ABSTRACT

Title of dissertation: MECHANISMS UNDERLYING LEXICAL ACCESS IN NATIVE AND SECOND LANGUAGE PROCESSING OF GENDER AND NUMBER AGREEMENT

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Dissertation directed by: Professor Kira Gor
Second Language Acquisition

Despite considerable evidence suggesting that second language (L2) learners experience difficulties when processing morphosyntactic aspects of L2 in online tasks, the mechanisms underlying these difficulties remain unknown. The aim of this dissertation is to explore possible causes for the difficulties by comparing attentional mechanisms engaged at the early stage of lexical access in native and nonnative language processing.

The study utilized a grammatical priming paradigm to examine the manner in which native and L2 speakers of Russian access and integrate morphosyntactic information when processing gender and number agreement that operates between nouns and adjectives within the same noun phrase (e.g., *prostoj kozjol* “simple-MASC-SG goat-

MASC-SG”) and between nouns and verbs across phrasal boundaries (e.g., *byl kozjol* “was-MASC-SG goat-MASC-SG”).

While native participants (N=36) invoked both automatic and strategic attentional mechanisms, highly proficient L2 participants (N=36), who had been able to perform at the native-like level in offline tasks, exhibited delayed activation of morphosyntactic information and reliance on strategic mechanisms that operate after lexical access. The finding suggests that L2 difficulties with grammar, that are usually regarded as deficits, may reflect differences in the dynamics of lexical activation.

The study also found robust priming effects for both categories and evidence of the Markedness Effect (Akhutina et al, 1999) in both groups of participants: nonnative participants recorded differences in the magnitude of priming between feminines and masculines as well as between singulars and plurals, and native participants showed differential contribution of facilitatory and inhibitory components of priming in response to different genders and numbers. The findings suggest that gender and number may require different processing mechanisms, which, along with salience of morphological markers and agreement structures, may contribute to agreement processing in local dependencies more than syntactic distance.

MECHANISMS UNDERLYING LEXICAL ACCESS IN NATIVE AND SECOND LANGUAGE PROCESSING OF GENDER AND NUMBER AGREEMENT

By

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University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2013

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To my parents, Vyacheslav Lavrov and Nina Lavrova, and
to my husband, Peter Romanov

Acknowledgements

I could not have finished this long journey without God's grace and provision and the invaluable support of many people who deserve special mention.

Dr. Kira Gor has been a strong and supportive advisor since my first days in the MA program, throughout my PhD program, and during the writing of this dissertation. Her study of second language morphology processing first piqued my interest and has ultimately shaped my research path. The freedom she gave me to pursue independent work, her thoughtful guidance, insights, flexibility, and understanding have sustained me along the way. Thank you, Kira!

I would like to thank Dr. Robert DeKeyser, who has been a steady influence over the years: I thoroughly enjoyed his classes, have always been inspired by his research, and appreciate his participation in all my committees—for both of my qualifying papers and for my dissertation. My gratitude goes to the remaining members of my dissertation committee, Drs. Steven Ross and Polly O'Rourke, whose knowledge, recommendations, and personal cheering were invaluable, and to Dr. Min Wang for her constructive feedback. I am also grateful to Dr. William Milberg from the Harvard Medical School, whose research of semantic memory deficits in Alzheimer's disease opened for me a novel path in the investigations of second language processing. Although not a member of my dissertation committee, he showed genuine interest in my work and took time to respond to my questions and guide my thinking.

I am indebted to the faculty who started the MA program in second language acquisition (SLA) in the School of Languages, Literatures, and Cultures (SLLC) over 12 years ago. Their commitment to offering the best graduate education in SLA and their passion for the field had been so contagious that, when a new PhD program in SLA opened at the SLLC, I did not think twice about transferring there from an established and respected PhD program in the College of Education where I was continuing my studies.

I am eternally grateful to all those professors not already mentioned who have imparted their knowledge and experience over the years so generously, particularly Drs. Alene Moyer, Mike Long, Catherine Doughty, Colin Phillips, Cynthia Martin, Masha Lekic, and Rebecca Oxford. I also gratefully acknowledge the institutional support that I received while in graduate school and working on this dissertation.

My sincere thanks go to my classmates and colleagues for being a tremendous resource, and I would like to specifically note Tatyana Vdovina, Svetlana Cook, Charles Mueller, and Mari Rasmussen, who, at different points of the journey, provided advice, encouragement, and a listening ear.

I would like to thank Artemi Romanov, who pointed to the SLA program at the University of Maryland many years ago and encouraged me to apply, and to Alyssa Gillespie, who guided me through the application process—it was on the strength of their personal encouragement and professional recommendations that I found myself back in school in 2001. Thank you both for your invaluable assistance with my research, too!

I appreciate with all my heart Edie Furniss, Elisa Koshkina, Natalya Reznik,[1] Boris Meyerson, and Vlad Fotiyev, who helped with participant recruitment and/or items review; Katia Goryunova, who also helped with data preparation; William Dardick, who answered my statistical questions; and Nancy O. Graham, who helped with editing. It should go without saying, however, that any errors or oversights are mine alone.

I would especially like to thank all the study participants in Russia and the USA who incorporated several (often tedious) testing sessions into their busy schedules to make this research possible.

My deep gratitude goes to my friends for being there for me, for sharing my joys and sorrows, for their prayers, illuminating discussions, and generous help in times of need: Luba Levina, Izolda Fotiyeva, Yuri Petrov, Nina Adams, Kathia Flemens, and Twila and Jack Jackson.

Most of all I thank my family for having endured it all with me so patiently: my husband and soul mate (and a solid researcher!), Peter Romanov, for his love, wisdom, friendship, and for his scientific advice and technical support; and our

[1] Thank you, Natalya, for your gracious permission to include your one-line poems in my language proficiency tests!

children, Kirill and Andrei, for being amazing sons and for fueling my fascination with language acquisition every day. I am thankful for our dog, Roma: he had been my faithful guardian and a cheerful companion since my first weeks in the program and died soon after my defense.

I certainly owe much gratitude to my parents for their neverending love, sacrifice, and faith in me.

And, finally, all the glory belongs to God, for “from him and through him and for him are all things” (Rom. 11:36).

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CHAPTER ONE: INTRODUCTION

The dissertation was motivated by evidence suggesting that second language (L2) learners experience more difficulties acquiring morphosyntax in comparison with lexical-semantic information (Bowden, 2007; Clahsen & Felser, 2006a, 2006b; Clahsen et al, 2010; Hahne & Friederici, 2001), by recent re-examination of the Fundamental Difference Hypothesis (Bley-Vroman, 1989, 2009), and by the debates about the nature of native/nonnative differences in the processing of inflected words (see Gor, 2010, for review). Several hypotheses have been proposed to explain L2 difficulties with grammar.

