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The effects of spatio-temporal metaphors on the conceptualization of duration: Evidence from Croatian-English bilinguals

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Abstract

The present study explored the conceptualization of duration within Croatian-English bilinguals. Two established psychophysical tasks of duration reproduction were implemented to this extent, namely, modified versions of Casasanto's (2005) *growing lines* and *filling containers task*. Participants were either tested with Croatian linguistic prompts or English linguistic prompts. The results showed that Croatian-English bilinguals tested with Croatian linguistic prompts were affected by spatial displacement in both conditions, and that the correlation of displacement and estimated duration was significant in both conditions. Spatial interference was somewhat greater in the filling containers condition, as reflected by the corpus query, which indicated that amount-based and distance-based spatio-temporal metaphors were employed somewhat equally, but that there was an overall prevalence of quantity-based metaphors. These results align with previous research, which showed that speakers of distance-based languages tended to display more spatial interference in the growing lines condition, whereas speakers of quantity-based languages tended to be affected by spatial interference to a greater extent in the filling containers condition (cf. Casasanto et al., 2004; Bylund and Athanasopoulos, 2017; Casasanto et al., 2026). Regarding the English language context, participants were affected by spatial displacement in both conditions, though to a greater extent in the filling containers condition. There were no great effects of English or individual bilingual background variables (i.e., age of acquisition of English, proficiency of English, and frequency of use of English) on the participants' performance, presumably since Croatian speakers already conceptualized duration both in terms of distance and quantity, and therefore did not need to shift their patterns of the conceptualization of duration to those of English speakers. Overall, the results align with the predictions of the linguistic relativity principle and The Conceptual Metaphor Theory, though further studies need to be conducted to address the limitations of the present study.

Keywords: Conceptual Metaphor Theory (CMT), the linguistic relativity principle, spatio-temporal metaphors, duration reproduction, growing lines experiment, filling containers experiment, distance-based languages, amount/quantity-based languages, Croatian, English

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Abbreviations

CMT – Conceptual Metaphor Theory
MSV – Metaphorical Structuring View
MS – Metaphoric Structuring
GSV – Generic Structuring View
ms – milliseconds
px – pixels

AoA – age of acquisition

L2 – second language

L3 – third language

L4 – fourth language

L5 – fifth language

RQ – research question

1 Introduction

If I were to talk to my friends in Lund about writing the present introduction, I would probably say something along the lines of ‘It took such a long time to write this introduction.’ If I were then to talk to my family and friends in Croatia, one of the most natural expressions that comes to mind is ‘Treballo mi je tako puno vremena da napišem ovaj uvod’ (‘I needed so much time to write this introduction’). While these two utterances generally have the same meaning, they differ in regard to the spatio-temporal metaphors used in either language, namely the uni-dimensional ‘long’ in English, and the multi-dimensional ‘puno’ (much) in Croatian. As a speaker of both languages, does this then mean that I somehow conceptualize the time it took to write this introduction differently depending on which language I am thinking in, due to the cross-linguistic differences in the spatio-temporal metaphors these languages employ?

A theoretical approach which offers insight into this question is The Conceptual Metaphor Theory (CMT henceforth), posed by Lakoff and Johnson (1980), where metaphor is defined as “seeing or understanding one thing in terms of another” (*ibid.*, p. 6). CMT proposes that metaphors are not only linguistic phenomena, but also cognitive phenomena, governing both language and thought. On a broader note, the question of whether language shapes thought, in linguistics often associated with Benjamin Lee Whorf, has been a topic of debate throughout millennia, with Greek philosophers such as Herodotos and Aristotle exhibiting opposing views (Bylund, 2019). The more modern view in favour of the idea that language shapes thought is Whorf’s linguistic relativity principle (1941/1956, as cited in Bylund, 2019), which presumes that the language one speaks does influence one’s perception of reality (Bylund, 2019). Newer research has developed from aiming to answer the binary question of whether language shapes thought or not, and has instead turned to exploring the specifics – which *specific* cognitive and perceptual properties are affected by which linguistic categories under which conditions (Bylund, 2019, p. 8). Such research has found that cross-linguistic differences have an effect on (among others) the domains of colour perception (e.g., Thierry et al., 2009; Simoncelli et al., 2025), object perception (e.g., Casaponsa et al., 2024), motion event construal (e.g., Athanasopoulos and Bylund, 2013) and importantly, for

the purposes of the present study, duration (e.g., Casasanto et al., 2004; Athanasopoulos and Bylund, 2023; Casasanto et al., 2026).

Lakoff and Johnson (1980) provided a plethora of ‘metaphorical concepts’ which they argued provide structure to people’s everyday lives, with a key metaphorical concept for the present research being ‘TIME IS SPACE’. The implications for this concept are twofold. First, the concept implies that the abstract, intangible domain of *time* is represented through the more concrete domain of *space*, i.e., that one’s mental representation of temporal concepts such as duration is based on spatial representations, which then presumes that the domains share relational structure. The second implication refers to the notion that cross-linguistic differences in spatio-temporal metaphors lead to differences in the conceptualization of such temporal concepts.

Boroditsky (2000) offered some of the first empirical evidence to this extent, indicating that the domains of space and time do share relational structure. Miles et al. (2011) found that cross-linguistic differences in Mandarin and English led to speakers of those languages conceptualizing/spatially representing past and future events differently. Núñez and Sweetser (2006) explored gesturing within speakers of Aymara (often Aymara-Spanish bilinguals), and found that older speakers with less Spanish experience were more likely to gesture behind themselves when talking about the future, and in front of themselves when talking about the past. Conversely, younger speakers of Aymara with more Spanish experience who exhibited the opposite gesturing patterns, due to the cross-linguistic differences in the metaphorical concepts these languages employ.

The focus of the present study is the influence of cross-linguistic differences on the conceptualization of duration, based on whether the languages in question tend to employ unidimensional (distance-based) or multidimensional (amount/quantity-based) metaphors. Casasanto et al. (2004), by employing two non-linguistic psychophysical tasks of duration, and displacement reproduction, namely, the *growing lines* and *filling containers* tasks, found that speakers of distance-based languages (English and Indonesian) were more likely to be affected by spatial displacement when estimating duration for the lines condition, while the opposite pattern was found for speakers of amount-based languages (Greek and Spanish). These results aligned with their predictions, reasoning that speakers would have an easier time distinguishing spatial and

temporal information in the condition not analogous to the type of spatio-temporal metaphors their language employs.

More research has begun exploring the effects of language on cognition within bilinguals, with Bylund and Athanasopoulos (2014) arguing that such development can be considered a natural extension of the linguistic relativity principle (*ibid.*, p. 431) and act as an ideal vessel for exploring whether aspects of cognition are dynamic and flexible (Athanasopoulos et al., 2010). Studies from Bylund and Athanasopoulos (2017) and Athanasopoulos and Bylund (2023) extended the findings of Casasanto et al. (2004) and provided important implications for the conceptualization of duration within bilinguals. Their evidence suggested that bilingual cognition (in regard to duration representation) is highly malleable, with variables such as age of acquisition and proficiency in a second language having the greatest effects on participants' performance in the 2023 study. Importantly, the results of Casasanto et al.'s (2026) study indicated that this aspect of cognition can also be malleable within monolinguals by training them to use spatio-temporal metaphors not preferred in their native language, suggesting that experience with specific types of spatio-temporal metaphors also influences the conceptualization of duration. However, further studies need to be conducted in the field to shed light on these nuances, and provide a broader insight into which bilingual variables have a causal role in duration representation.

The present study builds on previous research (Casasanto, 2005; Casasanto et al., 2004; Bylund and Athanasopoulos, 2017; Athanasopoulos and Bylund, 2023) and explores the conceptualization of duration in Croatian-English bilinguals. Croatian has previously been unexplored in this regard. The corpus query (based on Bylund and Athanasopoulos' (2017) methods) used to determine whether Croatian is a distance- or an amount-based language, indicates that Croatian might lie somewhere in between distance- and amount-based languages. Specifically, the results indicate that Croatian employs both types of metaphors somewhat equally, thus not presenting as clear-cut of a case as other languages so far researched. Therefore, the present study aims to shed light on the conceptualization of duration in speakers of a hitherto unexplored language, as well as add to the growing body of research investigating the effects of speaking a second language (bilingualism) on this aspect of cognition.

The procedure consisted of participants completing two established non-linguistic duration reproduction tasks, modified versions of Casasanto's (2005) *growing lines* and *filling containers* tasks. Two groups of Croatian-English bilinguals were tested, with varying the language context. The research questions addressed in the study are as follows:

- 1a. Were the participants' duration estimations influenced by spatial displacement?
- 1b. If so, was this influence more pronounced for the growing lines or the filling containers condition?
- 1c. Did these results differ based on the language context, and if so, how?

Based on the corpus query which indicated that Croatian may lie somewhere between distance- and amount-based languages, it is predicted that the group tested with Croatian linguistic prompts may exhibit similar performance across both tasks regarding displacement. Specifically, the participants might be somewhat equally affected by spatial displacement for both conditions, exhibiting a difference not as stark as found in previous studies (given that the difference in distance- and amount-based metaphors was not as stark as in previous studies). However, due to the prevalence of quantity-based spatio-temporal metaphors, the spatial interference might be somewhat greater in the filling containers condition. The third question regarding the effects of the language context is an exploratory question. If the results show that Croatian speakers were influenced by spatial displacement in both conditions, further indicating that Croatian speakers conceptualize duration both in terms of distance and quantity, there might not be a strong effect of language on the conceptualization of duration when shifting the language context to English, given that previous research which found strong effects of varying the language context (cf. Bylund and Athanasopoulos, 2017; Athanasopoulos and Bylund, 2023) dealt with languages that had strongly preferred one type of metaphor over the other. The second research question (divided into three sub-questions) focuses on the effects of bilingualism on the conceptualization of duration. The research questions are as follows:

- 2a. Did individual bilingual background variables affect the participants' performance?
- 2b. If so, which bilingual background variable(s) (age of acquisition, frequency of use, and proficiency of English) affected the participants' performance?
- 2c. Did these results differ with respect to the language context, and if so, how?

Previous research (cf. Athanasopoulos and Bylund, 2023) found that individual bilingual background variables such as age of acquisition and proficiency of Swedish (distance-based language) affected participants' spatial interference, such as the higher their self-estimated Swedish proficiency was, the more likely they were to be affected by spatial displacement in the line condition, and similarly, the later they had acquired Swedish (higher AoA), the more likely they were to be affected by spatial displacement in the containers condition. However, since Croatian speakers might conceptualize duration both in terms of distance and quantity, there are no current predictions regarding whether individual bilingual background variables will have an effect on the participants' conceptualization of duration, and if so, which ones.

The remainder of the thesis is structured as follows: Chapter 2 further discussed theories mentioned in Chapter 1, i.e., it covers relevant empirical research for the present study, and concludes by describing the methods used to determine whether Croatian is a distance- or amount-based language (including the results and a brief discussion of the results). Chapter 3 covers the methodology used to address the research questions. Chapter 4 provides the results of the experiments discussed in Chapter 3. Lastly, Chapter 5 provides an in-depth discussion of the results provided in Chapter 4, and covers the contributions and limitations of the present study, as well as implications for future research.

2 Background

The Background begins by introducing i) the Conceptual Metaphor Theory (CMT), the theoretical framework in which research exploring the effects of spatio-temporal metaphors on the conceptualization of time is rooted in, ii) the metaphorical concept which guides this research, ‘TIME IS SPACE’, and iii) the linguistic relativity principle (2.1). The chapter then includes a detailed overview of relevant empirical research, namely, general, broader, research within language and cognition (in regard to the conceptualization of time), previous research investigating cross-linguistic differences in the spatio-temporal metaphors (distance and amount-based) on the conceptualization of duration within mono- and bilinguals, and the central ideas from these bodies of research which guide the present study (2.2). The chapter concludes by discussing the methods used for determining whether Croatian is a distance- or amount-based language, followed by the results, and brief discussion of the results (2.3).

2.1 Conceptual Metaphor Theory, the metaphorical concept ‘TIME IS SPACE’, and the principle of linguistic relativity

Much of linguistic research focusing on the interplay between language and cognition is rooted in Conceptual Metaphor Theory, regarded as a ‘standard’ view of metaphor in cognitive semantics (Geeraerts, 2009), and posed by Lakoff and Johnson in their 1980 work *Metaphors We Live By*:

“We have found [...] that metaphor is pervasive in everyday life, not just in language but in thought and action. Our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature.”

(Lakoff and Johnson, 1980, p. 4).

Lakoff and Johnson (1980) argue that people’s conceptual systems govern their everyday lives, structuring their perception, how they get around the world, and the way they relate to others (*ibid.*,

p. 4). Some of the metaphorical concepts they proposed include ‘ARGUMENT IS WAR’ and ‘TIME IS MONEY’, illustrated in examples (1) and (2), respectively:

(1) He *attacked every weak point* in my argument. His criticisms were *right on target*.

You disagree? Okay, *shoot!*

(2) You're *wasting* my time.

This gadget will *save you* hours.

(Lakoff and Johnson, 1980, pp. 5; 8)

Lakoff and Johnson define metaphor as “understanding and experiencing one thing in terms of another” (*ibid.*, p. 6). As illustrated in example (1), they write that arguments are partially understood, talked about, and structured in terms of war, and because arguments are “conceived as wars”, humans talk about them as such and act according to their conceptual system (*ibid.*, p. 6). Following similar logic, they explain that time is viewed through the prism of money because it is considered, much like money, a valuable and limited resource, and is, in Western cultures, quantified and directly associated with work, which inherently implies compensation (*ibid.*, p. 9).

2.1.1 The three pillars of CMT

In order to expand on these examples and situate CMT within the area of language and cognition, more specifically, research exploring the interplay between spatio-temporal metaphors and their influence on cognition, it is important to elucidate the three pillars which CMT rests on (Geeraerts, 2009).

