat. Nu heb je de volgende informatie.
De nieuwe Star Wars film is goed, maar Jessica heeft hem niet gezien.
Jessica is your friend. You chatted for a while. Jessica told you how she's been doing lately. Now you have the following information.
The new Star Wars movie is good, but Jessica hasn't seen it.

21f.
James is jouw huisgenoot. Je kent hem behoorlijk goed. Dit is iets wat je over hem weet.
James is geboren in China, maar hij spreekt geen Mandarijn.
James is your roommate. You know him pretty well. This is something you know about him.
James was born in China, but he doesn't speak Mandarin.

22f.
Jij bent Tims baas. Jullie werken al jaren samen. Je kent hem aardig goed. Dit is iets wat je over hem weet.
Tim is zo gezond als een paard, maar hij heeft zich vandaag ziekgemeld.
You are Tim's boss. You have worked together for years. You know him pretty well. This is something you know about him.
Tim is as healthy as a horse, but he called in sick today.

23f.
Je hebt net gewandeld in het park. Je zag je buurjongen Mark met andere kinderen buitenspelen. Het volgende gebeurde toen.
Mark struikelde over een steen en schaafde zijn knie, maar hij huilde niet.
You have just been walking in the park. You saw your neighbour's boy, Mark, playing outside with other children. Then the following happened.

Mark tripped over a stone and scraped his knee, but he did not cry.

24f.

Jij en jouw vriendin Lisa kletsen aan de telefoon. Lisa had het over haar buurvrouw Janneke. Nu weet je het volgende over Janneke.

Janneke en Lisa zijn buren, maar ze zien elkaar zelden.

You and your friend Lisa are chatting on the phone. Lisa was talking about her neighbour Janneke. Now you know the following about Joanna.

Joanna and Lisa are neighbours, but they rarely see each other.

25f.

Je kwam je vriendin Lotte tegen. Jullie hebben een tijdje gepraat. Nu weet je iets over haar reis naar Londen

Lottes vlucht vertok later dan gepland, maar het vliegtuig landde op tijd.

You met your friend Lotte. You talked for a while. Now you know something about her trip to London.

Lotte's flight left later than planned, but the plane landed on time.

26f.

Sam en jij zijn vrienden. Jullie spraken elkaar aan de telefoon. Hij vertelde iets over zijn opdracht.

De wiskunde-opdracht was moeilijk, maar Sam wist hem zelf op te lossen.

You and Sam are friends. You talked on the phone. He told me about his assignment.

The math assignment was difficult, but Sam managed to finish it himself.

27f.

Je kwam een oude vriendin tegen, Roos. Ze vertelde je over een jurk die ze zag in het winkelcentrum. Nu heb je de volgende informatie.

Roos vond de jurk heel mooi, maar ze besloot hem niet te kopen.

You met an old friend, Roos. She told you about a dress she saw in the shopping centre. Now you have the following information.

Roos thought the dress was very beautiful, but she decided not to buy it.

28f.
Dylan en jij zijn vrienden. Jullie zijn aan het kletsen aan de telefoon. Jullie hebben het over zijn project. Nu heb je de volgende informatie.
Dylan had zijn project zorgvuldig gepland, maar het project ging niet goed.
Dylan and you are friends. You are chatting on the phone. You are talking about his project. Now you have the following information.
Dylan had planned his project carefully, but the project did not go well.

29f.
Je collega David is net teruggekomen van zijn lunchpauze. Hij vertelde hoeveel geluk hij had in de kantine. Nu heb je de volgende informatie.
De kantine was heel vol, maar David heeft een tafel kunnen vinden.
Your colleague David has just returned from his lunch break. He told how lucky he was in the canteen. Now you have the following information.
The canteen was very full, but David managed to find a table.

30f.
Sam werkt als jouw assistent. Hij heeft je een update gegeven van het verslag waar hij aan heeft gewerkt. Nu weet je het volgende over de voortgang.
Het verslag was al gecontroleerd, maar Sam vond een aantal extra fouten.
Sam works as your assistant. He gave you an update on the report he has been working on. Now you know the following about the progress.
The report had already been checked, but Sam found some errors.