Generative second language acquisition researchers examine the nature of adult L2 speakers' interlanguage grammar representations compared to the native grammar of the target language (for a full discussion of generative approaches in second language acquisition, see Ionin, 2012). Some posit that these representations are in some way impaired, and that L2 speakers' errors with morphology are indicative of their deeper problems with syntax (e.g., Eubank's Weak Transfer/Valueless Features Hypothesis [1993/94, 1996], Beck's Local Impairment Hypothesis [1998], Hawkins and Chan's Failed Functional Features Hypothesis [1997], Hawkins' Representational Deficit Hypothesis [2003], and the Interpretability Hypothesis [Hawkins & Hattori, 2006; Tsimpli 2003; Tsimpli & Dimitrakopoulou, 2007; Tsimpli & Mastropavlou, 2008]). These approaches have primarily focused on whether adult L2 learners are capable of acquiring formal features that are not part of their first language (L1) grammar suggesting that learners' native language transfer may influence the accessibility of morphosyntactic features in L2 (e.g., Chen, Shu, Liu, Zhao, & Li, 2007; Hawkins & Casillas, 2008; Hopp, 2007, 2010; Sabourin, 2003; Sabourin & Haverkort, 2003; Tokowicz & MacWhinney, 2005; Tsimpli & Dimitrakopoulou, 2007). In direct opposition to these approaches are full-access-to-universal-grammar models of L2 acquisition (Frenck-Mestre, 2009; Rothman, Judy, Guijarro-Fuentes, & Pires, 2010; Schwartz & Sprouse 1994, 1996), which claim that adult L2 learners are capable of acquiring native-like syntactic representations and that their problems are not due to any underlying syntactic deficits, but rather to a mapping problem between syntax and morphology, or difficulty retrieving inflectional morphemes (the Missing Surface Inflection Hypothesis [MSIH)] [Haznedar & Schwartz, 1997; Lardiere, 1998a, 1998b, 2000; Prévost & White 2000; Schwartz & Sprouse, 1996; White et al., 2004). In other words, missing inflection is seen as an access failure, rather than a representation deficit, due to heavy processing demands.

These different theoretical positions have stimulated research of important issues in second language acquisition; however, each account has problems. There is a logical flaw in the representational accessibility-deficit dichotomy: "the burden of proof to accept the hypothesis that a knowledge structure is absent is very difficult to achieve. Just as in any signal-detection problem, a failure to detect a knowledge structure could be due to the sensitivity of the measure or the criterion being used" (Milberg et al., 1999, p. 644). Moreover, evidence of cortical reactivity to gender violations, especially in highly inflected language, in lower-proficiency L2 learners (Tokowicz & MacWhinney, 2005; Tokowicz & Warren, 2010) suggests that even beginning learners may have grammatical representations which they may only access implicitly and that with growth in proficiency they may demonstrate convergence with native speakers (e.g., MacLaughlin et al., 2010). As for L1 language transfer, it cannot not be the only factor that would explain L1/L2 differences (Clahsen et al, 2010): L2 learners from typologically distinct L1 backgrounds exhibit similar performance patterns (e.g., Sato, 2007; but see Portin et al., 2008).

The representation-processing dichotomy cannot fully account for the wide range of behavioral phenomena in L2, either. Each position has largely drawn support from a specific and limited set of experimental paradigms (using either online or offline measures). For example, studies that provide evidence for impaired representations have used offline tasks that measure effects observed at the end-points of a number of processes after the test stimulus has been presented and processing has been completed (e.g., grammaticality judgment, picture selection, word reading and repetition, sentence-picture matching, categorization, etc.). Since offline tasks involve both linguistic and non-linguistic processing components, such as memory and attention, they can obscure performance in any single area, including language domain (Shapiro, Swinney, & Borsky, 1998). In contrast, most of those studies that have concluded that L2 learners' grammatical difficulty stems from processing deficits, have relied almost entirely on online tasks. These tasks measure effects occurring at various temporal points during ongoing processing and are sensitive to fast-acting, automatic processes, as well as to processes that rely on the integration and interaction of several types of information, and so may offer a better insight into the underlying processing mechanisms. However, the outcomes of online studies depend on which temporal point during language processing the experimental procedures are targeting and on which type of priming procedure these experimental procedures employ: in recent studies using regularly inflected *–ed* primes, L2 learners did not show facilitation in masked priming experiments (Neubauer & Clahsen, 2009; Silva & Clahsen, 2008), but were similar to native speakers in terms of the amounts of facilitation they showed in cross-modal priming experiments (Basnight-Brown et al., 2007, cited in Clahsen et al., 2010). Since masked priming is believed to tap access-level representations, whereas cross-modal priming is believed to tap central-level representations (e.g., Marslen-Wilson, Tyler, Waksler, & Older, 1994; Marslen-Wilson, 2007), the findings suggest that the observed L1/L2 differences are confined to early stages of form-level access, and that central or lemma-level processing is similar in the L1 and L2. Hence, methodological differences may tap into different representations and falsely suggest or inconsistently detect processing anomalies in L2.

Cognitive second language acquisition researchers emphasize the role of psycholinguistic and neurolinguistic processes underlying and conditioning knowledge acquisition and real-time production and comprehension in L2. To explain L2 learners' problems with acquisition of grammar, Ullman ties aspects of the lexicon-grammar distinction to the distinction between two brain memory systems, declarative and procedural memory and suggests that the acquisition of grammatical-procedural knowledge in adults is more problematic than the acquisition of lexical-declarative knowledge as a result of decreased rule-abstraction abilities due to augmented working memory capacity, the attenuation of procedural memory, and the enhancement of declarative memory (Ullman, 2001, 2005). Similarly, Paradis (2004, 2009) notes that the ability of procedural memory to support learning and computational operations diminishes with age, forcing adult second language learners to rely more heavily on declarative memory than do children acquiring a first language. DeKeyser posits that L2 acquisition is governed by general laws of human learning and, since L2 is acquired through the same mechanisms of proceduralization of declarative knowledge as other cognitive skills, that different cognitive mechanisms are engaged in L1/L2 learning before and after the critical period (2000). According to the Shallow Structure Hypothesis, L2 grammar does not provide the kind of information required to process complex syntax in native-like ways and forces L2 learners to rely on "shallow" parsing strategies favoring lexical-semantic and other non-syntactic cues to interpretation (Clahsen & Felser, 2006a; b; Silva & Clahsen, 2008; Clahsen et al, 2010).

In contrast with these positions is a view that ties the poor mastery of morphosyntax exhibited by L2 learners to difficulties with non-syntactic, domain-general factors such as low L2 working memory capacity, poor decoding, and/or slower L2 processing speed (McDonald 2000, 2006) resulting in weaker links between semantic and phonological representations and poor lexical access (McDonald & Roussel, 2010). However, simple processing speed, according to Segalowitz, is "a relatively uninteresting feature because it is purely relative" (2007, p. 2), and does not necessarily reflect automaticity characterizing native-like processing (Segalowitz & Segalowitz, 1993) that is not only fast but is essentially effortless, attention-free, unconscious, obligatory, parallel, and (almost entirely) ballistic (Hulstijn, van Gelderen, & Schoonen, 2009). Besides, there is evidence that even those L2 learners who perform a given task with the same speed as native speakers show the same nonnative-like processing patterns as more slowly performing L2 learners, suggesting that resource deficits in L2 may compound the effects of morphosyntactic processing difficulties in the language-specific stages of processing rather than account for them (Clahsen et al., 2010; Trenkic, 2007).[2]