The first pillar implies, as mentioned previously, that metaphors are both lexical and cognitive phenomena, rather than a purely lexical phenomenon, shaping both the way people speak and think, as illustrated in the examples (1) and (2) (Geeraerts, 2009). Metaphoric images can also be used creatively, Geeraerts (2009) illustrates this notion through the metaphorical concept ‘ARGUMENT IS A JOURNEY’ (e.g., ‘We will proceed in a *step-by-step* fashion’), arguing that the knowledge of that metaphorical concept can be combined with the knowledge that journeys are defined by paths, resulting in arguments being defined by paths (e.g., ‘Do you *follow* my

argument?') (*ibid.*, p. 206). Metaphors can also occur outside of, i.e., transcend, language, exemplified via the simple 'thumbs up', and 'thumbs down' gestures, wherein the metaphorical concepts at hand are 'GOOD IS UP', and 'BAD IS DOWN' (e.g., Things are looking *up*; It's been *downhill* ever since) (Geeraerts, 2009; Lakoff and Johnson, 1980, p. 17).

The second pillar is the analysis of the mappings inherent in metaphorical concepts, i.e., metaphors conceptualize a target domain through a source domain (Geeraerts, 2009, p. 206). Note that CMT distinguishes between simple and complex metaphors (among other distinctions), illustrated in Geeraerts (2009) via Reddy's CONDUIT METAPHOR of communicative behaviour:

(3) It is hard to *get that* idea *across* to him. I *gave you* that idea. It is difficult *to put* my ideas *into* words.

(Reddy, 1979, as cited in Geeraerts, 2009, p. 206).

This complex metaphorical concept combines three simple ones, namely, *ideas are objects*, *expressions are containers*, and *communication is sending* (Geeraerts, 2009, p. 206). Another distinction Lakoff and Johnson (1980) make is that of structural, ontological, and orientational metaphors.

Structural metaphors enable one to use a 'highly structured and clearly delineated concept to structure another', as well as orient, refer to and quantify concepts (Lakoff and Johnson, 1980, p. 62). An example of such metaphor is the expanded 'ARGUMENT IS WAR' (see example (1)) – 'RATIONAL ARGUMENT IS WAR'. Lakoff and Johnson (1980) argue that this metaphor enables one to experience a rational argument through the familiar concept of physical conflict. They argue that humans, as 'rational animals' have evolved to the institution of verbal argument in order to gain what they want without subjecting themselves to physical harm, but highlight that the terms used to comprehend such 'rational' arguments are the same ones employed in physical conflict. Ontological metaphors include metaphors in which objects are specified as being persons, i.e., something non-human is understood and talked about through the lens of being a human (e.g., '*The fact argues* against the standard theories'; '*His theory explained* to me...') (Lakoff and Johnson, 1980, p. 34). Lastly, orientational metaphors, which include the previously mentioned

‘GOOD IS UP’ and ‘BAD IS DOWN’, apply “a spatial or sensorimotor image schema (like vertical direction) onto an abstract domain” (Geeraerts, 2009, p. 207), which [abstract domain] is the moral concept of ‘good’ or ‘bad’ in this case.

The third pillar of CMT posits that metaphors are grounded in experience, and that language is shaped by human experience (Geeraerts, 2009, p. 207). Lakoff and Johnson (1980) recognize directionality in metaphors; they [metaphors] help people understand one concept in terms of another, and tend to be structured so that vague, less concrete concepts are comprehended through use of more concrete concepts (*ibid.*, p. 112), as illustrated in previously mentioned metaphorical concepts ‘GOOD IS UP’ and ‘BAD IS DOWN’.

2.1.2 The metaphorical concept ‘TIME IS SPACE’

Lakoff and Johnson (1980) introduced the core metaphorical concept which is central to this research: TIME IS SPACE. Consider the following examples:

- | | |
|--|---------------------------------|
| (4) The concert was <i>pushed back</i> . | The wheel was <i>pushed</i> . |
| (5) The rehearsal was too <i>short</i> . | The rope was too <i>short</i> . |
- (Athanasopoulos et al. 2017, pp. 2-3)

Athanasopoulos et al. (2017) used these examples to illustrate that “events with temporal reference are encoded in the same way as spatial events, thus showing that basic time concepts such as succession and duration are expressed through spatial terms” (*ibid.*, p. 3).

Tying the metaphorical concept of ‘TIME IS SPACE’ back to the three pillars of CMT, the concept illustrates that the vague, abstract concept of *time* is comprehended through the more concrete concept of *space*, because the spatial can be perceived, while the temporal can only be imagined (Ornstein, 1969, as cited in Casasanto and Boroditsky, 2008). *Time* is then the target domain conceptualized through the source domain of *space*. Certainly, the first pillar of CMT, which implies that metaphors are lexical and cognitive phenomena, influencing not only the way one speaks, but also the way one thinks (Geeraerts, 2009), is central for the present research.

Languages differ with regard to what kind of spatio-temporal metaphors they employ to talk about temporal events such as succession and duration – whereas English speakers tend to use unidimensional spatial terms (e.g., ‘long’ and ‘short’), Greek speakers often employ multidimensional spatial terms (e.g., ‘big’ (megalos) [μεγάλος] and ‘small’ (mikros) [μικρός]) (Casasanto et al., 2026). These cross-linguistic differences and their implication on cognition (specifically the conceptualization of time) have been attested and investigated across several different languages through empirical research, discussed in detail in subsection 2.2.1.

2.1.3 The linguistic relativity principle and implications for bilingualism

The first pillar of CMT inherently rests on the linguistic relativity principle, posed by Benjamin Lee Whorf, which posits the following:

“...the linguistic relativity principle [...] means [...] that users of markedly different grammars are pointed by their grammars toward different types of observations and different evaluations of externally similar acts of observation, and hence are not equivalent as observers but must arrive at somewhat different views of the world.”

(Whorf 1941/1956, as cited in Bylund, 2019)

In essence, the linguistic relativity principle encapsulates the notion that the language one speaks influences their perception of reality (cf. Bylund, 2019; Casasanto, 2008). While it [the linguistic relativity principle] has long sparked extensive debate and research across disciplines like linguistics, philosophy, psychology, and anthropology (Boroditsky, 2001; Bylund and Athanasopoulos, 2014), the question of whether language influences thought has been a topic of Western philosophy for millenaries (Bylund, 2019); the Greek historian and philosopher Herodotos (444 BC) asserted that the conflicts between Greeks and Egyptians lay in the opposite directionalities of the two cultures’ orthographies, making their thought patterns incompatible (Bylund, 2019). Aristotle on the other hand viewed language only as an instrument via which reality is discussed, with reality being unaffected by linguistic categories (Allen, 2004, as cited in Bylund, 2019). Modern research has since adopted a more nuanced approach than attempting to answer the “binary” question of whether language shapes thought or not, as it is more productive

to “investigate which cognitive and perceptual processes are affected by which linguistic categories under which conditions” (Bylund 2019, p. 8). Indeed, a growing body of evidence suggest that one’s native language influences certain aspects of cognition across various domains, including (but not limited to) colour perception (e.g., Thierry et al., 2009; Simoncelli et al., 2025), object perception (e.g., Casaponsa et al., 2024), and motion event construal (e.g., Athanasopoulos and Bylund, 2013). To illustrate with an example from the domain of temporal duration, Bylund and Athanasopoulos (2017) found that language affects duration estimation only when verbal prompts were present in the task, but not when the task had non-verbal prompts.

The principal tenet of linguistic relativity is then the notion that crosslinguistic differences in language lead to crosslinguistic differences in cognition (Levinson, 2012, as cited in Bylund and Athanasopoulos, 2014). Athanasopoulos et al. (2017) thus argue that i) testing the psychological reality of spatio-temporal metaphors is essential for probing the boundaries of CMT and has significant implications for the study of linguistic relativity, and ii) that if spatio-temporal metaphors influence one’s construal of time, then speakers whose languages employ different spatio-temporal metaphors should conceptualize time differently (*ibid.*, p. 3).

Research investigating this phenomenon is described in detail in subsection 2.2.1. Furthermore, research on bilinguals’ differences in cognition is essential, and serves as a “natural extension of the linguistic relativity principle” (Bylund and Athanasopoulos, 2014, p. 431). Athanasopoulos et al. (2010) claim that testing bilinguals is ideal for exploring whether cognitive representation is fixed and static or dynamic and flexible. De Groot (2026) argues that bilingualism “has the potential to critically inform the linguistic relativity debate” (p. 5). De Groot reasons, citing Pavlenko, that “bilinguals are the only ones to experience directly the effects of linguistic relativity” (Pavlenko, 2005, as cited in De Groot, 2026, p. 5). Simoncelli et al. (2025) compared differences in perception and categorization of the blue spectrum among groups of French and Italian mono- and bilinguals. While French only has one term for blue hues, *bleu*, Italian employs two terms - *blu* for darker blue hues, and *azzurro* for lighter blue hues. The researchers found that the colour perception in the monolingual groups was influenced by their native language. Interestingly, the results showed that the French-Italian bilingual group behaved like the Italian monolingual group, indicating that their L1 categories were influenced by their L2 categories.

Research discussed in Chapters 2.2.1 and 2.2.2 further presents empirical evidence in favor of the flexible and dynamic cognitive representations within monolinguals and bilinguals.

2.2 Relevant empirical research

This chapter is divided into three subsections which provide an overview of i) relevant empirical research regarding the relational structure of *time* and *space*, theories on metaphoric structuring, as well as the effects of cross-linguistic differences in temporal cognition (general), ii) the effects of cross-linguistic differences on the conceptualization of duration, and iii) the central ideas from these bodies of research.

2.2.1 General research investigating effects of language on the conceptualization of time, evidence in support of CMT

Boroditsky (2000) presented some of the first empirical evidence for metaphoric structuring, investigating whether the abstract domain of *time* gets its structure from the concrete domain of *space*. Building on CMT, she aimed to develop what she termed The Metaphorical Structuring View (henceforth MSV), which proposes that the aspects of time which are specified through spatial metaphors will be shaped by the metaphors (*ibid.*, p. 4). Boroditsky separated two versions of this view – *the weak view*, which implies that spatial metaphors do play a role in structuring the domain of time, but may not need to be accessed when thinking about time after frequent use (because an independent representation is established), and *the strong view*, which presumes that spatial schemas are always necessary when thinking about time (*ibid.* p. 4).

To investigate these two views of the MSV, Boroditsky conducted three experiments designed to explore whether the domains of time and space were conceptually related, whether spatial schemas can be used to understand time, and whether spatial schemas were necessary to understand time. The research focused on the event sequencing of conceptual time, i.e., “the way events are temporally ordered with respect to each other and to the speaker” (*ibid.*, p. 5), distinguishing between ego-moving (e.g., “We are coming up on the thesis viva”) and time-moving metaphors

(e.g., “The thesis viva is coming up”), arguing that the two metaphors lead to different assignments of front and back to a time line (*ibid.*, p. 5). In the former metaphor, front is assigned to a future or later event, whereas in the latter metaphor, front is assigned to a past or earlier event (*ibid.* p. 6).

In the first experiment, participants were given questionnaires which consisted of priming questions (TRUE/FALSE), i.e., spatial scenarios consisting of a sentence description and picture, after which they read an ambiguous temporal sentence (e.g., “Wednesday’s meeting has been moved forward two days”) and had to answer if the meeting had been moved to Monday or Friday. Participants were either primed with ego-moving or time-moving frames of reference. 71.3% participants responded according to the prime. Based on these results, Boroditsky concluded that the domains of space and time are similar in conceptual structure, and not just in language (*ibid.*, p. 10). Athanasopoulos et al. (2017) argued that due to the primes being both linguistic and pictorial, it is unclear whether the results were influenced by linguistic priming, the visual representation, or both.

In the second experiment Boroditsky investigated whether spatial schemas were necessarily accessed to think about time. Participants answered ambiguous target questions about spatial and temporal scenarios, after being primed with either ego-moving or object/time moving schemas. Target questions about time were primed with spatial schemas, and target questions about space were primed with time schemas. Two control groups were primed either with spatial primes preceding spatial target questions, or temporal primes preceding temporal target questions. Spatial primes were represented both visually and verbally, while temporal primes were only represented verbally (e.g., days of the week). The results showed that participants were influenced by spatial primes when thinking about time (63.9% consistent), but were not influenced by temporal primes when thinking about space (47.2% consistent). Boroditsky (2000) thus concluded that these results were aligned with the weak view of MS (Metaphoric Structuring), i.e., that while spatial schemas can be used to think about time, they were unnecessary to do so (*ibid.* p. 14) (because participants were not influenced by temporal primes when thinking about space). Athanasopoulos et al. (2017) argued that this effect may have been found due to an abstract domain like time being more

susceptible to priming from the more concrete domain of space (which can be represented verbally and visually, unlike time) than vice versa.

In Experiment 3, Boroditsky sought to corroborate the results of Experiment 2, arguing that there should be greater effects of consistency when the transfer is from space to time than from time to space. The experiment was designed to test on-line processing, and to determine whether MS or what she termed the Generic Schema View (GSV henceforth) could provide a better description of the data (*ibid.*, p. 17). The GSV presumes that that space and time both use a set of generic, underlying, domain-independent (neither spatial nor temporal) schemas that can be used to mentally organize objects in space and events in time (*ibid.*, p. 16). The experiment measured response times to consistently and inconsistently primed questions regarding spatial and temporal relations. The target questions were preceded by two prime questions that either used the same relational schema (consistent) as the target question, or a different relational schema (inconsistent). Spatial primes preceded spatial or temporal targets on half of the trials, and temporal primes preceded spatial or temporal targets on half of the trials. The results indicated that participants were again influenced by spatial primes when thinking about time, but not influenced by temporal primes when thinking about space, which is aligned with the weak version of MS, and contradicts the predictions of the GSV. Overall, Boroditsky concluded that the domains of space and time share relational structure, and that both spatial and temporal schemas can be used to think about time, but that access to spatial schemas is not required to think about time (*ibid.*, p. 23).