31f.
Abel is je broer. Jullie spraken elkaar net via WhatsApp. Nu weet je het volgende over zijn reis naar Boedapest.
Het weer was slecht, maar Abel had het naar zijn zin.
Abel is your brother. You just spoke to each other via WhatsApp. Now you know the following about his trip to Budapest.
The weather was bad, but Abel had a good time.

32f.
Lisa en jij praten over een gemeenschappelijke vriendin, Amber. Lisa gaf jou de

volgende informatie over Amber.
Amber voelt zich niet zo goed, maar ze is niet naar de dokter gegaan.
Lisa and you talk about a mutual friend, Amber. Lisa gave you the following information about Amber.
Amber is not feeling very well, but she didn't go to the doctor.

33f.
Benjamin is jouw collega. Je kent hem aardig goed. Dit is iets wat je van hem weet.
Benjamin heeft een auto, maar hij rijdt er niet heel vaak in.
Benjamin is your colleague. You know him quite well. This is something you know about him.
Benjamin has a car, but he doesn't drive it very often.

34f.
Bregje en jij zijn hechte vrienden. Ze heeft je verteld over haar nieuwe baan. Nu heb je de volgende informatie.
Het is geen goedbetaalde baan, maar Bregje wil hem toch houden.
Bregje and you are close friends. She told you about her new job. Now you have the following information.
It's not a well-paying job, but Bregje wants to keep it anyway.

35f.
Alex is je collega. Jullie werken al jaren samen. Je kent hem aardig goed.
Alex is normaal gesproken heel stipt op tijd, maar vanochtend was hij te laat bij de vergadering.
Alex is your colleague. You have worked together for years. You know him pretty well.
Alex is normally very punctual, but this morning he was late for the meeting.

Appendix F Chapter 4 Instructions

Welcome to this survey. In this survey you are going to listen to sentences. To be able to perceive the subtle sound variations in the sound bites, please wear headphones or earphones. You are going to listen to sentences introducing events taking place in the real world. After each sentence, you will see two continuations shown in the form of text on the screen. Please select the one you think best continues the sentence you just heard. Please listen to the intonation in the sound clips carefully. You can play the sentences as many times as you want.

Appendix G Chapter 4 Items

Items (in italic) were presented to the participants in audio form. Each target item (1-15) was presented twice, with the connective *so* having objective and subjective prosody. After each stimulus, two continuations (indexed as A and B) appeared on the screen, one forming objective causality with the stimulus and the other subjective causality. In the texts below, for illustration purpose, the objective continuation is always Option A and the subjective continuation Option B; in the experiment, the order of objective and subjective continuation was alternated. Filler items (16-35) were presented once each, after which two continuations were shown on the screen, with Option A being the only reasonable choice and Option B having no semantic relevance (in the experiment, the position of A and B was alternated).

1 *Jim got his nose pierced so*
A: He bled a lot. B: He wants attention.

2 *Alan has a drinking problem so*
A: He goes to AA meetings. B: He has weak self-control.

3 *Tom tripped over his shoelaces so*
A: He fell. B: He is an idiot.

4 *Susan left her wallet on the bus so*
A: She lost her money. B: She is scatterbrained.

5 *Tom went bankrupt so*
A: He moved out of his big house. B: He knew nothing about business.

6 *Jack was always late for work so*
A: He was fired. B: He is not a morning person.

7 *The boat spun around on the current so*
A: Marie fell into the water. B: Marie doesn't know much about rowing.

8 *Heidi won the first prize at the art festival so*
A: She was happy. B: She is talented.

9 *Hans won the lottery so*
A: He bought a new house. B: He is lucky.

10 *Ian made the school team so*

A: He went to basketball practice. B: He is a talented basketball player.

11 *Joshua played the guitar for hours so*

A: His fingers hurt. B: He has a great passion for music.

12 *Julia has so many books so*

A: She gave some away. B: She loves reading.