Evidence of dissociation between L2 performance in offline and online tasks parallels the dissociation between native and nonnative processing and suggests that L1/L2 differences are not only quantitative but qualitative due to insufficiently automatized (DeKeyser, 2001, 2009) or not fully integrated morphosyntactic knowledge (Jiang, 2004, 2007; Jiang et al., 2011). However, it is not clear how such selective integration and automatization can be explained. Nor is it clear what cognitive mechanisms underlie morphosyntactic processing in L2. The distinction between mechanisms that are automatic (i.e., unstoppable or ballistic rather than simply fast) and those that are under strategic control pervades the cognitive psychological literature on skill acquisition (Anderson, 1983; Levelt, 1989), literature on language disorders (Blumstein et al., 1991; Milberg et al., 1995; 1999; Arnott, 2001; Arnott et al., 2005, 2010; 2011), and is central to many accounts of L2 acquisition (DeKeyser, 2001, 2007a, 2007b; N. Ellis, 2002; Hulstijn & Hulstijn, 1984; Hulstijn, Gelderen, & Schoonen, 2009; Segalowitz & Hulstijn, 2005; Favreau & Segalowitz, 1983; Segalowitz, 1997, 2003, 2007, 2010). The acquisition of grammatical fluency in L2 is manifested in accuracy in production and comprehension, while the acquisition of cognitive fluency is manifested in “access fluidity—the process

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[2] The extent to which the processing is noise-free can be captured by a coefficient of variation (CV) of a person’s RT in a judgment task computed by dividing the standard deviation of all responses of a given test taker by the mean RT ($CV = SD_{RT}/\text{mean RT}$) (see Segalowitz, 2003; Segalowitz & Hulstijn, 2005). When, in the case of automatization, component processes become routinized or are eliminated altogether, mean RTs and SD_{RT} reduce along with CV_{RT}, suggesting not only quantitative differences in speed but also qualitative differences in how information is processed (DeKeyser & Criado-Sanchez, 2012; Segalowitz, 2003, 2010).

of connecting words and expressions to their meanings (often referred to as lexical access)," and in "attention control—the process by which a language user focuses and refocuses attention in real time as the message being communicated unfolds" (Segalowitz, 2007, p.2). Investigating these processes in combination offers more leverage to SLA research than investigating each process separately.

Gender and number agreement has proven particularly suitable for investigations of morphosyntactic variability in L2. Despite numerous studies (e.g., Acuña-Fariña, 2009; Ayoun, 2007; Friederici et al., 1999; Granfeldt, 2005; Grüter, Lew-Williams, & Fernald, 2012; Hawkins & Franceschina, 2002; 2004; Jiang, 2004, 2007; Jiang et al., 2011; McCarthy, 2008; Vatz, 2009; White et al., 2004), evidence regarding the extent of morphological insensitivity in L2 learners continues to be a matter of debate. For example, it has been suggested that L2 learners are not sensitive to morphemes that are not instantiated in their L1 compared to ones that are (e.g., Hawkins & Casillas, 2008; Chenet al., 2007; Sabourin, 2003; Sabourin & Haverkort, 2003; Tokowicz & MacWhinney, 2005; Tsimpli & Dimitrakopoulou, 2007, Jiang, 2007; Jiang et al., 2011). Further, while early and proficient late bilinguals of gendered languages are sensitive to noun-adjective agreement in both gender and number, this sensitivity to agreement violations was shown to be absent in low-proficient late bilinguals (e.g., Alarcón, 2009; Keating, 2009; Osterhout et al., 2008; Sagarra, 2007; Sagarra & Herschensohn, 2008; Tokowicz & MacWhinney, 2005), implying that sensitivity to grammatical gender and number discord is modulated by L2 proficiency level (Sagarra & Herschensohn, 2011).

Empirical evidence is inconclusive regarding whether gender and number agreement are represented differently at the lexical level and, if they are, regarding the complexity of gender processing versus number processing. Some monolingual studies claim that gender and number are processed similarly (e.g., Lukatela et al., 1987; Osterhout & Mobley, 1995), whereas other studies reveal that monolinguals have more difficulty processing gender than number agreement (e.g., Antón-Méndez et al., 2002; Barber & Carreiras, 2003, 2005; De Vincenzi, 1999). This larger cognitive difficulty of processing gender is explained by the fact that grammatical gender is a stem-inherent feature of a lexical representation that is stored and not computed. In contrast, number is considered a morphological feature that combines with the stem of the word (e.g., Franceschina, 2001; White et al., 2004). So, while gender discord forces the processor to return to the lexical identification stage, number discord merely requires checking of the final processes of syntactic recognition without having to return to the initial processes of lexical access (e.g., Domínguez, Cuetos, & Ségui, 1999). There is insufficient evidence regarding the acquisition of gender versus number agreement in L2, especially, in a richly inflected language, as the picture becomes "more intricate" when models of gender versus number processing "are extended to more complex morphological systems" (De Diego-Balaguer & Rodriguez-Fornells, 2010, p. 233).

This dissertation takes as its starting point the notion that, despite current considerable evidence suggesting that L2 learners experience difficulties with morphosyntactic aspects of their L2, the mechanisms underlying morphosyntactic processing remain unknown. Since language processing is a dynamic process that involves a number of time-dependent processing components or stages, it can be assumed that disruptions during early stages of lexical access (prelexical, or pre-access processes), such as changes in the dynamics of activating morphosyntactic information and maintaining it for a critical time frame may induce a cascading effect and disrupt the integration stages (postlexical, or post-access processing) (Arnott, 2001; Arnott et al., 2011; Blumstein, 1997; Blumstein & Milberg, 2000; Milberg et al., 1999). The bases for language deficits have been widely investigated in patients with aphasia, Alzheimer's dementia, Parkinson disease, and schizophrenia (e.g., Barch et al., 1996; Chertkow et al., 1994; Milberg et al., 1995), and extending findings from aphasics research to the field of second language acquisition can offer a promising perspective for examining language deficits in L2 learners.

A new account of the diverse range of priming phenomena reported in Alzheimer's dementia has been proposed by Milberg and colleagues (1999). According to their Gain/Decay Hypothesis, language pathologies can cause subtle changes in either the level or rate of semantic activation: a slight delay in accessing information or an early decay of activated information at early stages of processing, such as lexical access, may disrupt language processing at a later stage of information integration. Since similar mechanism operate in both semantic and morphosyntactic priming (e.g., Barber & Carreiras, 2005; Bates et al., 1996; Cacciari & Padovani, 2007; Gunter et al., 2000; Gurjanov, Lukatela, Lukatela et al., 1985; Gurjanov, Lukatela, Moskovljevic et al., 1985; Hagoort & Brown, 1999; Hillert and Bates, 1996; Lukatela, Kostic, Feldman et al., 1983; Vainio et al., 2003; Wicha, Bates, Hernandez et al., 1997), an examination of morphosyntactic priming patterns in L2 learners from the perspective of the Gain/Decay Hypothesis may offer valuable insight into why L2 learners performance on grammar is not native-like. The Gain/Decay Hypothesis (Milberg et al., 1999) predicts that deviant performance may be caused by changes in either the level or rate of semantic activation rather than by impaired syntactic knowledge or impaired syntactic processing. Based on the assumption that lexical access represents a crucial entry-level stage of virtually all aspects of language processing, exploring the dynamics of lexical access in L2 seems to be an ideal point of departure in the investigations of L2 difficulties with morphosyntax. To the best of my knowledge, no study so far has attempted to simultaneously investigate the complex interplay of the attentional mechanisms underlying the access to morphosyntactic information in L2 and the types of morphosyntactic structures to determine why and where online L2 processing may be failing.