Murphy (1996) proposed another hypothesis aimed at refuting MS, the Structural Similarity View, which implies that there is no strong metaphoric representation, that is, all concepts are directly presented (with their own structure), and metaphors arise out of the similarity of pre-existing conceptual structures (*ibid.*, p. 179). According to this hypothesis, domains such as ‘love’ and ‘journey’, in the conceptual metaphor ‘LOVE IS A JOURNEY’, are separately represented and ‘journey’ did not influence the structure of ‘love’. Extending this notion to the domains of ‘space’ and ‘time’, Murphy’s hypothesis implies that the domains are separately presented, and one (*space*) does not influence the other (*time*). Boroditsky (2000) then argued that this view presumes that even if there are cross-linguistic differences in metaphors used to describe abstract domains such as time, speakers of these languages should not differ in their conceptualization of these

domains, and empirical evidence tends to suggest otherwise, as evident in research discussed further in the present chapter (for a detailed overview of CMT, including criticisms and evidence in favour of CMT, see Gibbs, 2011).

Boroditsky (2001) explored whether cross-linguistic differences in spatio-temporal metaphors employed in English and Mandarin Chinese lead to different conceptualizations of time in speakers of those languages. While English employs horizontal metaphors, i.e., front and back terms to talk about time (e.g., “The meeting has been moved forward”, “The worst is behind us”), Mandarin employs an additional vertical dimension as well (via the spatial morphemes *sha`ng* (“up”) and *xi`a* (“down”); *ibid.*, p. 5). Boroditsky conducted three experiments to this end.

Experiment 1 investigated whether using spatial metaphors to talk about time had immediate and long-term implications for online processing. Mandarin and English speakers answered spatial priming questions followed by target questions about time, wherein the spatial primes were either horizontal or vertical spatial relations between two objects. Half of the target questions used horizontal spatio-temporal metaphors (designed to investigate the immediate effects), and half used purely temporal terms ‘earlier’ and ‘later’ (designed to investigate long-term effects). Boroditsky predicted that i) if horizontal spatio-temporal metaphors are processed by horizontal spatial knowledge, one should be faster to understand such a metaphor if they had just been primed with a horizontal spatio-temporal metaphor, and ii) if one’s native language has long-term effects on how speakers think about time, than English speakers should be faster after using horizontal primes, whereas Mandarin speakers should be faster when using vertical primes. The results aligned with her predictions, indicating that cross-linguistic differences in spatio-temporal metaphors do lead to cross-linguistic differences in cognition. Interestingly, both the English and Mandarin speakers completed the experiment in English, and Mandarin speakers showed vertical bias “even when thinking for English”, which Boroditsky suggest might be due to the ability of language-encouraged habits in thought to operate regardless of the language one is currently thinking for (*ibid.* p. 12). However, since no bilingual background variables were analysed (the participants’ mean age of acquisition of English was 12.8 years), it is unclear whether there were in-group differences regarding age of acquisition (AoA), proficiency, use of English, etc, which could shed light on these results and corroborate Boroditsky’s explanation.

Therefore, Boroditsky conducted the second experiment, focusing on Mandarin-English bilinguals with a lower AoA of English, with Boroditsky predicting that participants who had acquired English earlier in life/had more experience in English should show less of a vertical-bias when thinking about time. The experiment design was nearly identical to that implemented in Experiment 1, with the exception of all the targets being purely ‘temporal’ metaphors (earlier/later statements). As expected, vertical-bias was more prevalent in speakers who had started learning English later in life. However, vertical-bias was not correlated to length of exposure of English. Boroditsky suggested that these results could have occurred due to difference in orthographies – English is written and read from left to right (horizontally), while Mandarin is traditionally written in vertical columns read from right to left.

In Experiment 3, native English speakers learned to use vertical spatial terms (‘above’, ‘below’, ‘higher than’/‘lower than’) to talk about time. After the training, the participants completed the same experiment implemented in Experiment 1. Boroditsky argued that if language was the culprit behind the results from Experiment 2, and not cultural factors, English speaker should behave more like Mandarin speakers after the training. The only difference between the trained English group and the Mandarin group (Experiment 1) was that English speakers answered targets faster. Boroditsky thus concluded that differences in talking lead to differences in thinking even in the absence of other cultural differences such as writing direction (*ibid.* p. 18).

Further research has explored succession, specifically whether linguistic space-time mappings impact one’s mental representation of temporal succession. Miles et al. (2011) explored whether Mandarin-English bilinguals possessed two ‘time lines’, one arranged horizontally, and another vertically. They conducted two experiments. In the first experiment, English monolinguals and Mandarin-English bilinguals were asked to categorize stimuli (pictures of buildings and cities) representing the past or future according to a spatial location. They found that Mandarin-English bilinguals were faster at categorizing stimuli regardless of whether they did so on a horizontal or vertical axis, whereas English monolinguals only showed this effect when organizing the stimuli horizontally, indicating that Mandarin-English bilinguals did possess two time lines. In the second experiment, the authors explored whether socio-linguistic context would shape the bilinguals’ performance. They provided three sets of pictures of a popular Chinese actor (Jet Li), and a popular

USA actor (Brad Pitt), depicting each of these actors at three different ages, and asked participants to arrange the pictures representing the past or the future. They found that the bilinguals had a higher tendency to arrange the stimuli along the vertical axis in the case of Jet Li, with the opposite effect found for Brad Pitt. They concluded that these results do not only indicate that Mandarin-English bilinguals indeed had two time lines (whereas English monolinguals only displayed the horizontal time line), but also that sociolinguistic context can shape the manner in which bilinguals think about world.

Núñez and Sweetser (2006) explored the spatial construal of time within speakers of Aymara, a language which opposes the space-mapping norms that the future is metaphorically conceptualized in front of and the past as behind. They found that when older Aymara speakers (with less exposure to Spanish) spoke about time, they gestured behind themselves when talking about the future, and in front of themselves when talking about the past. A converse pattern was found for younger Aymara speakers with more exposure to Spanish. Essentially, whereas most languages adopt the metaphorical concepts ‘KNOWN IS BEHIND EGO’, and ‘UNKNOWN IS IN FRONT OF EGO’, Aymara speakers adopt the opposite concepts – ‘UNKNOWN IS BEHIND EGO’, and ‘KNOWN IS IN FRONT OF EGO’. This research provides further evidence that the conceptualization of time is language-dependent.

2.2.2 Research investigating the effects of cross-linguistic differences regarding distance- and amount-based spatio-temporal metaphors on the conceptualization of duration

As mentioned previously in Chapter 2.1.1, languages differ with regard to what kind of spatio-temporal metaphors they tend to employ to discuss temporal concepts like duration and succession. Among these differences, the distinction between distance- and amount-based metaphors, later also referred to as ‘time as distance’ and ‘time as quantity’ metaphors, is essential for the present research. Based on whether languages tend to utilize unidimensional terms, i.e., distance-based metaphors (e.g., ‘long’ and ‘short’) or multidimensional terms, i.e., amount/quantity-based metaphors (e.g., ‘small’ and ‘big’), they can be grouped into distance- or amount-based languages.

To illustrate, Greek and English both use spatial terms like ‘long’ (makris) [μακρύς] and ‘short’ (kontos) [κοντός] in the same way for spatial contexts (e.g., ‘long rope’, ‘ena makry skoini’ [ένα μακρύ σκοινί]) (Casasanto et al., 2026). In English, these spatial terms are also used for temporal contexts (e.g., ‘long meeting’), and far more prevalently so than possible multidimensional counterparts. Greek on the other hand tends to reserve these terms for spatial contexts, and employs multi-dimensional metaphors for temporal contexts (e.g., the spatial term ‘big’ in the phrase ‘a big night’ in Greek, ‘(mia megali nychta) [μία μεγάλη νύχτα]’, would signify the night’s duration, and not its importance, like in English) (Casasanto et al., 2026, p. 2). While languages usually employ both distance- and amount-based spatio-temporal metaphors, a significant discrepancy in preference of one type of metaphor over the other has so far been attested in every language researched.

Casasanto et al. (2004) aimed to find out whether these cross linguistic differences, i.e., a preference and prevalence of one type of metaphor (‘time as distance’ or ‘time as quantity’) in a language, would influence the speakers’ duration estimations, thus shaping their non-linguistic, low-level, non-symbolic representations, by adapting a task designed by Casasanto and Boroditsky (2003). They tested native speakers of English, Indonesian, Greek, and Spanish, classifying the two former languages as distance-based, and the two latter languages as quantity-based languages. This assessment was conducted via a corpus query; the researchers entered the most natural phrases (elicited from native speakers of the four languages) expressing the ideas ‘long time’ and ‘much time’ in Google and compared their distributive frequencies.

All participants completed the same pair of non-linguistic psycho-physical tasks (the growing lines and filling containers tasks) in which they had to estimate duration while overcoming spatial interference. That is, participants viewed growing lines/containers being filled (one at a time), and had to estimate either the duration or displacement (line length/volume (fill) level) of each growing line/filling container. Only the duration estimation data was analysed. The researchers predicted that speakers of distance-based languages would be more affected by spatial displacement for the growing lines task than the filling containers task. Conversely, they predicted that the speakers of quantity-based languages would be more affected by spatial displacement when completing the filling containers task. They justified their hypotheses by reasoning that speakers of languages that

do not ordinarily express duration in terms of distance would have an easier time distinguishing the spatial and temporal information conveyed in the growing line stimuli (*ibid.*, p. 189).

The researchers found (confirming their hypotheses) that English and Indonesian participants showed a strong effect of distance (displacement) on time estimation in the growing lines task, while Greek and Spanish speakers showed weak, non-significant effects of distance on time estimation. The opposite pattern was found for the filling containers task, i.e. English and Indonesian speakers were not affected by spatial displacement when estimating the duration of the filling containers, contrasted with Greek and Spanish speakers who showed strong effects of spatial displacement (volume) on time estimation. These results indicate that one's language does influence their non-linguistic, low-level, non-symbolic temporal representations, i.e., the spatio-temporal metaphors employed in a language influence one's conceptualization of duration.

Similarly, Bylund and Athanasopoulos (2017) tested cross-linguistic differences and their effects on duration estimation (adopting Casasanto's (2005) growing lines and filling containers tasks) across monolingual Swedish (distance-based language) and Spanish (quantity-based language) speakers, as well as Swedish-Spanish bilinguals. Half of the participants completed the lines and half the containers condition. For the monolingual groups, Bylund and Athanasopoulos (2017) conducted two experiments, one with the presence of linguistic cues, and one without the presence of linguistic cues.

The linguistic cues for duration reproduction consisted of an hourglass symbol and a verbal label, i.e., the terms for 'duration' in Spanish and Swedish ('duración' and 'tid', respectively), and preceded each trial (a growing line/filling container) shown on screen. With the presence of linguistic cues (verbal prompts), the researchers found that Spanish speakers showed more interference than Swedish speakers for the filling containers condition (only for the medium stimuli¹), whereas Swedish speakers showed more interference than Spanish speakers for the lines

¹ The medium stimuli included the five intermediate duration (2000, 2500, 3000, 3500, and 4000 ms) and displacement (200, 250, 300, 350, and 400 px) values, whereas the durations and displacement ranged from 1000-5000 ms and 100-500 px, in 500 ms and 50 px increments, respectively.

condition (only for the medium stimuli), as predicted in the study, and aligned with the linguistic relativity principle.

Interestingly, the researchers found no interaction between language and stimulus type in the absence of linguistic cues. Based on the latter results, Bylund and Athanasopoulos hypothesized that human temporal cognition may flexibly adapt to environmental constraints such as the presence or absence of verbal cues (*ibid.*, p. 914), and conducted Experiment 3 to test this hypothesis. The materials and procedure were identical to those implemented in Experiment 1 (with the absence of the distractor task, i.e., displacement estimation). Swedish-Spanish bilinguals completed either the growing lines or the filling containers condition twice, with a varying language context of the linguistic cues. The researchers found that the bilinguals' performance was correlated with the language context, i.e., there was a significant interaction between language context and stimulus types for both conditions (only for medium stimuli), making these results the first evidence of shifting duration representation within the same bilingual, depending on the language context (*ibid.*, p. 914). Based on these results, the researchers concluded that human temporal cognition is malleable, a part of a highly adaptive computational system wherein language flexibly functions as a source of information for duration estimation (*ibid.*, p. 912).

Building on this research, Athanasopoulos and Bylund (2023) explored how an acquisition of a new language influences time perceptions, specifically, to which extent native Spanish speakers with L2 Swedish resembled native speakers of either language (the Swedish and Spanish monolinguals analysed in Bylund and Athanasopoulos (2017) were used as control groups), using Casasanto's (2005) growing lines and filling containers tasks.

The researchers focused on the effects of the following bilingual variables: L2 AoA, L2 proficiency, L2 frequency of use (Swedish) and length of residence in the L2 country (Sweden). For the lines condition, the researchers found that Spanish-Swedish bilinguals did not differ from Swedish monolinguals, and differed scantily from Spanish monolinguals. Importantly, the researchers found that L2 proficiency significantly affected the results, i.e., the higher the Swedish proficiency, the more the bilinguals were affected by the line displacement, while length of residency in the L2 country and frequency of L2 use did not significantly affect the

results/improved the model fit². As for the containers condition, the bilingual group's results differed significantly compared to both the Swedish and Spanish monolinguals. Age of L2 acquisition had the greatest influence on the results (yielded the most significant model) of all other bilingual variables, i.e., the bilinguals with a later L2 AoA were more likely to exhibit greater spatial interference in their duration estimations. These findings contribute to the research exploring cognition within bilinguals, and indicate that spatio-temporal metaphors influence individuals' temporal construal. The researchers shed light on these findings via *the framework of distributed cognition*, which "assumes a distributed representational system that places the interaction between internal mental computations and their embedding in external environmental features at its core" (*ibid.*, p. 816), arguing that the findings indicate that the interactions between external stimulus (growing lines/filling containers) and internal mental computation (estimating duration) are highly malleable, revealed in the changing cognitive patterns of the bilingual individuals (*ibid.*, p. 816).