13 *The kite is flying so*

A: The girl is laughing. B: The wind is blowing.

14 *Jonny can lift a sofa easily so*

A: He helped his friend move house. B: He is strong.

15 *The boy is playing in the mud so*

A: He gets covered in it. B: He likes mud.

16 *Ben locked himself out of his own house but*

A: He managed to get in. B: Becky wants to take it.

17 *John worked very hard but*

A: He failed his exams. B: The plane landed on time.

18 *Leo went to Paris but*

A: He didn't visit the Eiffel Tower. B: David found a table.

19 *Bill is a big fan of basketball but*

A: He missed the all-star game yesterday. B: He doesn't drive it very often.

20 *The new "Star Wars" is nice but*

A: Jessica hasn't watched it. B: She didn't go to see the doctor.

21 *Alan was born in China but*

A: He doesn't speak Mandarin. B: Sam finished it on his own.

22 *Tim is healthy as a horse but*

A: He called in sick today. B: Sam found additional mistakes in it.

23 *Mark tripped over a rock and scratched his knee but*

A: He did not cry. B: They rarely see each other.

24 *Jane and Lisa are neighbors but*

A: They rarely see each other. B: The project didn't go very well.

25 *Lily's flight departed later than scheduled but*

A: The plane landed on time. B: He failed his exams.

26 *The math paper was difficult but*

A: Sam finished it on his own. B: He didn't visit the Eiffel Tower.

27 *Rose liked the dress very much but*
A: She decided not to buy it. B: He missed the all-star game yesterday.

28 *Dylan had planned his project carefully but*
A: The project didn't go very well. B: He managed to get in.

29 *The café was crowded but*
A: David found a table. B: He was late for the meeting this morning.

30 *The report was already proofread but*
A: Sam found additional mistakes in it. B: Andy had a good time.

31 *The weather was bad but*
A: Andy had a good time. B: He doesn't speak Mandarin.

32 *Alex didn't feel very well but*
A: She didn't go to see the doctor. B: He called in sick today.

33 *Benjamin has a car but*
A: He doesn't drive it very often. B: Jessica hasn't watched it.

34 *The job is not well-paid but*
A: Becky wants to take it. B: He did not cry.

35 *Andy is usually very punctual but*
A: He was late for the meeting this morning. B: She decided not to buy it.

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Nederlandse samenvatting

Inleiding

Causaliteit is een fundamenteel concept in menselijke cognitie. De menselijke geest lijkt daarbij systematisch onderscheid te maken tussen twee typen causaliteit. Het eerste type betreft objectieve causaliteit: de relatie van *oorzaak-gevolg* (of *gevolg-oorzaak*) tussen twee feiten of gebeurtenissen in de werkelijkheid, zoals in (1.a) in het Engels en (1.b) in het Nederlands. Het andere type betreft subjectieve causaliteit: de relatie tussen de *bewering* van sprekers of schrijvers en *argumenten* voor die bewering, zoals in (2.a) en (2.b).

(1) a. The temperature was below zero for weeks. So the lake was frozen.
    b. De temperatuur was wekenlang onder nul. Daardoor was het meer bevroren.
(2) a. Their car is not there. So they are not at home.
    b. Hun auto staat er niet. Dus de buren zijn niet thuis.

Hoe worden deze twee typen causaliteit in taal uitgedrukt? Naar deze vraag is veel onderzoek gedaan in studies naar tekst en *discourse*. Een belangrijk resultaat daarvan is dat er in diverse, maar niet in alle talen, specifieke lexicale markeringen zijn die deze verschillende typen relaties uitdrukken. Zo worden beide typen causale relaties hierboven in het Engels uitgedrukt met het connectief *so*. In het Nederlands is het niet onmogelijk om in beide gevallen het connectief *dus* te gebruiken, maar we weten uit onderzoek dat *daardoor* gebruikt wordt voor objectieve relaties. Andersom is het onmogelijk om *daardoor* te gebruiken om de subjectief-epistemische relatie in (2b) uit te drukken.