This dissertation aims to: (1) define the morphosyntactic language abilities of a group of L2 learners of Russian within a specified proficiency range; (2) determine whether native/nonnative differences in processing morphosyntactic structure arise pre- or postlexically during online processing; (3) examine the dynamics of the automatic and attentional mechanism(s) involved in accessing morphosyntactic information in the lexicon in order to determine whether automatic or controlled (expectancy-based) mechanisms account for L2 grammatical deficits; and (4) investigate priming patterns in different types of syntactic dependencies and in gender and number agreement in order to compare their nature, locus, and direction in native and nonnative participants.

To this end, this dissertation explores Russian native and nonnative speakers' sensitivities to morphosyntactic markers in gender and number agreement governed by two types of local dependencies: noun-adjective (NA) agreement reflecting a within-phrase dependency in word pairs that form a single constituent and noun-verb (NV) agreement reflecting a dependency that crosses syntactic phrase boundaries. It also compares the processing of gender and number agreement in order to identify any differences in processing patterns that may be have been caused by differences in the nature, locus, and direction of priming, as well as in the underlying mechanisms involved. By using online (lexical decisions with priming) tasks the dissertation not only examines the ability of nonnative speakers to implement their linguistic knowledge in real-time processing but examines events that can reveal dissociations of linguistic knowledge structures from the operations required to access those structures (Blumstein, Milberg, Dworetzky, & Rosen, 1991; Milberg & Blumstein, 1981).

Chapter 2 reviews the literature on lexical access and theoretical models of the mechanisms of priming, and the literature on gender and number agreement. Chapter 3 reports on two preliminary studies. The first study one aimed to characterize the language performance of L2 learners in comparison to native speakers in an offline task and the second study aimed to develop a priming paradigm that allowed subsequent explorations of the time course of morphosyntactic priming and the underlying processing mechanisms. Chapter 4 presents the methodology of the main study, Chapter 5 presents the results, which are discussed in Chapter 6. Chapter 7 presents the general discussion and concludes.

The dissertation represents a comprehensive evaluation of events at the access level of native and nonnative language processing, dissociating processes that previously have been confounded and, therefore, signifies a novel approach to examining language processing in L2. Understanding the underlying mechanisms of lexical access in L2 has important implications for theories of both native and nonnative language processing and contributes to the current debates about the nature of L1/L2 differences in processing grammar.

CHAPTER TWO: BACKGROUND

2.1 Lexical access and theoretical models of the mechanisms of semantic priming

Each word of a language is defined in terms of its semantic, syntactic, morphological, and phonological properties (Levelt, 1989, 1999) and can be accessed via perceptual analysis of its visual or acoustic features (Becker, 1980; Morton, 1969). In order to understand the meaning of a printed word, the reader consults the word's representation in his/her internal lexicon. This consultation is referred to as lexical access and is generally assumed to be necessary when deciding whether an orthographically legal letter string is a word or not (Besner & Swan, 1982).

There are two classes of models that explain how lexical access occurs (Gleason & Bernstein, 1998): (1) serial search models propose that the lemma and lexeme levels of lexical access are in a feed-forward serial relation and that lexical access occurs by sequentially scanning all lexical entries, one entry at a time, to determine whether the item is a word or not, and then retrieving the necessary information about it (e.g., the autonomous search model by Forster, 1976), whereas (2) parallel access (activation) models posit that perceptual input about a word activates lexical items directly, that multiple entries can be activated simultaneously, and that the lexical item which shares the most features with the targeted stimulus is the one that is chosen (e.g., Marslen-Wilson's (1987) cohort model, McClelland & Seidenberg's (1989) connectionist model, and Morton's (1969) logogen model). Parallel access models, which describe the process or word recognition in terms of activation of a word's mental representation in memory, are currently more widely accepted than serial models to explain lexical access

(McNamara, 2005). I, in this dissertation, will examine lexical access on the basis of these parallel models, which postulate the existence of automatic and strategic mechanisms of attentional control that can operate before or after lexical access (e.g., Collins & Loftus, 1975; McNamara, 2005; Neely, 1977, 1991; Posner & Snyder, 1975).[3]

2.1.1 Automatic spreading activation

Spreading activation models (Anderson, 1976, 1983, 1993; Collins & Loftus, 1975; Posner & Snyder, 1975) can be considered the canonical models of semantic priming. They share three fundamental assumptions: (a) retrieving an item from memory amounts to activating its internal representation, (b) activation spreads from a concept to related concepts, and (c) residual activation facilitates a concept's subsequent retrieval. For example, the visual presentation of the word *lion* activates its internal representation. This activation spreads to all related lexical entries, such as *tiger*. If the word *tiger* appears soon after the word *lion*, it can be identified more quickly than it otherwise would, and more quickly than an unrelated word such as *chair*, because it is already partially activated (or 'primed'). This process is known as '*automatic spreading activation'*, or ASA (Collins & Loftus, 1975). The process of spreading activation has been incorporated into network models of memory, or mental lexicon, conceptualized as a network of interconnected or linked neuron-like elements (Neely, 1991), or nodes. The nodes correspond to concepts and links correspond to various types of relations between concepts (McNamara, 2005).

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[3] Note that the distinction among mechanisms that are related to attentional control does not reflect the distinction between sublexical (below the word) (Taft, 1994) and supralexical (above the word) (Giraudo & Grainger, 2000) accounts of morphological processing.

Automatic cognitive processes are defined as those having a quick onset, proceeding without intention, awareness, or the participant's control, are fast-acting, effortless, do not demand attentional resources, do not interfere with other tasks, and are not strategic (Neely, 1977, 1991; Posner & Snyder, 1975; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). "Once appropriately initiated, activation obligatorily and automatically spreads from structural constituent to structural constituent in a dynamic wave front of activation that rises and falls over time" (Milberg et al, 1999, p. 644). It is generally assumed that ASA occurs at each level of linguistic representation within the lexicon, namely semantics, syntax, morphology, and phonology (Blumstein & Milberg, 2000) and is expected to operate in *all* priming experiments (Ober & Shenaut, 1995). However, the individual elements within the storage architecture may vary in how active they are, with the magnitude of activation being graded as a function of associative strength (i.e., distance) and determined by the degree to which a particular connection has been reinforced through previous experience (Milberg et al, 1999). Importantly, ASA produces only benefits but not costs: while facilitation is commonly found for stimulus onset asynchronies (SOAs) of less than 250 ms, inhibition—the traditional index of strategic processing—is small to nonexistent at such short SOAs (Neely, 1991). Besides, automatic priming is not affected by the proportion of related pairs in the list or instructions, or by the effect of unrelated as compared to neutral primes.[4]

[4] The priming effect is usually quantified by subtracting reaction times (RTs) for word targets in related or congruent contexts from RTs for word targets in unrelated or ungrammatical contexts and can be further defined in terms of "facilitation,"or the extent to which priming reflects the speeding of responses to targets in congruent contexts, and "inhibition," or the extent to which priming reflects the slowing of responses to targets in ungrammatical contexts. Using a neutral prime such as the letter string "xxxx," facilitation and inhibition are calculated as the difference in the reaction time between the neutral and congruent and neutral and ungrammatical prime conditions, respectively.