Casasanto et al. (2026) expanded on Casasanto et al.'s (2004) work, exploring the effects of cross-linguistic differences on the conceptualization of duration in Greek and English speakers. This time, the researchers conducted a more thorough investigation to determine whether these languages were indeed amount- (Greek) and distance-based (English) languages, by implementing an experiment in which native speakers heard two pairs of stimuli (tones and dots) of varying durations and were asked to describe the difference in duration between the members of the two pairs.

Overall, the results confirmed that Greek speakers used amount-based metaphors more frequently than distance-based metaphors, with the opposite pattern found for English speakers. In Experiment 2, the participants completed either the aforementioned growing lines or filling containers task, without the presence of verbal (linguistic) prompts preceding the trials. Instead, an 'X' symbol appeared indicating that the participants were to estimate displacement, and an

² The researchers ran linear mixed effects models; they tested for inclusion of predictors (L2 proficiency/AoA/frequency of use, and length of residence in the L2 country) to see which would improve the model significantly. See Athanasopoulos and Bylund (2023) for a detailed description of the data analysis.

hourglass symbol appeared to indicate duration estimation. Greek speakers were more affected by spatial displacement when estimating the duration for the filling containers task, whereas English speakers were more affected by spatial displacement when estimating the durations of growing lines, in accordance with previous research³. The authors hypothesised that these results might be caused by differences in the spatial orientation of the stimuli (horizontal (lines) vs. vertical (containers)). To test this, they implemented a control experiment in which Greek and English participants estimated the durations of vertical lines. The results showed no significant difference in the cross-domain effects of displacement on duration estimation between groups and no significant group by task interaction.

They conducted a third experiment to rule out the possibility that participants were labelling stimuli covertly even without the presence of linguistic cues. The participants (only English speakers) viewed a string of letters before each trial and were asked to repeat that string aloud while viewing the stimuli and estimating duration. The results did not differ from those of English speakers in Experiment 2, effectively ruling out the possibility that participants were labelling stimuli covertly. Lastly, the researchers conducted a fourth experiment designed to test whether linguistic metaphors determined what kind of non-linguistic spatial schemas people activate when estimating duration. To this end, they trained English speakers to use either distance-based or amount-based metaphors to describe relations between objects and events. They then tested the two groups using the same filling containers task implemented in Experiment 2. The results showed that amount-trained English speakers behaved more like native Greek speakers than like native speakers of English, with the authors concluding that language (linguistic experience) has a causal role in shaping time representations. Additionally, these results add to the so-far growing body of evidence that human temporal cognition is highly malleable.

³ In accordance with previous research regarding the findings that spatio-temporal metaphors employed in a language influence the conceptualization of duration. This evidence does not align with the study conducted by Bylund and Athanasopoulos (2017), as they had not found this effect without the presence of linguistic prompts.

2.2.3 Key takeaways

Based on the literature overview, several key takeaways, central ideas, which guide this research, can be distinguished:

- a. the domains of ‘time’ and ‘space’ share relational structure
- b. cross-linguistic differences in spatio-temporal metaphors result in differences in cognition
- c. these differences may be present even in the absence of other, cultural differences
- d. (bilingual) cognition is highly malleable

Some theories, such as the Structural Similarity View (Murphy, 1996) propose that there is no strong metaphoric representation, with each concept having its own structure which does not influence the structure of another. Despite this, empirical evidence suggests that the domains of *time* and *space* share relational structure (Boroditsky, 2000). This is further supported by a growing body of evidence which indicates that cross-linguistic differences in spatio-temporal metaphors lead to differences in cognition regarding the conceptualization of time. Specifically, they lead to differences in spatial representations of the past and the future (Miles et al., 2011), gesturing differences in representations of the past and the future (Núñez and Sweetser, 2006), and duration representation differences (Casasanto et al., 2004; Bylund and Athanasopoulos, 2017; Athanasopoulos and Bylund, 2023; Casasanto et al., 2026). Some evidence suggests that such differences are present even in the absence of cultural differences (Boroditsky, 2001). Interestingly, research indicates that temporal cognition is highly malleable, in mono- and bilinguals alike, as suggested by Boroditsky’s (2001), Bylund and Athanasopoulos’ (2017), and Athanasopoulos and Bylund’s (2023) works. However, evidence suggesting which bilingual variables may be responsible for this malleability is still conflicting. It appears that experience with specific types of spatio-temporal metaphors has a causal effect on differences in i) gesturing behaviours regarding representations of the past and the future (Núñez and Sweetser, 2006), ii) duration estimations (Casasanto et al., 2026), and iii) spatial organization of past and future events (Boroditsky, 2001; Miles et al., 2011). Age of acquisition of a second language also appears to have an effect on differences in cognition, that is, the earlier one acquires a second language, the

more likely they are to conceptualize some aspects of ‘time’ as native speakers of that language (Boroditsky, 2001; Athanasopoulos and Bylund, 2023). Aside from Athanasopoulos and Bylund’s (2023) evidence that L2 proficiency affected bilinguals’ displacement interference for the lines condition, evidence suggesting to what extent proficiency and frequency of use of a second language is still limited in this regard, though frequency of use did not significantly affect the participants’ performance in Athanasopoulos and Bylund’s (2023) study.

2.3 Determining whether Croatian is a distance- or quantity-based language: Method, Results, and Discussion

As mentioned before, Croatian has hitherto been unexplored in this regard, meaning that preliminary research had to be conducted in order to draw potential predictions regarding the outcomes of Experiments 1 (Croatian language context) and 2 (English language context). The present subsection outlines i) the method (2.3.1) used to determine whether Croatian is more prone to distance- or quantity-based metaphors and ii) the results of the analysis, as well as a brief discussion of the results (2.3.2). The method was conducted in accordance with previous research within the field, namely Bylund and Athanasopoulos’ (2017) work.

2.3.1 Method

The distributive frequencies of amount (quantity)- and distance-based duration metaphors in Croatian were compared using Google (www.google.com). Two amount-based and two-distance based metaphors were entered into Google’s search bar. The number of hits for each phrase was then compared. Google’s ‘Tools’ were used to limit search results to i) include only the exact phrase (as opposed to including all of the words of the phrase, but not necessarily as a phrase), ii) include only pages in Croatian, and iii) only include results from a specific region, i.e., Croatia. These steps were taken to somewhat ensure the validity of the results, by comparing only the exact phrases in Croatian, published in the country of Croatia, thus disregarding hits from pages published in other, similar languages which employ the same phrases (e.g., Bosnian and Serbian).

The amount-based metaphors included ‘puno vremena’ and ‘malo vremena’, i.e., ‘much time’ and ‘little time’, respectively. The distance-based metaphors included ‘dugo vremena’ and ‘kratko vrijeme’, i.e., ‘long time’ and ‘short time’, respectively. The phrases and their English counterparts are depicted in Table 1:

Table 1: Amount- and distance-based metaphors in Croatian and their English counterparts.

	Croatian	English
Amount	puno vremena	much time
	malo vremena	little time
Distance	dugo vremena	long time
	kratko vrijeme	short time

The phrases compared were chosen using my own native judgment as well as the native judgment of other Croatian speakers I had access to, mostly consisting of personal connections. It is important to note that three of these phrases are in the genitive case, given that the Croatian item ‘vrijeme’ is used to denote both ‘time’ and ‘weather’, meaning that searching for these phrases in the nominative case would result (and had resulted in the preliminary research) in plenty of hits not concerning ‘time’. The metaphor for expressing short time, ‘kratko vrijeme’, was kept in the nominative case as the genitive case is quite unnatural (as per native speakers’ judgements). The last query did not result in expressions pertaining to weather⁴.

2.3.2 Results and Discussion

The results of the analysis are illustrated in Figure 1 and Figure 2:

⁴ The first 100 results were checked, the number of hits was 491 000.

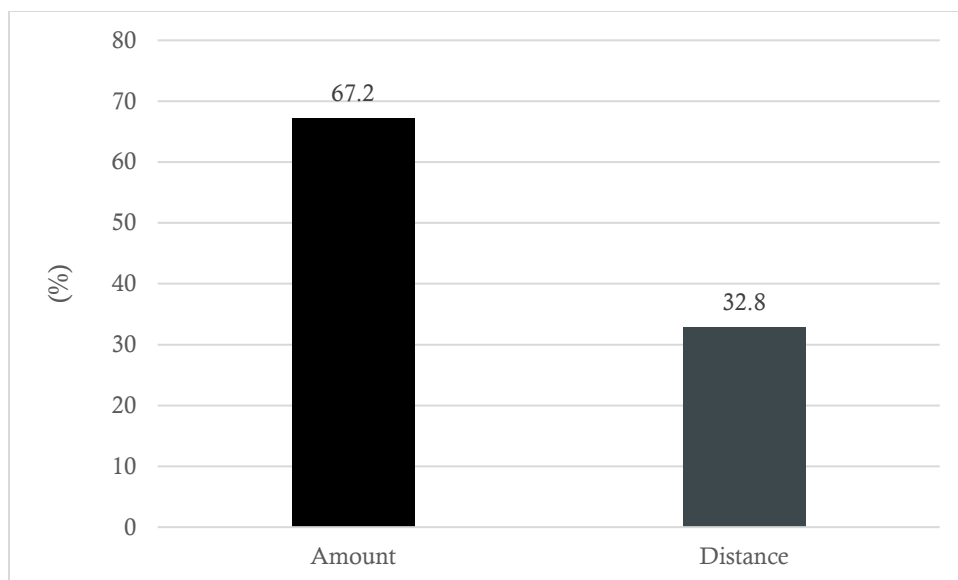


Figure 1: Distributive frequencies (%) of amount- and distance-based metaphors in Croatian.

The results shown in Figure 1 indicate a general prevalence for amount-based metaphors in Croatian. However, these results are skewed by the overall prevalence of ‘little time’ compared to other metaphors. Regarding distance-based metaphors, the expression ‘long time’ yielded more results than the amount-based counterpart of ‘much time’. The overall results of the search queries are shown in Figure 2:

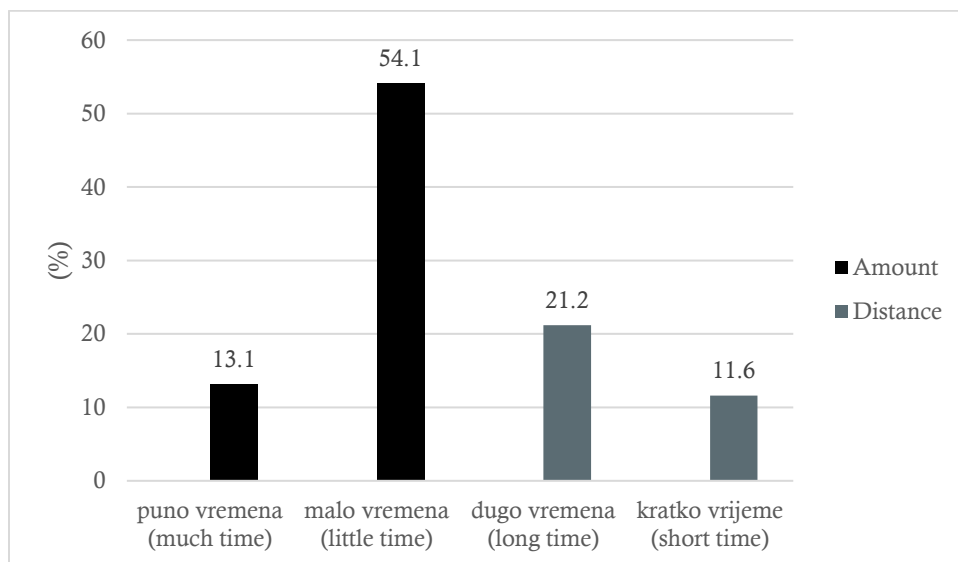


Figure 2: Distributive frequencies (%) of specific amount- and distance-based metaphors.

As stated previously, the quantity-based ‘malo vremena’ (‘little time’) was widely more prevalent than the distance-based variant ‘kratko vremena’ (‘short time’). Herein lies a challenge of the corpus query – while the Croatian expression for the phrase ‘short time’ would be (as per native judgement) used far less than its amount-based counterpart, further supported by the corpus search results, the expression for ‘short’, i.e., ‘kratko’ would also be a perfectly suitable way of expressing duration in Croatian, as illustrated in example (6):

(6) No, dakako, kratko je trajalo.

But of course short.ADV be.AUX.3SG last.PTCP.PST.N.SG

But, of course, it lasted a short time.

(Hrvatski nacionalni korpus, Vjesnik 2000-2003, document ID: 15851)

Of course, searching only for the item ‘kratko’ resulted in plenty of hits not regarding time, rendering the execution of a comprehensive comparison of metaphors quite difficult. Having said that, the other three metaphors, ‘puno vremena’, ‘malo vremena’, and ‘dugo vremena’, are all considered (based on native speakers’ judgement and corpus queries) natural ways of expressing the ideas ‘much time’, ‘little time’, and ‘long time’, respectively. However, as is the case with ‘kratko’, the three adverbs ‘malo’, ‘dugo’, and ‘puno’ can also be used to express duration (without the need for ‘time’ as part of the phrase). Again, searching for these adverbs as standalone phrases would result in plenty of hits referring to space as well as time. As such, the present corpus analysis may indicate that Croatian lies somewhere in-between distance- and quantity-based languages, employing both types of metaphors somewhat equally, though the method does pose a research limitation. At the very least, Croatian does not present a clear-cut case, unlike the previously explored languages where the corpus data indicated strong preferences for one type of metaphor (distance or amount) over the other (cf. Casasanto et al., 2004; Casasanto et al., 2026; Bylund and Athanasopoulos, 2017).