Dergelijke connectieven en andere lexicale signalen helpen lezers en luisteraars bij het interpreteren van deze typen causaliteit. Daarbij is het opvallend dat we veel meer weten over geschreven dan over gesproken taal. In gesproken taal hebben taalgebruikers toegang tot andere, aanvullende

informatiebronnen dan in geschreven taal, zoals prosodie. Afgezien van enkele verkennende studies is tot nu toe weinig bekend over de vraag of, en zo ja hoe, prosodie een rol speelt bij het uitdrukken van subjectiviteit in causale relaties. Dit proefschrift wil verandering brengen in deze situatie. Het onderzoek waarvan hier verslag wordt gedaan richt zich eerst op de rol van prosodie in het uitdrukken van subjectieve versus objectieve causale relaties. Vervolgens wordt onderzocht wat het effect is van prosodische informatie op de interpretatie van subjectieve versus objectieve causaliteit.

De rol van prosodie bij het uitdrukken van subjectieve versus objectieve causaliteit

De eerste vraag die in dit proefschrift wordt onderzocht is of, en zo ja hoe prosodie wordt gebruikt bij het uitdrukken van subjectieve versus objectieve causaliteit. De *Functionele Hypothese* suggereert een *trade-off*-relatie tussen het gebruik van morfo-syntactische elementen en prosodische kenmerken die betekenis en functie uitdrukken. Op basis daarvan is de volgende hypothese geformuleerd: Prosodie wordt vaker gebruikt om subjectieve van objectieve causaliteit te onderscheiden wanneer sprekers geen lexicale markeerders (bijvoorbeeld specifieke connectieven) inzetten om dat te doen, dan wanneer sprekers die lexicale signalen wél gebruiken.

Om deze hypothese te toetsen, wordt in hoofdstuk 2 de prosodie onderzocht van uitingen die subjectieve versus objectieve causale relaties uitdrukken, waarin geen specifieke, maar wel algemene causale connectieven voorkomen. Deze hypothese werd onderzocht voor het Engels. Volgens de literatuur gebruiken sprekers van het Engels vaak een algemeen causal connectief (*because*, *so*) om beide typen relaties uit te drukken. We verwachtten derhalve duidelijke prosodische verschillen te zien tussen objectieve versus subjectieve uitingen.

Hoe zagen die causale relaties eruit? De *antecedens P* en de *consequens Q* kunnen in een causale relatie in twee volgordes worden gepresenteerd: voorwaarts ($P \rightarrow Q$; zoals in P *dus* Q) of achterwaarts ($Q \leftarrow P$) (Q, *omdat* P). We bestudeerden beide volgorden van causaliteit in twee afzonderlijke experimentele studies. We ontwikkelden een dialoogtaak om uitingen met objectieve en subjectieve relaties in beide volgorden aan sprekers te

ontlokken. In deze taak converseerden participanten met een gesprekspartner (interlocutor) over informatie die werd gegeven via PowerPoint-dia's. De gesprekspartner stelde steeds drie vragen over elke dia. Met de tweede vraag werd een uiting van de participant uitgelokt die een causale relatie bevat (zie voorbeelden 3 en 4).

(3) Jim bled a lot because he got his nose pierced.
(4) Jim wants attention because he got his nose pierced.

Diverse akoestisch-fonetische maten werden onderzocht om de geproduceerde causale relaties te analyseren. Daarbij ging het niet alleen om statische kenmerken van f0 (minimum, maximum) en duren, maar ook om dynamische kenmerken die het verloop van f0 beschrijven. Het effect van de cruciale factor 'type causaliteit' (objectief vs. Subjectief) op deze akoestisch-fonetische parameters werd onderzocht met behulp van Bayesiaans statistiek: de zgn. Bayes-factoren drukken de ratio uit van waarschijnlijkheden van een nulmodel zonder, en een alternatief model mèt dat cruciale effect, gegeven de data.