2.1.2 Strategic processes in priming

Semantic priming, however, is not purely automatic. Two strategic processes have been identified and studied, *expectancy* and *semantic matching*. Expectancy refers to the active generation of candidates for the upcoming target related to the prime. Targets that are in this expectancy set are processed more quickly than those that are not (Becker, 1980). Expectancy is relatively slow-acting, effortful, under the participant's conscious control (hence, a controlled process); it uses attentional resources and interferes with other tasks (Posner & Snyder, 1975; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977; Neely, 1977, 1991). Expectancy-driven effects emerge when SOAs are 400-500 ms and longer, and the priming effect increases with an increase in the proportion of related pairs in the list, can be influenced by instructions, and can involve inhibition or interference from unrelated (as opposed to neutral) primes (de Groot, 1984; McNamara, 2005; Neely, 1977, 1991). It is important to note that, as ASA, expectancy is a prelexical mechanism: it precedes lexical access of the target and can speed up or slow down access of the target concept.

Another controlled priming process is *semantic matching* or *coherence-checking,* the search for a relationship between the target and the prime that proceeds from the target back to the prime (de Groot, 1984; Forster, 1981; Neely, 1977, 1991). Unlike ASA and expectancy,coherence-checking is postlexical. Rather than speeding up access to the target's lexical node, semantic checking produces priming via processes that either affect the selection of the target's node after it has been entered into a visually defined set between lexical access and conscious recognition (Becker, 1980; Norris, 1986), or after lexical access for the target has occurred (de Groot, 1984; Neely & Keefy, 1989). The presence of a relationship seems to bias a "word" response, thus producing facilitation for related words, whereas the absence of a relationship seems to bias a "nonword" response, producing facilitation for nonwords and inhibition for unrelated "words." The process of semantic matching, as expectancy, takes time to develop, and thus, it has greater effects at long SOAs.

2.1.3 The three-process hybrid model of semantic priming

Although each of the theoretical mechanisms discussed above can account for data not explained by other approaches, no single one of them provides a complete explanation for the complex array of priming phenomena (for review see Neely, 1991). Neely and Keefe's (1989) hybrid three-process model of semantic priming, which contains all the three independent processes described above (ASA, expectancy, and semantic matching) can account for nearly all of the existing data and is particularly useful for the purposes of this study, as this model can be used to isolate the contributions of each of the three processes and associate them with a particular priming effect.

Neely and Keefy propose that ASA spreads rapidly, occurs unconsciously and is not under strategic control, and produces facilitation in the processing of semantically related items but no inhibition in the processing of semantically unrelated items. The expectancy process operates when related primes and targets frequently occur together within an experimental session. Subjects use the prime to generate candidates for the target. The process is relatively slow acting, is consciously controlled, and produces facilitation in the processing of expected items and inhibition in the processing of unexpected items. Finally, a semantic matching process occurs in the lexical decision tasks after lexical access has occurred and subjects check for a relationship between the target and the prime. The presence of a relationship creates a bias towards the word response, whereas the absence of a relationship creates a bias towards a nonword response.

2.2 Morphosyntactic priming in L1

While the dichotomy between automatic and controlled processing has been developed with respect to lexical access in semantic processing, there is evidence that this division between involuntary/rapid/unconscious processes and voluntary/slow/conscious processes may underlie morphosyntactic, or grammatical, processing as well (Blumstein et. al, 1991; Arnott et al., 2005; Nicol, 1996). Goodman, McClelland, and Gibbs (1981) demonstrated that lexical decision latencies are shorter when a word is preceded by another word producing a syntactically legal phrase (e.g., *men swear*) than when the target is preceded by a word producing a syntactically illegal phrase (e.g., *whose swear*). Investigations focusing on sensitivity to grammatical structure have shown that local syntactic dependencies may be used to facilitate lexical access and process relationships with greater speed.

In a series of papers, Lukatela and colleagues used a continuous lexical decision methodology, similar to a priming paradigm, in which preceding items could be interpreted as being in a syntactic relation to following items. They used Serbo-Croatian, in which adjectives are overtly marked for case, gender, and number matching the associated noun, and found that lexical decision response times to targets preceded by grammatically congruent words were faster than lexical decision response times to targets preceded by grammatically incongruent words (Lukatela et al., 1982, 1983, 1987; Gurjanov et al., 1985). In addition, Wright and Garrett (1984) used sentence fragments as priming context and found that the grammatical structure of these fragments affected lexical decision latencies to targets, even though the targets were not semantically related to the preceding context and the sentence fragments were semantically anomalous. For example, modal verb contexts preceding main verb targets and preposition contexts preceding noun targets yielded shorter decision latencies than the contrary pairings (modal-noun and preposition-verb). Finally, Caramazza, Laudanna, and Romani (1988) showed that even lexical decisions for nonwords are affected by the morphological structure of the stimuli.

Various studies have reported that the presence of a predictive modifier speeds processing for gender/number agreement relative to an unpredictive modifier and that congruency in agreement speeds up processing, whereas incongruency slows it down (Barber & Carreiras, 2005; Cacciari & Padovani, 2007; Gunter et al., 2000; Hagoort & Brown, 1999; Vainio et al., 2003). Grammatical gender priming effects in L1 have been demonstrated across several languages and tasks: in Italian using picture naming (Bentrovato, Devescovi, D'Amico et al., 1999), cued shadowing (Bates, Devescovi, Hernandez et al., 1996), and gender monitoring (Bates et al., 1996); in French using auditory lexical decision and gating (Grosjean, Dommergues, Cornu et al., 1994); in German using picture naming (Hillert & Bates, 1996; Jacobsen, 1999) and cross-modal visual naming (Jacobsen, 1999); in Spanish using picture naming and semantic judgment (Wicha, Bates, Hernandez et al., 1997); in Russian using cued shadowing (Akhutina, Kurgansky, Polinsky et al., 1999; Akhutina, Kurgansky, Kurganskaya, et al., 2001), reading time (Taraban & Kempe, 1999), and a forced-choice gender agreement task for verbs (Taraban & Kempe, 1999). The presence of gender marking on prenominal adjectives was shown to prime word access in Serbo-Croatian (Gurjanov, Lukatela, Lukatela et al., 1985; Gurjanov, Lukatela, Moskovljevic et al., 1985; Lukatela, Kostic, Feldman et al., 1983). It is believed that gender priming may be explained by existence of a shared gender node to which all nouns of a given grammatical gender are linked (Levelt, Roelofs & Meyer, 1999; Schriefers & Jescheniak, 1999).