3 Methodology

This chapter outlines the methodology used to address the research questions. The methodology was adopted from and based on previous research within the field (cf. Casasanto, 2005; Casasanto et al., 2004; Bylund and Athanasopoulos, 2017). The procedure consisted of the participants completing two established duration reproduction tasks analogous to amount- and distance-based temporal metaphors, and filling out a language background questionnaire, which is described in detail in Chapters 3.1.2, 3.1.3, and 3.2.2, as well as the information about participants (Chapters 3.1.1 and 3.2.1) and the data analysis (Chapter 3.1.4).

3.1 Experiment 1 – Croatian language context

3.1.1 Participants

Forty-two students took part in the experiment. The participants' involvement was voluntary; they received no form of payment or reward for their contribution. Participants were collected via personal connections. The data for the container task of two participants was lost, rendering their (remaining) data unusable for the analysis. The data from four participants was excluded from the analysis due to poor performance in at least one of the two tasks. Poor performance was characterized as such if the slope of the correlation between estimated and actual duration was less than .5, indicating that the participants had not been consistent with their duration estimation responses, following previous research (e.g., Athanasopoulos and Bylund, 2023).

The remaining participants ($N = 36$) had the following characteristics:

Participants ranged in age from 18 to 29 years ($M = 22.69$ years, $SD = 2.03$ years). All participants were bachelor's or master's students enrolled at a Croatian university at the time of testing. Their average age of acquisition of English was 6.06 years, ranging from 4 to 8 years ($SD = 0.97$ years). Most participants ($N = 28$) rated their self-estimated English proficiency at 4 (labelled as

“advanced”, on a scale from 1-5, wherein 1 was labelled as “poor” and 5 as “very advanced”), followed by five participants who had estimated their English proficiency as “very advanced”, and three who had estimated it as “intermediate”. No participants reported higher frequency of use of English (or other languages they listed) compared to their native language, Croatian.

Regarding other languages, 16 participants spoke German as a third ($N = 15$) or fourth language ($N = 1$), and had all labelled their self-estimated proficiency and use of English as higher than that of German; their mean English proficiency was 4.19 ($SD = 0.54$), and their mean frequency of use of English (estimated in hours per week) was 27.31 hours ($SD = 13.06$ hours), compared to their mean German proficiency of 1.19 ($SD = 0.81$), and their mean frequency of use of German of 0.52 hours per week ($SD = 1.01$ hours). Six participants spoke Italian as a third ($N = 5$) or fourth ($N = 1$) language, and had all labelled their self-estimated proficiency and use of English as higher than that of Italian; their mean English proficiency was 4.17 ($SD = 0.41$), and their mean frequency of use of English was 22.50 hours ($SD = 14.40$ hours), compared to their mean Italian proficiency of 1.67 ($SD = 0.52$), and their mean frequency of use of Italian of 0.67 hours per week ($SD = 1.21$ hours). Participants also spoke Russian ($N = 1$), Spanish ($N = 2$), and Swedish ($N = 1$). The participant who spoke Russian estimated their proficiency as ‘advanced’ both in Russian and English, though had reported somewhat lower use of Russian than English (14 hours compared to 20 hours per week, respectively). The participants who spoke Spanish, labelled their proficiencies as ‘poor’ (they reported no frequency of use, i.e., zero hours per week), and ‘basic’ (their reported frequency of use was 7 hours per week). They had both labelled their English proficiency as ‘advanced’, and had reported their English frequencies of use as 14, and 35 hours per week, respectively. The participant who spoke Swedish reported lower proficiency (‘intermediate’), and frequency of use (17.50 hours per week) compared to English (‘advanced’ proficiency, and 28 hours per week, respectively).

Three participants spent most of or some of their lives in Bosnia and Herzegovina (18, 19, and 6 years, respectively), in the culturally Croatian part of Bosnia and Herzegovina⁵, where Croatian is an official language and the native language of the participants in question. Several other participants ($N = 4$) had spent less than a year living in other countries (Panama, Spain, Sweden, and Italy, respectively). Two of the participants did not speak the official languages of the countries they had lived in (Spanish (Panama) and Italian). One participant had lived in Austria for three years, and assessed their German proficiency at the time of testing as intermediate, but reported no usage (zero hours per week).

Out of the mentioned languages (excluding English), only Spanish and Swedish have been researched with respect to the conceptualization of duration (based on whether the language tends to employ spatio-temporal metaphors of distance or quantity), and labelled as a quantity-, and distance-based language, respectively (cf. Bylund and Athanasopoulos, 2017; Athanasopoulos and Bylund, 2023; Casasanto et al., 2004; Casasanto et al., 2026). It remains unclear whether German or Italian are distance- or quantity-based languages.

3.1.2 Materials

Both the growing lines and the filling containers task were run on PsychoPy (version 2024.2.4, Peirce et al., 2019), an open-source application used for creating experiments employed in scientific research. The experiments were programmed by Emir Akbuga, a Postdoc researcher at Lund University, and adapted for Croatian by the author of the thesis. The consent form and the language background questionnaire, which were provided by Professor Panos Athanasopoulos, were adapted for Croatian by the author of the thesis. Care was taken so that no distance- or quantity-based spatio-temporal metaphors were used in the instructions preceding the tasks.

⁵ The three largest ethnic populations in Bosnia and Herzegovina include Croats, Bosniaks, and Serbs. Croatian, Bosnian, and Serbian are the country's official languages (and all have equal status), and are usually spoken with respect to the ethnic groups (Malcolm et al., 2026).

3.1.2.1 Lines Experiment

A modified version of Casasanto's (2005) growing lines experiment was used to elicit duration reproduction. Lines of varying lengths were presented on a laptop screen (1080x1920 pixels, 60 Hz) for varying durations. Nine different line durations were fully crossed with nine different line distances (displacement) to create 81 distinct line types. The displacement ranged from 100 to 500 pixels with 50-pixel increments (e.g., 100, 150, 200, etc.). The duration ranged from 1000 to 5000 milliseconds with 500 millisecond increments. The lines were black and grew horizontally from left to right across the vertical midline on a white background. Each line remained on the screen until it reached its maximum displacement, after which it disappeared. In accordance with previous research, the starting point of each line was jittered in comparison to the average starting point, so that the screen could not be a reliable spatial frame of reference (Casasanto, 2005). The lines were presented in random order.

3.1.2.2 Containers Experiment

Casasanto's (2005) filling containers experiment was used to elicit duration reproduction. In this experiment, nine varying fill levels were fully crossed with nine varying durations to produce 81 distinct filling container stimuli. The volumes (fill levels; displacement) ranged from 100 to 500 pixels with 50-pixel increments, the duration ranged from 1000 to 5000 ms (500 ms increments). The containers were simple line drawings, 600-pixel high x 500-pixel wide. The fill levels were black and grew vertically one row of pixels at a time on a white background. Each container remained on the screen until it reached its maximum fullness, after which it disappeared. The starting point of each container was again jittered with regards to the average starting point so that the screen would not be a reliable spatial frame of reference. The filling containers were presented in random order.

A language background questionnaire was administered in between the two tasks, consisting of questions designed to elicit information about the participants' overall language use. This includes information about their native language, as well as information about any other language(s) they spoke, i.e., the language(s) in question, their age of acquisition of the language(s), their self-estimated proficiency and their frequency of use of the language(s) (see Appendix C).

3.1.3 Procedure and Experiment Design

The data was collected in July and August of 2025. The participants were tested in Croatia, individually, on a 15.6'' screen laptop. Prior to completing the tasks, the participants were given informed consent forms in Croatian (see Appendix B). The participants were tested in Croatian with Croatian instructions. Written instructions were shown on the screen prior to starting either task (see Appendix A). Both the lines and the containers tasks were preceded by a trial task (not analysed) consisting of 9 stimuli, implemented to further ensure that the participants were prepared for completing the tasks. Each trial was preceded by a prompt consisting of an hourglass symbol next to the verbal label “trajanje”, i.e., the Croatian expression for duration. Unlike in previous research, the participants did not complete the distractor task, i.e., estimating duration, a choice made to minimise fatigue, since all participants completed both tasks (see Bylund and Athanasopoulos, 2017).

While all of the participants completed both tasks, the task order was counter-balanced, with 18 participants completing the growing lines task first, followed by the filling containers task, and 18 participants completing the filling containers task first, followed by the growing lines task. This decision was implemented to ensure that the results were not affected by the order of the experiments, accounting for the possibility of factors such as fatigue or impatience to influence the data. Each task took about 15 minutes to complete, with the entire testing session lasting roughly 40-45 minutes per participant.

3.1.4 Data analysis

The data was analysed in RStudio⁶ (version 2026.1.1.403; Posit Team, 2026). The analysis was largely based on previous research (cf. Casasanto and Boroditsky, 2008; Bylund and Athanasopoulos, 2017; Athanasopoulos and Bylund, 2023). Correlation slopes between the estimated and actual duration were calculated for each task and participant. If the correlation slope in any of the two tasks was $<.5$, their data was excluded from the analysis (see 3.1.1). Time estimation accuracy slopes along with r^2 values were calculated for each condition type, in accordance with previous research (e.g., Casasanto et al., 2004), in order to establish whether the participants were generally able to estimate time well. The stimuli were divided into *medium* and *extreme* stimuli, the medium stimuli included the five intermediate durations (2000, 2500, 3000, 3500, and 4000 ms) and the five intermediate fill levels/line lengths (200, 250, 300, 350, and 400 px); the extreme stimuli included the remaining outer four durations (1000, 1500, 4500, and 5000 ms) and fill levels/line lengths (100, 150, 450, and 500 px). The analysis was conducted separately for each stimulus type, following previous research, which found that medium stimuli were harder to process (since medium stimuli are harder to process language is recruited as a strategy to solve the task), and that no language-specific affects were found for extreme stimuli regarding spatial interference (Bylund and Athanasopoulos, 2017). A stimulus was classified as ‘medium’ if both the actual duration and spatial displacement were medium values. Conversely, a stimulus was classified as ‘extreme’ if either the actual duration or the spatial displacement were extreme values. This resulted in 25 trials per participant regarding medium stimuli. To estimate whether displacement (fill level/line length) had an effect on duration estimation and to what extent, spatial interference slopes were calculated and grouped by stimulus (medium/extreme) and condition

⁶ The analysis was conducted independently, though Emir Akbuga helped with the analysis of the individual bilingual background variables (the analysis was done by the author of the thesis and cross-referenced with Emir Akbuga to ensure that it was done correctly). Generative Artificial Intelligence (Gemini) was used as a tool to help with the R code regarding spatial interference slopes (in the cases where the information could not have been found elsewhere). This was the only use of AI in the analysis, and the thesis as a whole (the slopes to determine whether data was usable, as well as the duration estimation slopes and r^2 values were conducted independently).

(lines/containers) type. Higher slopes indicated greater spatial interference, i.e., higher slopes indicated that participants estimated larger volumes/longer line lengths as having a greater duration.

Linear mixed effects models were run for each experiment with estimated duration as the dependent variable. The actual duration and displacement were treated as fixed effects. The analysis was only conducted for medium stimuli. Proficiency was treated as categorical with five levels (poor-very advanced; see Appendix E). Random intercepts for participants and items were included for the containers condition. The random intercept for items was removed for the lines condition due to a singular fit error in R. As such, the model that converged for the container condition included both random intercepts for participants and items, and only the random intercept for participants for the line condition (regarding both the Croatian and English language context). To test whether bilingual background variables (proficiency, age of acquisition and frequency of use of English) influenced the results, the interaction between each of the background variables and displacement was added to the base models to see if any of them improved the fit significantly. The models were compared to see which model fit the data best using ANOVA.

3.2 Experiment 2 – English language context

3.2.1 Participants

29 students took part in the experiment. The participants' involvement was voluntary; they received no form of payment or reward for their contribution. Participants were collected via personal connections. The data from 1 participant was excluded from the analysis due to poor performance (see 3.1.1) in the filling containers condition.

The remaining participants ($N = 28$) had the following characteristics:

Participants ranged in age from 19 to 25 years ($M = 22.89$ years, $SD = 1.63$ years). All participants were bachelor's or master's students enrolled at a Croatian university at the time of testing. Their average age of acquisition of English was 6.43 years, ranging from 4 to 8 years of age ($SD = 1.02$

years). Most participants ($N = 17$) rated their self-estimated English proficiency as ‘advanced’ (labelled 4 on the scale, see Appendix F), 9 participants labelled it as ‘very advanced’, followed by 2 participants who had labelled it as ‘intermediate’. None of the participants labelled their English proficiency as ‘poor’ or ‘basic’, as indicated by the two lowest values on the scale. 10 participants spoke an additional third language, determined by the age of acquisition, and all of these participants had English as a second language (as indicated by their age of acquisition), see Table 2:

Table 2: Information about the participants' third language, including age of acquisition (AoA), self-estimated proficiency on a scale from poor-very advanced (1-5; Proficiency), and Frequency of use, estimated in hours per week, as well as information about their second language (English), including the latter two variables to serve as comparison.