In lijn met de hypothese vonden we in de resultaten van de twee experimenten zeer sterke steun voor de invloed van de factor 'type causaliteit' op de prosodie van de uitingen. Uitingen die subjectieve causaliteit uitdrukken verschilden van objectieve causale relaties door een grotere f0-range, een langere pauzeduur duration, en een andere vorm (parabolische stijging) van de f0-verloop in het connectief *so*.

Uit de experimenten in hoofdstuk 2 kunnen we dus concluderen dat prosodie een actieve rol speelt bij het uitdrukken van het verschil tussen subjectieve en objectieve causaliteit, wanneer sprekers geen gebruik maken van specifieke connectieven om het verschil tussen de twee typen causaliteit uit te drukken. De volgende vraag is of prosodie ook een rol speelt wanneer de specifieke connectieven wél worden ingezet. Die vraag is onderzocht in hoofdstuk 3 en 4.

Als er inderdaad een trade-off is tussen lexicale en prosodische middelen om subjectiviteit aan te geven, dan volgt daaruit dat de rol van prosodie veel minder wordt of zelfs verdwijnt als gespecialiseerde

connectieven worden gebruikt, omdat deze specifieke connectieven het verschil tussen de typen causaliteit al duidelijk markeren. Om dit te toetsen bestudeerden we de prosodische realisatie van subjectieve en objectieve causaliteit in het Nederlands en in het Mandarijn-Chinees. Uit eerder corpus-onderzoek is bekend dat sprekers van die twee talen vaak gebruik maken van specifieke connectieven om subjectieve danwel objectieve relaties uit te drukken. De hypothese voor Mandarijn-Chinees was dat prosodische verschillen tussen objectieve en subjectieve relaties niet zo groot zullen zijn als in het Engels. In het Nederlands kiezen sprekers vaak *daarom* en *daardoor* om een objectieve causale relatie uit te drukken, terwijl *dus* vaak wordt gekozen voor een subjectieve relatie. *Dus* kan echter ook objectieve causale relatie uitdrukken. Voor het Nederlands was de hypothese derhalve: uitingen die subjectieve versus objectieve causaliteit uitdrukken, vertonen minder prosodische verschillen wanneer ze specifieke connectieven bevatten dan wanneer de causale relatie wordt uitgedrukt met een algemeen causaal connectief. De twee talen werden onderzocht in afzonderlijke productie-experimenten, waarbij we gebruik maakten van dezelfde dialoogtaak als gebruikt in hoofdstuk 2.

De resultaten voor Mandarijn-Chinees waren in lijn met onze hypothesen: het type causaliteit had een beperkt effect op de prosodische realisatie van de uitingen met causale relaties waarin specifieke connectieven werden gebruikt. Met andere woorden: Uitingen waarin subjectieve en objectieve relaties worden gemarkeerd door specifieke connectieven (in dit geval *kejian* en *yushi*) verschilden niet drastisch in termen van prosodie – althans niet in de prosodische dimensies die we in deze studies hebben gemeten. De resultaten voor het Nederlands laten zien dat het gebruik van *dus* – dat zoals gezegd een subjectief maar ook generiek gebruiksprofiel heeft – verschilt tussen participanten. Sommige sprekers behandelden *dus* strikt volgens het prototypische gebruiksprofiel van exclusief subjectieve causaliteit; anderen negeerden dit prototypisch gebruik en gebruikten *dus* als een generiek causaal connectief; weer andere sprekers vielen tussen deze twee extremen, waarbij ze *dus* zowel gebruikten als generiek causaal én als specifiek subjectief connectief. Door het gebruik van *dus* in ieder uitingenpaar preciezer te karakteriseren, vonden we uiteindelijk dat er alleen

maar duidelijke verschillen waren in prosodie wanneer *dus* werd gebruikt als generiek causaal connectief. Wanneer *dus* exclusief werd gebruikt als specifiek connectief om subjectieve causaliteit uit te drukken (en *daardoor* werd gebruikt voor objectieve causaliteit), was het prosodisch verschil tussen de twee typen causaliteit veel kleiner. Op die manier werd onze hypothese bevestigd.