2.3 Models of grammatical priming

The typical normal time course in which priming can be observed in native speakers is between 50 and 2000 ms. The locus of morphosyntactic priming effects, however, has been a subject of debates. Some researchers have supported Posner and Snyder's theory of automatic and controlled processing (1975) and have maintained that rules governing the relationships between contiguous words in a sentence may be accessed automatically as a result of ASA or of a strategic mechanism creating prime-based expectancies (Lukatela et al., 1982), and observed grammatical priming occurs prelexically (Bates et al., 1996; Blumstein et al., 1991; Samar & Berent, 1986). With respect to the precise nature of such prelexical mechanisms, Samar and Berent (1986) have proposed the "experiential-relatedness hypothesis" of grammatical priming (p. 267) suggesting that the establishment of associative links between contiguous syntactic categories such as articles and nouns (*the boy*) results in an organizational structure similar to the network postulated for category/exemplar semantic information. Therefore, grammatical priming reflects either the spread of activation from prime nodes (*the*) to associated target nodes (*boy*) or the creation of expectancies about the target based on prior experience of the prime.

Other researchers have regarded the notion of automatic spreading activation of grammatical information as highly improbable and have supported a postlexical coherence-checking account of grammatical priming similar to the postlexical semantic checking theory of semantic priming (Goodman et al., 1981; Friederici & Jacobsen, 1999; Goodman et al., 1981; Gurjanov et al., 1985; Gurjanov et al., 1986; Seidenberg et al., 1984; West & Stanovich, 1986). This school of thought suggests that grammatical priming involves postlexical coherence-checking mechanisms that conduct a conscious check for grammatical coherence after the lexical representations of both prime and target words have been accessed.

Deutsch and Bentin (1994) have postulated an interactive model of grammatical priming that reflects the interaction of pre- and postlexical processing mechanisms and maintained that grammatical priming effects are mediated by attention, different degrees of which are required at different stages of processing. Specifically, individuals generate covert expectancies regarding grammatical coherence. Such expectancies based on syntactic analysis are rather specific and may speed up the stimulus identification by facilitating its integration with the syntactic structure of the context. In this case subsequent coherence-checking requires only minimal attentional resources and may even be considered to operate more-or-less automatically. In the event of the expectancy of coherence being violated, however, attentional resources must be engaged to re-evaluate input, producing inhibition.

2.4 The costs and benefits of priming

The priming effect is a relative measure. The extent to which each of the underlying processing mechanisms contributes to observed priming effects can be determined by measuring the costs (inhibition) and benefits (facilitation). Typically, performance on target words preceded by related or grammatical primes is compared to performance on targets preceded by unrelated or ungrammatical primes. A methodological problem with this comparison is that one cannot determine whether related or grammatical primes facilitate performance on unrelated or ungrammatical primes, inhibit performance, or both (e.g., Posner & Snyder, 1975). To determine the relative contributions of such facilitatory and inhibitory effects to semantic priming, one needs a baseline condition with neutral primes that are neither semantically or grammatically related nor unrelated to the target (such as the letter string "*xxxx*"). As explained above, facilitation is quantified as the difference between the neutral condition and the related/grammatical condition, and inhibition is quantified as the difference between the neutral prime condition and the unrelated/ungrammatical prime condition (Posner & Snyder, 1975).

ASA reduces response times for targets in related/grammatical conditions but does not influence responses to targets in unrelated/ungrammatical conditions. Automatic mechanisms result, therefore, in "facilitation" (defined as faster reaction times for related/grammatical prime/target conditions than for a neutral or baseline condition) only.

In contrast to automatic mechanisms, controlled processing routines reduce response times for related/grammatical words and increase response times for unrelated/ungrammatical words. Both expectancy-based and semantic-matching strategies yield, therefore, facilitation and inhibition. Inhibition is defined as slowed reaction times in unrelated/ungrammatical prime/target conditions relative to a neutral condition.

As inhibition requires conscious attention, its presence or absence is a key feature in isolating the automatic and attentional processes that underlie priming effects. Accordingly, facilitation in the absence of inhibition reflects automatic processing, and facilitation in the presence of inhibition represents strategic processing. Whether these strategic mechanisms operate pre- or postlexically can be determined by examining inhibitory effects over time.

2.5 Dissociating processing mechanisms

In order to dissociate attentional processes and to examine the contributions of each of the three processes to a particular priming effect in morphosyntactic priming, the current study used the three-process model borrowed from semantic priming (Neely, 1991; Neely & Keefe, 1989).

It was assumed that prelexical processing, being time-dependent, would be represented by an interaction of SOA and prime. Fast, automatic activation of grammatical information would be reflected at short SOAs by priming effects with a facilitatory component only and may be expected to dissipate by 400 ms (de Groot, 1984; McNamara, 2005; Neely, 1977,1991). Expectancy mechanisms, on the other hand, require the engagement of limited-capacity attention, are slower to act, emerging after 400 ms, slower to degrade than ASA, increase over time, and are represented at longer SOAs by facilitation in the case of expected items and inhibition in the case of unexpected items. Expectancy effects can be promoted by (a) overtly instructing participants to develop expectancies about the target words based on their preceding prime (Balota, Black, & Cheney, 1992; Favreau & Segalowitz, 1983; McDonald et al., 1996; Neely, 1977; Spicer et al., 1994), (b) covert relatedness proportion manipulations of either the stimulus list (Neely et al., 1989) or the practice stimulus list (Milberg, Blumstein, Katz, Gershberg, & Brown, 1995), or by (c) allowing prime information to remain available for most of the SOA (Balota et al., 1992).

Postlexical coherence-checking processes operate irrespective of SOA, thus, they frequently confound attempts to dissociate prelexical mechanisms underlying lexical access (Balota et al., 1992; Neely, Keefe, & Ross, 1989). According to Neely (1991), coherence-checking can be minimized by using a low nonword ratio or by replacing the standard binary yes/no decision with a single choice or go/no-go response format where subjects need only to respond to word targets (Gordon & Caramazza, 1982, 1983). The discovery of inhibition at even the shortest SOA or lack of interaction between the magnitude of priming and SOA would indicate that attentional processing has occurred postlexically, or after the word's meaning was accessed, rather than prelexically (Arnott, 2001, 2005). The absence of inhibition at short SOAswould indicate that experimental procedures have minimized postlexical processing (Thompson-Schill et al., 1998).

Table 1a summarizes the characteristics of automatic and strategic mechanisms, and Table 1b summarizes the characteristics of prelexical and postlexical processes in relation to a set of variables that can help dissociate these different processes evoked during morphosyntactic priming.