Participant	L3	L3: AoA	L3: Proficiency	L3: Frequency of use	English: Proficiency	English: Frequency of use
P1	Italian	7	basic	0	very advanced	50
P2	Swedish	19	intermediate	21	very advanced	35
P3	Slovenian	18	intermediate	0	advanced	21
P4	German	17	basic	1	advanced	15
P5	Italian	10	intermediate	0	very advanced	10
P6	Italian	15	basic	2	advanced	60
P7	Swedish	19	intermediate	5	very advanced	63
P8	German	12	intermediate	0	very advanced	28
P9	Italian	15	basic	2	advanced	15
P10	German	10	poor	0	very advanced	49

Participants who spoke an additional L3 (without the presence of additional languages, e.g., a fourth, and/or a fifth language, spoke the following languages: Italian ($N = 4$), Swedish ($N = 2$), Slovenian ($N = 1$), and German ($N = 3$). Out of these four languages, only Swedish has so far been researched with respect to the conceptualization of duration (based on whether the language tends to employ spatio-metaphors of distance or quantity), and was labelled a distance-based language (cf. Bylund and Athanasopoulos, 2017; Athanasopoulos and Bylund, 2023). While it is unclear how speaking the other mentioned languages would affect the participants’ performance, none of the participants had labelled their self-estimated proficiency as ‘advanced’ or ‘very advanced’,

whereas they had all labelled their self-estimated English proficiency as ‘advanced’ or ‘very advanced’, and had reported higher usage of English compared to their L3. As such, their third languages were not expected to influence their performances in either of the two tasks.

One participant’s second language was Macedonian, and English was their third language. Their self-estimated proficiency of both Macedonian and English was labelled as ‘very advanced’, though their reported frequency of use was zero hours per week for Macedonian, and 42 hours per week for English. Another participant had German as a second first language, they had not indicated it as their native language but had reported learning it from birth. Their self-estimated proficiency of German was labelled as ‘very advanced’, compared to ‘advanced’ in English. Their use of English was reported as five times higher than that of German, and they had spent five months living in Austria. Four other participants had listed three ($N = 3$) or four ($N = 1$) additional languages apart from Croatian and English (English was their second language, as indicated by the age of acquisition). Those languages included German ($N = 2$), Spanish ($N = 3$), Italian ($N = 3$), Russian ($N = 3$), and French ($N = 1$). Out of these languages, only Spanish has so far been researched with respect to the conceptualization of duration, and labelled as a quantity-based language (cf. Casasanto et al., 2004; Bylund and Athanasopoulos, 2017; Athanasopoulos and Bylund, 2023), though the participants who listed Spanish as an additional language labelled their self-estimated proficiencies as ‘basic’ ($N = 2$), and intermediate ($N = 1$), and had either not used it at all (compared to 28 hours per week for English, which was labelled as ‘advanced’), or reported their frequency of use as 1 hour per week (compared to 12 hours per week for English, labelled as ‘advanced’), or reported their frequency of use as 4 hours per week (5 times less than that of English, labelled as ‘advanced’), respectively. Only one of the participants indicated that their frequency of use of their fifth language, Russian, was greater than that of English, and had estimated their proficiency in Russian (‘very advanced’) as higher than that in English (‘advanced’).

3.2.2 Materials, Procedure, Experiment Design, and Data analysis

The data was collected in April and May of 2026. The materials, procedure, experiment design and data analysis were nearly identical to those implemented in Experiment 1, with the only difference being the language used in the task, i.e., the written instructions, the language background questionnaire, and the consent form were provided in English (see Appendix D, Appendix E, and Appendix F). The experiment was run on PsychoPy (version 2026.1.1, Peirce et al., 2019). The task order was counter-balanced, 16 participants completed the containers condition first, and 12 participants completed the lines condition first.

3.3 Ethical considerations

The participants were issued a consent form prior to partaking in the experiment (see Appendix B and Appendix D). Participants were made aware that their data was confidential and anonymous, that the research is voluntary and that they had the right to withdraw at any time without penalty, as well as that they could omit questions they did not want to answer. Inquiries about (sensitive) information such as gender and age were present in the language background questionnaire, but such information was not essential for the present study.

4 Results

Chapter 4 covers the results of the experiments. The results are divided into two subsections based on the language context. Chapter 4.1 includes the results of the Croatian language context, namely the results of the duration estimations for both the growing lines and the filling containers condition, the spatial interference slopes, and the results of the effects of the individual bilingual background variables (age of acquisition of English, English proficiency, and frequency of use of English) on participants' spatial interference. Chapter 4.2 includes the results regarding the English language context.

4.1 Croatian language context – results

4.1.1 Duration estimation

In accordance with previous research (cf. Casasanto et al., 2004), time estimates were calculated for both conditions across all participants. Overall, participants were equally accurate in their time estimations regarding both conditions, as indicated by the similar correlation slopes between the actual stimulus duration and the participants' estimated stimulus duration. Perfect performance would be indicated by a slope of 1.00 and an r^2 of 1.00, see Table 3:

Table 3: Time estimation results (Croatian language context) for both conditions, and slope and r-square values for the correlation between actual stimulus duration and subjects' grand averaged estimates of stimulus duration.

Condition	Slope	r^2
Line	0.78	0.64
Container	0.79	0.75

Participants' correlation slopes were 0.78 for the growing lines condition and 0.79 for the filling containers condition. Estimates were somewhat more consistent for the filling containers condition, as indicated by the r^2 values of 0.64 and 0.75 for the growing lines, and the filling

containers condition, respectively. The less consistent estimates for the growing lines condition could reflect greater spatial interference, though both the extreme and medium stimuli were included in these calculations, and medium stimuli were shown to be harder to process in previous research (Bylund and Athanasopoulos, 2017). As such, these calculations only indicate that participants were able to estimate durations well in general.

4.1.2 Spatial interference

Spatial interference slopes were calculated to explore whether participants' duration estimations were affected by spatial displacement, i.e., line length (distance)/fill level. The analysis was done separately based on stimulus (extreme/medium stimuli, see Chapter 3.1.4) and condition (growing lines/filling containers) type. Following previous research (cf. Bylund and Athanasopoulos, 2017), the duration estimates for each fill level/distance, and the two variables (estimated duration and displacement) were entered in a regression to obtain the slope of spatial interference, to explore to which degree spatial displacement interfered with duration estimations. Regarding medium stimuli, the 'harder to process' stimuli (Bylund and Athanasopoulos, 2017, p. 915), the participants were more affected by spatial displacement in the filling containers condition than in the growing lines condition, as indicated by the greater spatial interference slope in the filling containers condition (Slope = 1.11 compared to Slope = 0.90 (growing lines condition), respectively). The correlation was significant in both conditions ($p < 0.5$, $t = 2.46$ (growing lines condition), $t = 2.09$ (filling containers condition)). Regarding extreme stimuli, spatial interference was greater in the growing lines condition (Slope = 0.63, $t = 1.73$) compared to the filling containers condition (Slope = 0.48, $t = 1.30$). The correlation was not significant in either condition ($p > 0.05$). These results are aligned with the prevalence of quantity-based spatio-temporal metaphors in Croatian, and further indicate that Croatian lies somewhere in-between quantity- and distance-based languages, as the correlation between displacement and estimated duration was significant in both conditions (with regards to medium stimuli). The spatial interference slopes are illustrated in Figure 3:

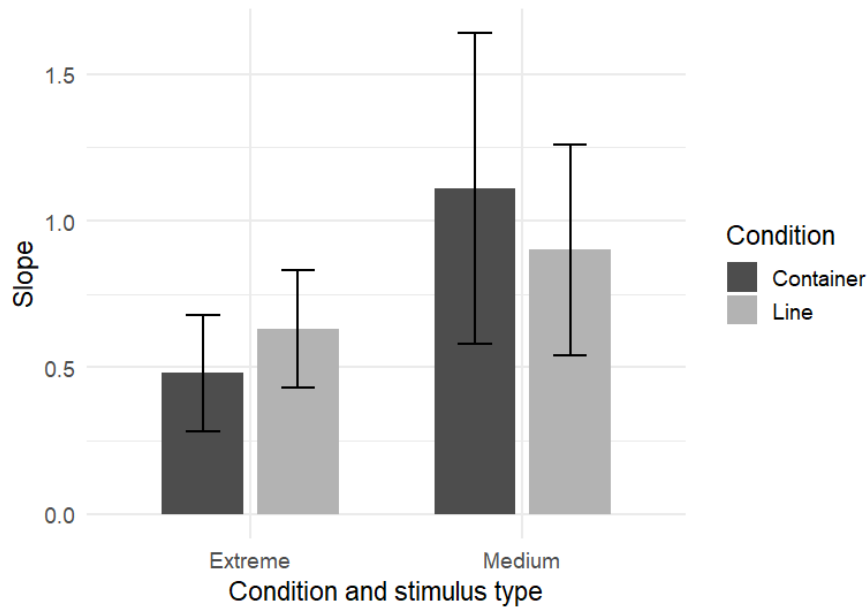


Figure 3: Spatial interference slopes for medium and extreme stimuli in the line condition and the container condition with standard error bars (standard error of the mean) (Croatian language context).

4.1.3 Individual bilingual background variables

Since the correlation of displacement and estimated duration was not significant regarding extreme stimuli, the analysis, exploring whether bilingual variables, namely the age of acquisition of English, the self-estimated proficiency of English, and the frequency of use of English, was conducted only for medium stimuli, following Athanasopoulos and Bylund (2023). In the baseline model for both the filling containers and the growing lines condition, participants' estimated duration functioned as the dependent variable, and the actual duration and displacement were treated as fixed effects. The baseline model for the filling containers task included random intercepts for items and participants. The baseline model for the growing lines condition included only the random intercept for participants (due to a singular fit (boundary) error in R). To investigate whether individual bilingual background variables had an effect on the data (improved the model fit), the interaction between displacement and each of the bilingual background variables was added to the baseline model. The covariate of actual duration had a significant effect on

duration estimation, regarding both conditions. Regarding the filling containers condition, the model with the interaction between displacement and proficiency of English (categorical) was the best fit for the data, and statistically significant ($p < 0.05$) regarding only ‘very advanced’ participants, meaning that highly proficient participants ($N = 5$) in English were more affected by spatial displacement in the filling containers condition than participants of ‘advanced’ and ‘intermediate’ proficiencies. Models with the interaction between age of acquisition/frequency of use and displacement were not significant, though the model including both the age of acquisition and proficiency of English was statistically significant (regarding the ‘very advanced’ proficiency subset of participants), indicating that participants with a higher age of acquisition of English combined with higher proficiency of English were more affected by spatial displacement in the filling containers condition, though this model was not a better fit for the data than the model only including proficiency. Regarding the growing lines condition, the baseline model, wherein estimated duration functioned as the dependent variable, and the actual duration and displacement were treated as fixed effects, was the best model fit (and statistically significant). No bilingual variables improved the model fit ($p > .10$).

4.2 English language context – results

4.2.1 Duration estimation

Similarly to the Croatian language context, participants were equally accurate in their time estimations regarding both conditions, as indicated by the correlation slopes between the actual stimulus duration and the participants’ estimated stimulus duration. Perfect performance would be indicated by a slope of 1.00 and an r^2 of 1.00, see Table 4:

Table 4: Time estimation results (English language context) for both conditions, and slope and r-square values for the correlation between actual stimulus duration and subjects’ grand averaged estimates of stimulus duration.

Condition	Slope	r^2
Line	0.75	0.63
Container	0.78	0.68

Estimates were somewhat more consistent for the filling containers condition, as indicated by the r^2 values of 0.63 and 0.68 for the growing lines, and the filling containers condition, respectively, though it is unclear whether this is due to a greater spatial interference in the line condition. The results of duration estimation across both language contexts suggests that participants estimated time well, and that their results did not differ across groups, as indicated by the slope values across both groups and both types of conditions.

4.2.2 Spatial interference

Regarding medium stimuli, spatial interference was greater in the filling containers condition (Slope = 1.15, $t = 2.51$) compared to the growing lines condition (Slope = 0.71, $t = 1.55$), though the correlation of displacement and estimated duration was only significant in the filling containers condition ($p < 0.05$). Regarding extreme stimuli, spatial interference was greater in the growing lines condition (Slope = 0.66, $t = 1.58$), than in the filling containers condition (Slope = 0.57, $t = 1.36$). The correlation of displacement and estimated duration was not significant in either condition ($p > 0.1$). These results indicate that Croatian-English bilinguals, presumably since they think in time both in terms of distance and quantity, did not shift their conceptualization of duration to that of English speakers, which were affected by spatial displacement to a significantly greater extent for the growing lines condition (Casasanto et al., 2004; Casasanto et al., 2026). The results are illustrated in Figure 4:

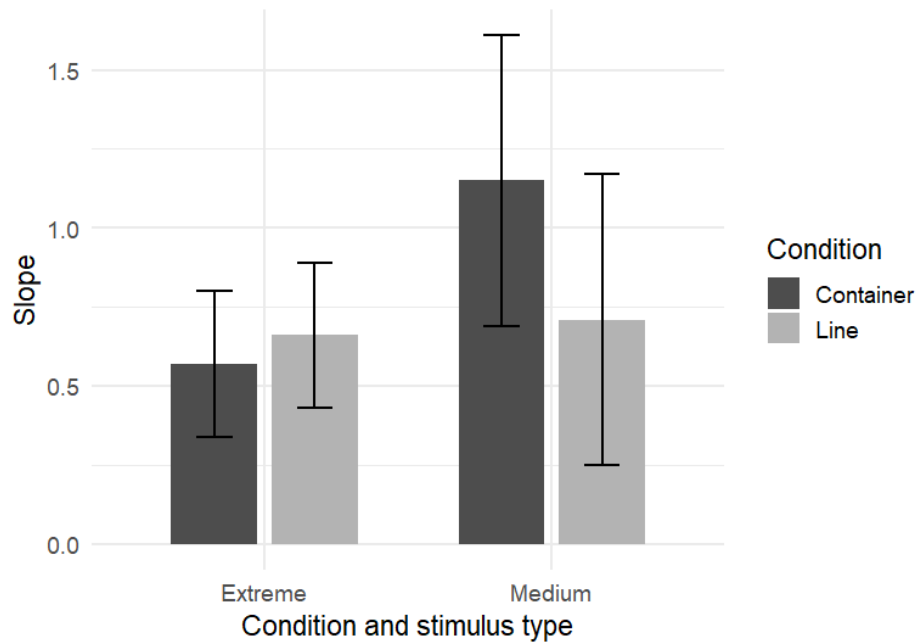


Figure 4: Spatial interference slopes for medium and extreme stimuli in the line and the container condition with standard error bars (English language context).