Omdat er duidelijke individuele verschillen zichtbaar waren in de data, is nagegaan of de sprekersvoorkeuren in connectief-gebruik van invloed zijn op het gebruik van prosodie bij het uitdrukken van subjectiviteit. Ondanks diverse pogingen om dit uit te zoeken (zie hoofdstuk 3) is het moeilijk om met een duidelijke conclusie te komen op dit punt. In hoofdstuk 3 bespreken we dat de effecten voor het Nederlands te zwak zijn, waarbij ook de mogelijkheid bestaat dat er uiteindelijk te weinig gevallen waren die konden worden meegenomen in de statistische analyse om een eventueel interactie-effect vast te stellen.

Uit de resultaten van hoofdstukken 2 en 3 kunnen we twee conclusies trekken. Ten eerste: de prosodische verschillen tussen subjectieve en objectieve causaliteit bevestigen de cognitieve realiteit van de conceptuele verschillen tussen deze twee typen causaliteit. De resultaten laten zien dat het subjectief-objectief contrast van invloed is op linguïstische representaties, en wel op diverse niveaus: lexicaal en non-lexicaal, namelijk prosodie. Een tweede, en misschien wel nog belangrijker conclusie betreft de manier waarop sprekers de mate van subjectiviteit in causaliteit uitdrukken. Daarbij is sprake van een *trade-off*-relatie tussen de verschillende linguïstische informatiebronnen: wanneer sprekers minder lexicale middelen gebruiken, maken ze meer gebruik van prosodie om het verschil in betekenis uit te drukken, en andersom. Zo balanceren sprekers hun inspanningen met het oog op cognitieve energie en communicatieve efficiëntie.

De rol van prosodie bij het begrijpen van subjectieve objectieve causaliteit

In de hoofdstukken 2 en 3 stond de rol van prosodie bij het formuleren van de twee typen causaliteit centraal. In hoofdstuk 2 werd vastgesteld dat prosodie door sprekers actief wordt ingezet als specifieke lexicale markeringen, zoals

specifieke connectieven, voor de twee typen causaliteit achterwege blijven. De vervolgvraag is nu: Kan deze prosodische informatie luisteraars helpen bij de verwerking van subjectieve en objectieve causaliteit?

Om die vraag te beantwoorden hebben we een *forced-choice discourse completion task* ontworpen. In deze taak luisterden participanten naar zinsfragmenten, gevolgd door het connectief *so*, als in (5):

(5) Jim got his nose pierced. So...

Vervolgens dienden de deelnemers de tekst af te maken door een vervolg te kiezen uit twee opties die op een scherm verschenen. Elk fragment werd twee keer gepresenteerd aan de participanten; een keer met *so* in een "subjectieve prosodie" en de andere keer met een *so* uitgesproken in een "objectieve prosodie". Deze twee prosodische versies werden gecreëerd op basis van de onderzoeksresultaten uit Experiment 2 (hoofdstuk 2). De duur van het connectief *so* was in de subjectieve versie 50 milliseconden langer dan in de objectieve versie. Daarnaast was de f0-contour van het connectief in de subjectieve versie van *so* anders van vorm dan in de objectieve versie (minder lineair, meer parabolisch). De twee mogelijke continueringen die op het scherm verschenen, lieten beide toe om met die continuering een causale relatie te vormen met het stimulus-fragment. In de objectieve continuering werd een gebeurtenis genoemd die een feitelijk gevolg was van de oorzaak in de stimulus, bijvoorbeeld: *He bled a little* ("*Hij bloedde een beetje*"). In de subjectieve continuering werd een conclusie genoemd die kan volgen uit de waarneming in de stimulus, bijvoorbeeld: He wants attention ("*Hij wil aandacht*"). Als de prosodie van het connectief *so* inderdaad informatie geeft over het type causaliteit, dan zou dat luisteraars moeten helpen bij het voorspellen van het type causale relatie dat sprekers uiten. Preciezer gezegd: als het connectief *so* wordt uitgesproken met kenmerken van een "subjectieve prosodie", zoals een langere duur en een meer parabolisch f0-contour, en als luisteraars die prosodische verschillen gebruiken, dan zouden luisteraars onmiddellijk een verwachting vormen over een subjectief causale voortzetting. De hypothese was dan ook dat participanten vaker kiezen voor een subjectieve continuering nadat ze *so* in een subjectieve

prosodie-vorm hebben gehoord dan wanneer *so* werd uitgesproken in een objectieve prosodie.