Table 1a. *Automatic versus strategic processes*

Variables	**Automatic processes**	**Strategic processes**
Speed	Fast-acting	Slow-acting
Expectations/ Attention	Unconscious, no attention required	Conscious, attention required
Effort	Effortless	Effortful
Costs/Benefits of Priming	Facilitation only	Facilitation and inhibition
SOA	Emerges at short SOAs, dissipates by 400 ms	Emerges at medium SOAs (400 ms), stays robust at long SOAs (e.g., 1000 ms)

Table 1b. *Prelexical strategic versus postlexical strategic processes*

Variables	**Prelexical strategic processes**	**Postlexical strategic processes**
Interaction with SOA	Yes, time-dependent	No, time-independent
Experimental manipulation	1. Can be promoted by • overt instructions • covert increase in grammaticality proportion • allowing prime to remain available for most of the SOA . 2. Can be minimized by • covert decrease in grammaticality proportion • brief presentation of the prime (less than 250 ms)	Can be promoted or minimized by • a high or low nonword ratio: - the presence of a grammatical relationship between the target and the prime biases the word response (causing facilitation for words in grammatical contexts) - the absence of a grammatical relationship biases a nonword response (causing facilitation for nonwords and inhibition for words in ungrammatical contexts)

2.6 The Gain/Decay Hypothesis

Priming procedures are often used to investigate the bases for semantic language decrements associated with aphasia, Alzheimer's dementia, Parkinson's disease, and schizophrenia (e.g., Barch et al., 1996; Chertkow et al., 1994; Milberg et al., 1995), and findings with these populations can offer valuable insights for second language acquisition research. Traditionally, abnormal measures of ASA have been thought to represent the degradation of semantic representations, whereas expectancy-based priming anomalies have signaled impairments in the attentional processes used to retrieve semantic information. Recently, however, in a landmark paper on semantic activation, Milberg and colleagues (1999) challenged the degradation/retrieval dichotomy and proposed the Gain/Decay Hypothesis to account for the diverse range of priming phenomena that have been reported in Alzheimer's dementia. The basic tenet of Gain/Decay Hypothesis is that different pathologies (such as Parkinson's disease, Alzheimer's dementia, and schizophrenia) are able to effect subtle changes in either the level or rate of semantic activation. As a result, an individual may be able to access semantic representations to a greater or lesser extent, and faster or slower, than normal. For example, a slight delay in accessing information or the decay of activated information at early stages of processing may disrupt sentence comprehension tasks that require the integration of linguistic information into an ongoing message or that operate within time constraints (Kilborn & Friederici, 1994). A series of studies (e.g., Swinney, Zurif, Prather, & Love, 1996; Zurif & Swinney, 1994, as cited by Shapiro, Swinney, & Borsky, 1998) demonstrated that agrammatic Broca's aphasics do not reactivate the appropriate antecedent (filler) at the gap site while comprehending object-relative sentences, nor do they show immediate, exhaustive access of the multiple senses of ambiguous nouns, suggesting that their difficulty with object-relative constructions may not reflect a disruption to syntactic knowledge or syntactic processing, per se, but may be a result of a difficulty in activating and reactivating lexical information rapidly enough during ongoing processing in real time (Shapiro, Swinney, & Borsky, 1998). Accordingly, researchers may not consistently detect processing anomalies; this will depend on which temporal point during the time course of spreading activation the experimental procedures are targeting.

According to Milberg and colleagues (1999), activation can be described by the exponential equation:

$$y = A\frac{t}{\tau^2}e^{-\frac{t}{\tau}} - \theta$$

where *A* represents a strength of association between nodes which influences the level of activation and, to a lesser extent, the rate at which activation increases and decreases; τ is a time constant that represents the summation of input from connected nodes and controls the rate of activation and decay; *t* represents a temporal point in the time course of ASA, *e* represents the exponential function, and θ represents activation threshold. Milberg et al. reasoned that disruptions such as generalized neural noise, destruction of semantic representations, or an increase in the recognition thresholds of semantic representations would lead to a decrease in strength of association *(A)* and subsequently, to reduced levels of activation. Alternatively, either increased or decreased input would change the time constant *(τ)* and, therefore, the rate of activation (Milberg et al. proposed that, in

Alzheimer's dementia, the time constant would decrease due to disease-related changes in synaptic density).

Based on Milberg et al.'s (1999) formula, Figures 1a and 1b display a hypothetical normal activation function where A=15 and τ=0.6 (shown as a solid line). Arbitrary changes to A (Figure 1a) and τ (Figure 1b) are also displayed as broken lines. As can be seen in Figure 1a, decreasing A from 15 to 10 leads to a flattening of the activation curve and, hence, to less than normal levels of activation. Activation is also slower and decays more quickly than normal. Hence, changes in the strength of association would be realized as an absence of facilitation at short and long SOAs and reduced facilitation at medium SOAs. A decrease in τ from 0.6 to 0.2, as shown in Figure 1b, would result in increased activation that rises and falls more quickly than normal and, depending on SOA, would be operationalized as the presence or absence of normal facilitation, the presence of facilitation earlier than normal, or greater-than-normal facilitation. The consequences of an increase in τ (say from 0.6 to 0.8), on the other hand, would be activation that is slower to both rise and decay than normal. An increase in the time constant would result, therefore, in the absence of normal facilitation at short SOAs, followed at longer SOAs, by a facilitation effect when normally the related prime advantage would have degraded.

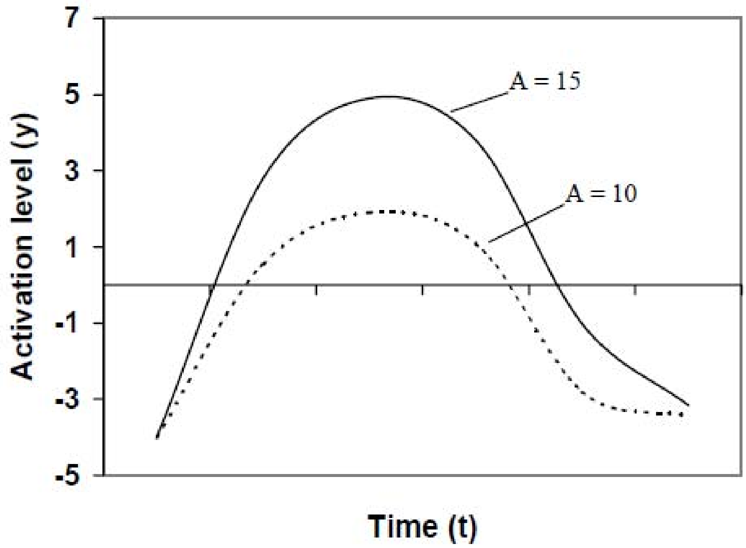

Figure 1a. Semantic activation functions for $\tau = 0.6$, $\theta = 4$, $A = 15$ and 10, threshold=zero (Arnott, 2001, p. 79).
Note: level and time units are unspecified.

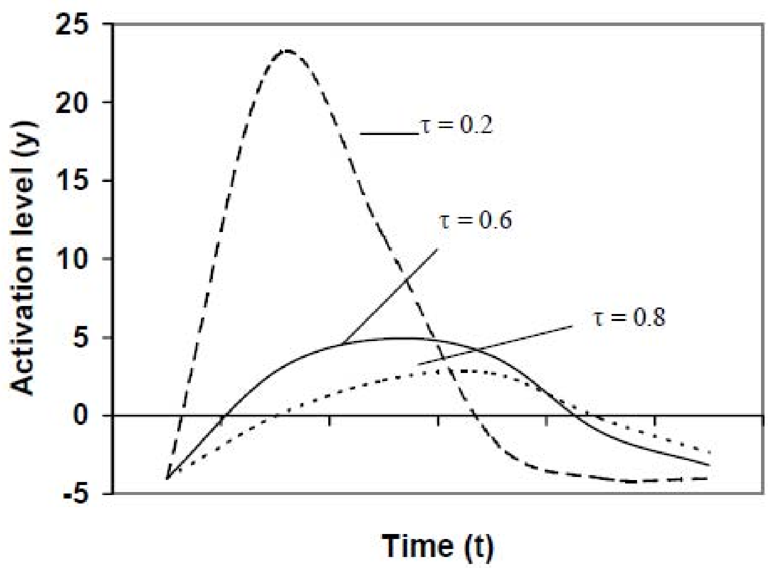

Figure 1b. Semantic activation functions for A =15, $\theta = 4$, $\tau = 0.2$, 0.6, and 0.8, threshold=zero (Arnott, 2001, p. 79).
Note: level and time units are unspecified.