4.2.3 Individual bilingual background variables

The analysis was conducted for medium stimuli only, following Athanasopoulos and Bylund (2023). In the baseline model for both the filling containers and the growing lines condition, participants' estimated duration functioned as the dependent variable, and the actual duration and displacement were treated as fixed effects. The baseline model for the filling containers task included random intercepts for items and participants. The baseline model for the growing lines condition included only the random intercept for participants (due to a singular fit (boundary) error in R). To investigate whether individual bilingual background variables had an effect on the data (improved the model fit), the interaction between displacement and each of the bilingual background variables was added to the baseline model. The covariate of actual duration had a significant effect on duration estimation, regarding both conditions. Regarding the filling containers condition, the baseline model, wherein estimated duration functioned as the dependent variable, and the actual duration and displacement were treated as fixed effects (as in the baseline

model for the growing lines condition), was the best fit for the data. For the model including the interaction between displacement and proficiency, the interaction was significant regarding the ‘advanced’ and ‘very advanced’ ($N = 26$) proficiency subsets of participants, indicating that those participants were more affected by spatial displacement in the filling containers condition compared to the ‘intermediate’ ($N = 2$) subset of participants. The model including the interaction between displacement and use of English was statistically significant, indicating that participants with higher frequency of use of English were more affected by spatial displacement in the filling containers condition, though neither of these models were the best fit for the data.

Regarding the growing lines condition, the baseline model was again the best fit for the data, and was statistically significant. For the model including the interaction between displacement and proficiency, the interaction was significant regarding only the ‘advanced’ proficiency subset of participants, indicating that those participants were more affected by spatial displacement in the growing lines condition compared to the ‘intermediate’ and ‘very advanced’ subsets of participants.

5 Discussion

The present chapter covers the discussion of the results for the Croatian and English language context, respectively, and addresses the two research questions posed in the introduction (5.1), followed by Chapter 5.2, which addresses the limitations of the present study, as well as its significance and contribution regarding the conceptualization of duration, and implications for future research (5.2).

5.1 Discussion of results

The present study aimed to contribute to the research exploring the effects of the spatio-temporal metaphors employed in a language on the conceptualization of duration, by focusing on Croatian-English bilinguals, with Croatian being a hitherto unexplored language in this regard. The study also aimed to add to the growing body of research investigating the effects of bilingualism on this aspect of cognition. This section addresses both research questions, each of them divided into three sub-questions (six research questions in total). The first research question served to investigate whether the participants' duration estimations were influenced by spatial displacement (RQ1a), whether this influence was more pronounced for the growing lines or the filling containers condition (RQ1b), and whether these results differed regarding the language context, and if so, in what ways (RQ1c).

Overall, all participants estimated durations well across both conditions, as indicated by the results in subsections 4.1.1 and 4.2.1. Both groups of participants, namely the Croatian-English bilinguals tested with the presence of Croatian linguistic prompts, and Croatian-English bilinguals tested with the presence of English linguistic prompts, were influenced by spatial displacement in both conditions. The correlation of displacement and estimated duration was not significant regarding extreme stimuli (the two shortest and two longest spatial displacement and actual duration values, namely 100, 150, 450, and 500 px, and 1000, 1500, 4500, and 5000 ms, respectively). These results

align with previous research (Bylund and Athanasopoulos, 2017), and further indicate that medium stimuli are harder to process, as well as that participants are less likely to be affected by spatial displacement regarding extreme stimuli, reflected by overall lower spatial interference slopes of extreme stimuli compared to medium stimuli, present both in the present study and previous research, namely Bylund and Athanasopoulos' 2017 work.

The corpus query, based on previous research (Casasanto et al., 2004; Bylund and Athanasopoulos, 2017), indicated that Croatian did not have a strong prevalence for one type of metaphor over the other, though metaphors depicting time-as-quantity were more prevalent overall (67.2% of quantity-based metaphors compared to 32.8% of distance-based metaphors), albeit the results were skewed by the overall prevalence of 'little time' ('malo vremena') compared to the other three spatio-temporal metaphors. The metaphor expressing 'long time' (dugo vremena) was more prevalent than its amount-based counterpart, 'much time' (puno vremena). Based on these results, it was predicted that Croatian speakers tested with Croatian linguistic prompts would exhibit similar performance across both tasks regarding displacement, i.e., that the participants could be somewhat equally affected by spatial displacement for both conditions, exhibiting a difference not as stark as found in previous studies. It was also predicted that spatial interference could still be more prevalent in the filling containers condition due to the general prevalence of amount-based metaphors in Croatian attested by the corpus query. The results aligned with this hypothesis; spatial interference was found both in the growing lines and the filling containers condition, and the correlation between displacement and participants' estimated duration was significant ($p < 0.05$) in both conditions.

Previous research dealt with languages that exhibited a strong prevalence of one type of metaphor over the other, as such, the results of those bodies of work showed a significant difference regarding spatial interference, depending on the condition type, analogous to the type of metaphor preferred in that language. That is, previous research found that speakers of distance-based languages (i.e., languages which usually tend to employ distance-based spatio-temporal metaphors) were more affected by spatial displacement in the growing lines condition compared to the filling containers condition (both with and without the presence of linguistic prompts), whereas an expected opposite pattern was found for speakers of amount-based languages (cf.

Casasanto et al., 2004; Bylund and Athanasopoulos, 2017; Athanasopoulos and Bylund, 2023; Casasanto et al., 2026). In this sense, the results of the present study, regarding the group tested with Croatian linguistic prompts, align with previous studies. On a broader scale, these results align with the predictions of The Conceptual Metaphor Theory, and the linguistic relativity principle, which imply that metaphors are cognitive phenomena that shape the way one thinks (as such, speakers of different languages, presuming that those languages employ different metaphors, should exhibit differences in cognition regarding those metaphors), and that the language one speaks influences the way one conceives reality.

The third sub-question of RQ1 aimed to address whether there were differences in the conceptualization of duration based on the language context, and if so, how the two groups differed. The Croatian-English bilinguals tested with English linguistic prompts were also more affected by spatial displacement in the container condition, though the correlation between the displacement and estimated duration was only significant in the filling containers condition⁷. Although this was more of an exploratory question, it was suggested that there might not be a considerable difference between the group tested with Croatian linguistic prompts compared to the group tested with English linguistic prompts.

Although previous research had found stark differences regarding spatial interference when changing the language context (Bylund and Athanasopoulos, 2017), as mentioned previously, such research explored the conceptualization of duration regarding languages that had a significant prevalence of one type of metaphor (quantity- or distance-based) over the other. As such, shifting the language context resulted in participants adapting their conceptualizations of duration to that of the language they were currently thinking in. Bylund and Athanasopoulos (2017) found that changing the language context within the same bilingual resulted in a vastly different performance in the same psychophysical task of duration reproduction, a performance expected of speakers of

⁷ Note that this correlation was significant in the baseline linear model for individual bilingual background variables for the growing lines condition, which also accounted for actual duration, and the random intercept for participants. This correlation was significant in all baseline models (both conditions and both the Croatian and English language context) regarding the models in the analysis of individual bilingual background variables.

that language, respectively. Specifically, they found that there was a significant interaction between language context and stimulus types for both conditions (for medium stimuli only). However, both of those languages, namely Spanish, and Swedish, are languages that tend to employ either quantity-based metaphors (Spanish) or distance-based metaphors (Swedish).

Since the present results indicate that Croatian speakers conceptualize duration both in terms of distance and quantity, they need not have ‘shifted’ their conceptualization of duration to that of English speakers because they had already possessed such conceptualization of duration. Because of this, the present results cannot point to whether bilingual cognition is or is not (highly) malleable, as the language explored in the present work, Croatian, is inherently different than languages studied previously (Indonesian, English, Greek, Spanish, and Swedish), given that the results (both of the corpus query and spatial interference) indicate that Croatian employs both distance- and amount-based spatio-temporal metaphors somewhat equally. This equal distribution of spatio-temporal metaphors is reflected in the speakers’ conceptualization of duration, i.e., the speakers were affected by spatial displacement in both psychophysical tasks of duration reproduction, and the correlation between displacement and estimated duration was significant in both conditions.

Boroditsky (2001) found that Mandarin-English bilinguals showed a vertical bias even when “thinking for English”, hypothesizing that language-encouraged habits in thought may operate regardless of the language one is currently thinking for (*ibid.* p. 12). Boroditsky (2001) then conducted another experiment, focusing on Mandarin-English bilinguals with a lower AoA of English, and found that vertical-bias was more prevalent in participants who had started learning English later in life. Regarding the conceptualization of duration, Athanasopoulos and Bylund (2023) investigated which specific individual bilingual background variables influenced the performance of Spanish-Swedish bilinguals. They found that L2 proficiency had the highest effect on performance in the growing lines condition, i.e., participants with a higher proficiency in Swedish were more affected by displacement than speakers with lower proficiency in Swedish. Similarly, they found that a higher AoA of Swedish resulted in participants being more affected by spatial displacement in the filling containers condition (as expected of Spanish monolinguals).

As such, the second research question (divided into three sub-questions) focused on individual bilingual background variables, namely the questions aimed to address whether individual bilingual background variables affected the participants' performance (RQ2a), and if so, which individual bilingual background variables, namely AoA, frequency of use and self-estimated proficiency of English, affected the participants' performance (RQ2b). Lastly, differences regarding the language context were explored (RQ2c).

Regarding the Croatian language context, the model with the interaction between displacement and proficiency of English (categorical) was the best fit for the data, regarding the filling containers condition, and was statistically significant ($p < 0.05$) regarding only 'very advanced' participants. This indicates that participants with a higher proficiency in English were more affected by spatial displacement than participants of lower-reported English proficiencies. This was not expected, as previous studies (Casasanto et al., 2004; Casasanto et al., 2026) indicated that English monolinguals were less affected by spatial displacement in the filling containers condition compared to the growing lines condition. However, there were only five participants who had estimated their proficiency as 'very advanced' in the dataset, a sample far too small to draw any certain conclusions. Since all of the participants were native Croatian speakers, who had been living in Croatia for their whole lives or vast majority of their lives (see 3.1.1), had reported higher frequency of use of Croatian than that of English, and were tested with Croatian linguistic prompts, the current results do not strongly indicate that English had an effect on the results, further attested by the unexpected pattern of the effect of proficiency on the participants' conceptualization of duration.

In the growing lines condition, the baseline model (not including any individual bilingual background variables) was the best fit for the data, though, as a reference point, the model which included the interaction between proficiency and displacement was significant regarding the 'intermediate' and 'advanced' subsets of participants, such as that lower proficiency of English (compared to the 'very advanced' subset) resulted in a greater effect of spatial displacement on the conceptualization of duration. If English proficiency affected the participants performance, an opposite pattern would have been expected (had the paper dealt with a quantity-based language).

However, these results further point to the fact that Croatian speakers truly conceptualize duration both in terms of distance and quantity.

Regarding the English language context, the baseline models, wherein estimated duration functioned as the dependent variable, and the actual duration and displacement were treated as fixed effects, were the best models for the data, and statistically significant. Adding interaction terms between displacement and each of the bilingual background variables (English proficiency, frequency of English use, age of acquisition of English) did not significantly improve the model fit. A somewhat unexpected pattern occurred again, regarding the filling containers condition, the interaction of displacement and proficiency was significant regarding the ‘advanced’ and ‘very advanced’ proficiency subsets of participants, indicating that participants with a higher proficiency of English were more affected by spatial displacement in the filling containers condition than participants with a lower proficiency of English (i.e., the ‘intermediate’ subset of participants). However, the ‘intermediate’ subset consisted only of two participants, a far too small sample to compare to the remaining subset ($N = 26$). The model including the interaction between displacement and use of English was statistically significant, indicating that participants with higher frequency of use of English were more affected by spatial displacement in the filling containers condition.

Regarding the growing lines condition, the interaction of displacement and proficiency was significant regarding the ‘advanced’ subset of participants, indicating that they were more affected by spatial displacement than participants with higher and lower proficiency. The term ‘unexpected’ is used simply to refer to the idea that had English truly affected the results, it would have been expected that participants with higher proficiencies of English would be more affected by spatial displacement in the growing lines condition, in accordance with previous research (Casasanto et al., 2004; Casasanto et al., 2026). These results could indicate that Croatian speakers were not thinking for English, even when tested with English linguistic prompts, presumably because there was no need to shift their line of thinking, since they already thought about duration in terms of distance (as well as in terms of quantity). It is important to note that these results could have been skewed since English proficiency was self-assessed, discussed further in Chapter 5.2.

5.2 Limitations, implications for further research, and contributions

There are several research limitations which need to be addressed regarding the present study. The original idea was to test Croatian monolinguals and compare them to highly proficient Croatian-English bilinguals. However, English is implemented as a mandatory school subject in the first grade of elementary school, at which point children are usually 6-7 years old, and remains a mandatory subject throughout high school. This means that students who are enrolled at a university (relevant for all participants in the present study) have spent 12 years of formal education in English. According to EF English Proficiency Index, Croatia was globally ranked as second regarding English proficiency in 2025, with the highest fluency scores present in young adults (21-25 years of age; EF, 2025). Since the desired sample of participants for the present study required students (in order to be comparable with previous research), no ‘true’ monolinguals exist in the dataset, in the sense that no participants only spoke their native language (Croatian). Having said that, it could be argued that English did affect the results entirely, though since previous research repeatedly showed that native speakers (including bilinguals) tested with linguistic prompts in their native language (and even without linguistic prompts; see Casasanto et al., 2004; Casasanto et al., 2026) tended to conceptualize duration accordingly, i.e., they were more affected by spatial displacement in the condition analogous to the spatio-temporal metaphors employed in their native language (cf. Bylund and Athanasopoulos, 2017; Casasanto et al., 2026), it is considered that this is not the case.