Uit de resultaten bleek ten eerste dat participanten een basis-preferentie hebben voor objectieve continueringen. Daarnaast vonden we dat de prosodie van het connectief *so* inderdaad de continueringen beïnvloedde: met een subjectieve prosodie nam de kans op een subjectieve voortzetting toe. Dit suggereert dat de genoemde prosodische kenmerken inderdaad een subjectief-causale verwachting oproepen. Ten slotte toonden de resultaten nog een behoorlijke variatie tussen participanten in hun effecten van de prosodische verschillen. Ook bleek er behoorlijk veel variatie tussen de stimuli.

Het resultaat dat het aanbieden van *so* met subjectieve prosodie inderdaad leidt tot een grotere kans op subjectieve continuering heeft tenminste twee implicaties. Ten eerste suggereert het dat de subjectieve prosodie (met langere duur en meer parabolisch f0-contour) van *so* inderdaad het type causaliteit encodeert. Deze prosodie suggereert een grotere betrokkenheid van de spreker, wat aan de luisteraars duidelijk maakt dat de causale relatie tussen de voorafgaande en volgende fragmenten gebaseerd is op een cognitieve redenering van de spreker, in plaats van op een rapportage van een objectieve oorzaak-gevolg-relatie tussen feiten of gebeurtenissen in de werkelijkheid. Ten tweede leiden deze resultaten tot de conclusie dat moedertaalsprekers van het Engels prosodische kenmerken inderdaad gebruiken om causaliteit te interpreteren; op basis van de prosodie van *so* vormen zij verwachtingen over de nog volgende *discourse*.

Deze bevindingen stellen ons in staat om veel beter te begrijpen wat de functie is van de zogenaamde generieke causale connectieven zoals *so* bij het begrijpen van subjectieve versus objectieve causaliteit. De resultaten suggereren dat connectieven als *so* niet zozeer generieke causale connectieven zijn zoals eerder onderzoek wel suggereert. In gesproken communicatie zijn deze connectieven met hun bijbehorende prosodische kenmerken juist duidelijke markeringen van subjectieve versus objectieve causaliteit, die aan de luisteraars duidelijk een signaal geven over het type causale relatie dat zij kunnen verwachten: een bewering of conclusie van de spreker, of een feitelijk gevolg van een gebeurtenis waarover juist daarvoor

iets werd verteld.

Conclusie

Dit proefschrift levert een belangrijke bijdrage aan het onderzoek naar de vraag hoe subjectiviteit in taal wordt uitgedrukt. Op grond van nieuw experimenteel onderzoek verschaft het inzicht in de wijze waarop prosodie, een essentieel kenmerk van gesproken taal, een rol speelt bij de uitdrukking van subjectieve versus objectieve causaliteit. Bovendien verschaft het nieuwe inzichten in de wijze waarop prosodie luisteraars helpt bij het interpreteren van het type causaliteit dat de spreker uitdrukt. Op deze manier draagt dit onderzoek bij aan ons begrip van hoe diverse bronnen van talige communicatie, zoals lexicale en prosodische elementen, samenwerken bij het communiceren van subjectiviteit in causaliteit.

Curriculum Vitae

Na Hu was born in Taiyuan, China. She received her Master's degree in Linguistics from Graduate University of Chinese Academy of Sciences (Now University of Chinese Academy of Sciences) in 2012. After that, she worked as a linguistic specialist in the Text-To-Speech group at iFlytek (China). In 2017, she received a scholarship from China Scholarship Council to pursue her PhD at Utrecht University. This dissertation is the outcome of her PhD research.