Furthermore, participants often spoke an additional third/fourth/fifth language, though most of them were functional monolinguals in that language (in the sense that they had poor or basic proficiency), and had either not used those languages at all, or had used them far less than their native language, Croatian, and their L2, English. As such, even though most of these languages had not previously been explored with regard to the conceptualization of duration (or labelled as distance- or quantity- based languages according to the types of spatio-temporal metaphors employed in the language), namely German, Italian, Russian, Macedonian, and French, it is unlikely that knowledge of those languages at the levels reported by participants would have an effect on the results. In the few cases where participants were highly proficient (though frequency

of use was often still minimal⁸), it is unclear whether knowledge of these languages had an effect on the results, but based on previous research, which indicates that the performance in the tasks is highly influenced, or rather determined, by the linguistic prompts preceding the trials (cf. Bylund and Athanasopoulos, 2017), it is unlikely that knowledge of these languages affected the results.

A separate issue is that of the methods used to determine whether Croatian is a distance- or quantity-based language. As mentioned in Chapter 2.3, the four phrases expressing the ideas ‘long time’, ‘short time’, ‘much time’, and ‘little time’, were entered into Google and their distributive frequencies were compared. The issues of this approach were discussed in detail in Chapter 2.3.2, though could be summarised as such that this approach may not be the most adequate for determining whether Croatians tend to express duration in terms of distance or quantity. All four terms (without the addition of ‘time’, namely, ‘long’, ‘short’, ‘much’, and ‘little’) could be used to express duration on their own, though as they are primarily used to refer to physical space, searching for these terms would result in plenty of hits not referring to time (duration), and the data would not be comparable. Ideally a more thorough approach could have been conducted (and could be conducted in future studies) to be able to cover the intricacies of metaphor use, perhaps one similar to that employed by Casasanto et al. (2006), i.e., playing participants pairs of tones and dots of varying durations and asking them to naturally express the difference of the two tones/dots. Unfortunately, this was not a possible approach for the present study due to time constraints. Having said that, the results of the participants tested with Croatian linguistic prompts did reflect the results of the corpus query. Participants were affected by spatial displacement in both conditions, the correlation between displacement and estimated duration was significant in both conditions, though spatial interference was somewhat greater for the filling containers condition, as expected by the prevalence of quantity-based metaphors indicated by the corpus query.

A possible extension of the study could be to test the same participant with varying language context, as was done in Bylund and Athanasopoulos (2017) study, though this would likely not yield starkly different results as individual bilingual background variables did not influence (did not improve the model fit) the participants’ performance in the two tasks (regarding the English

⁸ L3 information is described in detail in Chapters 3.1.1 and 3.2.1.

language context). Participants tested with English linguistic prompts could be primed with distance-based metaphors to see whether this would shift their conceptualization of duration patterns in such a manner that their performance resembles that of native English speakers (i.e., more spatial interference in the growing lines condition), due to the newest evidence suggesting that linguistic experience has a causal role on the conceptualization of duration (Casasanto et al., 2026).

An additional issue of the present study is that proficiency in a given language was entirely self-estimated. A possible extension of the study could include testing the participants' English knowledge, or testing Croatian-English bilinguals who have a formally recognized CEFR (Common European Framework of Reference for Languages) English level of C1/C2 (with C2 being the highest level of English proficiency). This would further ensure that participants are highly advanced English speakers, which would provide more validity of the results. Without implementing this measure, it is possible that participants of the present study either overestimated or underestimated their English proficiency. Given that most participants labelled their English proficiency as 'advanced', the presumption that a subset of these participants consisted of participants who had underestimated their English proficiency, could explain why the correlation of displacement and proficiency was significant only for 'advanced' participants in the line condition, regarding the participants who were tested with English linguistic prompts.

Overall, the findings of the present study contribute to the research area exploring the conceptualization of duration, and add to the growing body of research exploring the effects of bilingualism on the conceptualization of duration. To my knowledge, this is the first study exploring the conceptualization of duration within speakers of a language which nearly equally utilizes both distance- and quantity-based spatio-temporal metaphors. The findings align both with the linguistic relativity principle, and the predictions posed by The Conceptual Metaphor Theory. Regarding the effects of bilingualism on this aspect of cognition, further research needs to be conducted to address the limitations of the present study (namely the issue of self-assessed proficiency). The present results indicate that English did not have a strong effect on the conceptualization of duration of Croatian-English bilinguals tested with English linguistic prompts. It is reasoned that this English did not have a strong effect because the speakers already

had experience with distance-based metaphors in their native language. As such, the speakers did not need to alter their patterns of thinking about duration to accommodate those of English speakers, and were still affected by spatial displacement in both conditions (regarding medium stimuli).

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Appendix A

Written instructions for the growing lines and the filling containers tasks – Croatian

Growing lines task

Dobro došli!

U ovom eksperimentu ćete vidjeti linije kako rastu na ekranu. Nakon što vidite svaku liniju, od Vas će se tražiti da procijenite koliko je vremena bilo potrebno da linija nastane.

Na ekranu će se pojaviti pješčani sat da Vas podsjeti.

Kako biste procijenili vrijeme potrebno za nastajanje linije, kliknut ćete mišem jednom za početak. Kada smatrate da je točno vrijeme prošlo, kliknite mišem još jednom da stanete.

Nećete dobiti povratnu informaciju da ste kliknuli mišem, ali će računalo zabilježiti Vaš odgovor.

Ukoliko imate bilo kakvih pitanja u vezi uputa, molimo Vas da pitate ispitivača sada.

Kliknite mišem kako biste započeli probni zadatak.

Filling containers task

Dobro došli!

U ovom eksperimentu ćete na ekranu vidjeti praznu kutiju koja se postepeno puni. Zamislite da je ta kutija spremnik koji se puni vodom. Nakon što vidite “spremnik” djelomično napunjen, od Vas će se tražiti da procijenite koliko je vremena bilo potrebno da se spremnik napuni do te razine.

Na ekranu će se pojaviti pješčani sat da Vas podsjeti.

Kako biste procijenili vrijeme potrebno za punjenje spremnika, kliknut ćete mišem jednom za početak. Nakon što smatrate da je točno vrijeme prošlo, kliknite mišem još jednom da stanete.

Nećete dobiti povratnu informaciju da ste kliknuli mišem, ali će računalo zabilježiti Vaš odgovor.

Ukoliko imate bilo kakvih pitanja u vezi uputa, molimo Vas da pitate ispitivača sada.

Kliknite mišem kako biste započeli probni zadatak.

Appendix B

Informed consent form - Croatian

Obrazac informiranog pristanka na sudjelovanje u istraživanju

Naziv istraživanja: Temporal language and thought

Glavni istraživač: Panos Athanasopoulos

Asistent u provedbi istraživanja: Lea Bedić

Područje istraživačkog projekta

Ovaj je projekt smješten u znanstvenom području jezika i spoznaje te se bavi pitanjem misle li govornici različitih jezika drukčije.

Postupci istraživanja

Eksperiment uključuje rješavanje niza zadataka na računalu te ispunjavanje kratkog upitnika o uporabi jezika.

Koristi i mogući rizici

Korist ovog istraživanja je bolje razumijevanje utjecaja jezika na mišljenje.

Povjerljivost i anonimnost

Vaši će rezultati biti obrađeni povjerljivo i anonimno. Prikupljeni podaci će možda biti objavljeni u javno dostupnim bazama podataka, ali će biti potpuno anonimni, odnosno nitko neće znati koji podaci pripadaju Vama, a Vaše ime/identitet neće biti nigdje objavljeni. Ako imate dodatna pitanja o istraživanju i/ili želite informacije o konačnim rezultatima, molimo kontaktirajte prof. dr. sc. Panosa Athanasopoulou, SOL, Lunds universitet, Panos Athanasopoulos, Box 201, 221 00 LUND, SWEDEN. Email: panos.athanasopoulos@englund.lu.se

Pristanak

☐ Razumijem da mogu preskočiti pitanja na koja ne želim odgovoriti.

☐ Razumijem da je sudjelovanje u ovom istraživanju dobrovoljno te da ga mogu povući u bilo kojem trenutku bez posljedica.

"Pristajem sudjelovati u ovom istraživanju. Dobio/la sam primjerak ovog obrasca i imao/la ga priliku pročitati."

Potpis ispitanika: _____

Datum: _____

Potpis istraživača: _____

Appendix C

Language background questionnaire - Croatian

Br. ispitanika: _____

Upitnik o uporabi jezika

Dob: _____ Spol: _____

1. Navedite svoj prvi/materinji jezik: _____
2. Koliko sati tjedno (otprilike) trenutno provodite koristeći ovaj jezik? (U svoju procjenu uključite stvari poput druženja, slušanja radija, gledanja televizije, filmova te čitanja/učenja na ovom jeziku): _____
3. Navedite druge jezike koje govorite i procijenite svoju razinu znanja tih jezika prema donjoj skali. Navedite i dob u kojoj ste počeli učiti taj jezik te koliko sati tjedno ga koristite.
 1. Slabo = Imam vrlo ograničenu/nikakvu sposobnost govorenja i razumijevanja jezika
 2. Osnovno = Mogu razumjeti i koristiti neke osnovne riječi i fraze
 3. Srednje = Mogu razumjeti i voditi razgovore na ovom jeziku, ali imam poteškoća s kompleksnijim temama
 4. Napredno = Mogu sudjelovati u kompleksnim raspravama na ovom jeziku
 5. Vrlo napredno = Mogu koristiti ovaj jezik gotovo poput izvornog govornika

Jezik	Dob usvajanja	Razina znanja jezika	Broj sati tjedno
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

4. Koji je Vaš najviši postignuti stupanj obrazovanja (npr. srednja stručna sprema, viša stručna sprema, visoka stručna sprema)?
5. Jeste li trenutno student? Ako da, što studirate i na kojem fakultetu?
6. Koliko dugo (u godinama i/ili mjesecima) živite u Hrvatskoj?
7. U kojoj ste državi proveli većinu svog života?
8. Jeste li ikada živjeli u nekoj drugoj državi/državama i ako da, koliko dugo?
9. Koliko često koristite vizualne alate planiranja (npr. Google Calendar, iCloud Calendar)?

Nikada 1 2 3 4 5 Uvijek

Appendix D

Written instructions for the growing lines and the filling containers tasks – English

Growing lines task

Welcome!

In this experiment, you will see lines appearing on the screen. Once you have seen each line, you will be asked to estimate the time it took to draw the line.

An hourglass will appear on the screen to remind you.

To estimate the time it took to draw the line, click the mouse once to start. When the correct amount of time has elapsed, click the mouse again to stop.

You will not receive any visual feedback indicating that you have clicked the mouse, but the computer will record your response.

If you have any questions about these instructions, please ask the experimenter now.

Click the mouse to start the training phase.

Filling containers task

Welcome!

In this experiment, you will see an empty box on the screen that gradually fills up. Imagine that this box is a tank being filled with water.

When you see that the tank is partially filled, you will be asked to estimate the time it took to fill the tank partially. An hourglass will appear on the screen to remind you.

To estimate the time it took to partially fill the tank, click the mouse once to start. When the correct amount of time has passed, click the mouse again to stop.

You will not receive any visual feedback indicating that you have clicked the mouse, but the computer will record your response.

If you have any questions about these instructions, please ask the experimenter now.

Click the mouse to start the training phase.

Appendix E

Informed consent form - English

Informed Consent Form
Master's thesis project: Temporal language and thought

Researcher:

Lea Bedić
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Thesis supervisor:

Professor Panos Athanasopoulos
Lund University
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The nature of the research project

This experiment is being conducted as part of a master's thesis at Lund University. The project is in the research area of language and cognition, and explores whether speakers of different languages think differently.

Procedures of the study

The experiment involves completing a series of tasks on the computer, and a short language background questionnaire.

Benefits and harms of procedures

The benefits of the study will be the overall increase in understanding how language affects cognition.

Confidentiality and anonymity

Your results will be treated in a confidential and anonymous manner. Aggregate data may be published in public data repositories, but these will be completely de-identified, that is, no-one will know which data belongs to you and your name/identity will not appear anywhere. Should you have additional questions about the study and/or require information regarding the final research results please contact Lea Bedić or Panos Athanasopoulos. Email: lea.bedich@gmail.com; panos.athanasopoulos@englund.lu.se

Consent

☐ **I understand that I can omit questions that I do not want to answer.**

☐ **I understand that this research is voluntary and I have the right to withdraw at anytime without penalty.**

"I agree to participate in this study. I have been given a copy of this form and had a chance to read it."

Signature: _____

Date: _____

Signature of Investigator: _____

Appendix F

Language background questionnaire - English

Ppt nr: _____

Linguistic Background Questionnaire

Age: _____ Gender: _____

1. Enter your first/native language: _____
2. How many hours per week (approximately) do you think you currently spend using this language? (Include in your estimate things like socializing, listening to the radio, watching TV, and films, and reading/studying in this language): _____
3. List any other languages you speak, and give an assessment of your overall proficiency according to the scale below, the age at which you started learning it, and please state how frequently you use it in hours per week.
 1. Poor = Little or no ability to speak or understand
 2. Basic = Can understand and produce some basic words and phrases
 3. Intermediate = Can understand and carry out conversations in this language but can have some difficulty with more complex discussions
 4. Advanced = Can participate in complex discussions in this language
 5. Very advanced = I can use this language to near-native levels

Language	Age of acquisition	Proficiency	Hours per week
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

4. What is your most recent academic qualification (e. g. school leaving qualification, BA, other)?
5. Are you studying anything at the moment? If so, which institution and course?
6. How long (in years and/or months) have you been living in Croatia?
7. Which is the country that you have lived in for most of your life?
8. Have you lived in any other countries, and if so, for how long?
9. How often do you use visual time management tools (e.g., Google Calendar, iCloud Calendar)?

Never 1 2 3 4 5 Always