Extending the hypothesis to L2 processing may offer a useful theoretical framework for examining L2 activation patterns. According to Spitzer and Neumann (1996), neurons are slow and noisy. While neural “noise” is a normal aspect of cortical information processing, recent evidence suggests that L2 processing may increase neural noise levels to such an extent that the normal balance between noise and signal strength, known as the signal-to-noise ratio (SNR) may be reduced, and information processing may be compromised. Although the same neural structures responsible for L1 processing are engaged in L2 processing in both low- and high-proficient late bilinguals (e.g., Rueschemeyer, Zysset, & Friederici, 2006; Suh et al., 2007), these brain regions may be differentially engaged by the two languages in lower-proficiency bilinguals, with additional neural activity, mostly in prefrontal areas of the brain during L2 processing than during L1 processing (Briellmann et al., 2004; Marian et al., 2007; Hernandez, Hofmann, & Kotz, 2007), as learners may compensate for lower efficiency by “driving” these regions more strongly and activating a greater number of neurons to perform a given task (Indefrey, 2006). With respect to the expected impact of L2-related reductions in SNRs on events within the memory system, increased noise would result in reduced signal-to-noise ratios and in slower and less efficient processing of prime information and, therefore, in information activation that would be slower and less robust than normal (Milberg et al., 1999). Hence, L2 speakers would be expected to experience changes in both the automatic and controlled processes of lexical access. A systematic investigation of the processes using a range of grammatical features and types of dependencies would provide particularly interesting insights into the potential causes and loci of processing failures in L2.

2.7 L2 Processing of agreement and grammatical priming

2.7.1 Agreement

In the context of this study, *agreement* is defined as follows. "The term *agreement* commonly refers to some systematic covariance between a semantic or formal property of one element and a formal property of another" (Steele, 1978, p. 610). The element which determines the agreement is called the *controller*. The element whose form is determined by agreement is the *target*. For example, in *The system works*, *system* is the controller, and *works* is the target. The syntactic environment in which agreement occurs is the *domain* of agreement (e.g., subject-verb agreement), and when we indicate in what respect there is agreement, we are referring to agreement *features* (e.g., gender or number). Other factors that may have an effect on agreemet, like word order, are called agreement *conditions* (Corbett, 2003).

The agreement rule has no effect on semantic processing, and its role is to specify the syntactic relations between the constituents of a phrase or a sentence. In other words, the agreement rule links, or integrates, linguistic structures into meaningful structural units. When these links are established locally, or between contiguous structures, they are called *local dependencies*. Noun-adjective (NA) agreement is an example of a local dependency within the boundaries of a noun phrase (NP) that involves establishing a link between the noun head and the adjective (*small, dog* →[$_{NP}$ *small dog*]). Subject-verb, or noun-verb (NV) agreement occurs across phrasal boundaries and involves establishing a link between the head of the subject NP (*dog*), and the verb (*barked*). In both noun-adjective and noun-verb agreement, the targets, the adjective and the verb, depend on the properties of the controller, the noun head, for their gender/number specification, with which they must agree. These local gender and number agreement dependencies, NA and NV dependencies, are the focus of this study.

2.7.2 Processing agreement

The computation of agreement rules plays a central role in language comprehension, especially in richly inflected languages, and, when processing agreement, native speakers demonstrate congruency effects evidenced in shorter reaction latencies when syntactic items agree in gender or number, and incongruency effects, when items have incorrect agreement (e.g., *mesa*-F *blanco*-M ‘white table’). Syntactic agreement dependencies have been shown to be particularly difficult for L2 learners to establish during processing (Clahsen et al., 2010). For example, L2 learners’ sensitivity to agreement markers was reduced in an auditory grammaticality judgment task (McDonald, 2000), and in reading-based tasks (e.g., Chen et al., 2007; Jiang, 2004, 2007, Jiang et al., 2011). Other studies, however, reveal that, while sensitivity to L2 gender/number agreement violations is absent in low-proficient late bilinguals (e.g., Alarcón, 2009; Keating, 2009; Osterhout et al., 2008; Sagarra, 2007; Sagarra & Herschensohn, 2008; Tokowicz & MacWhinney, 2005), intermediate and advanced L2 learners are sensitive to both grammatical gender and number marking (e.g., Alarcón, 2009; 2011; Keating, 2009; Osterhout, Poliakov, Inoue, McLaughlin, Valentine, Pitkanen, Frenck-Mestre, & Herschensohn, 2008; Rossi, Gugler, Friederici, & Hahne, 2006; Sabourin, 2003; Sabourin, Stowe, & Haan, 2006; Sagarra, 2007; Sagarra & Herschensohn, 2011; Tokowicz & MacWhinney, 2005). These findings suggest that sensitivity to grammatical gender and number discord is modulated by L2 proficiency level (Sagarra & Herschensohn, 2011).

The debate about acquirability of morphosyntactic agreement in L2 goes along the same lines as the debate about the acquirability of formal features in L2 discussed in the Introduction, with some researchers supporting the view that morphosyntactic agreement is acquirable irrespective of the age of acquisition and the status of the grammatical features in the learner's L1 and arguing that maturational constraints affect agreement processing in late L2 learners, but not representation (see Lardiere, 2007, for a full discussion). Others claim that there are fundamental differences (Bley-Vroman, 1989, 2009) between L1 learners who acquire language since birth, or early age, and adult L2 learners, who acquire their second language after the critical period (see DeKeyser & Larsen-Hall, 2005, for discussions of the critical period debate). Yet others, who have examined L2 learners' sensitivity to agreement from the perspective of L1 transfer and L1-L2 morphological congruency, suggest that in post-puberty second language acquisition syntactic features that are not instantiated by the learners' L1 will not be acquired to native-like levels in their L2, regardless of proficiency (e.g., Hawkins & Chan, 1997; Hawkins & Casillas, 2008). [5] For example, in a study focusing on number and gender agreement in L2 Spanish, for example, Franceschina (2005) found that near-native speakers of Spanish whose L1 instantiates syntactic gender agreement were able to

[5] An important distinction between interpretable features that can be interpreted at LF (logical form) and uninterpretable features that cannot be interpreted is drawn in Minimalism (e.g., Chomsly, 2001, p.4-6). A feature is (un)interpretable with respect to a given element. According to the Interpretability Hypothesis (Tsimpli & Dimitrakopoulou, 2007), uninterpretable features become inaccessible in late L2 acquisition unless they are instantiated in the learners' L1. As an example, number and gender in Spanish are argued to be interpretable on the noun and uninterpretable on agreement targets, such as demonstratives and adjectives (Carstens, 2000).

perform at native-like levels with gender agreement in L2 Spanish, whereas near-natives of Spanish whose L1 was English, which does not instantiate gender, were not. By contrast, the English-speaking learners of Spanish performed at native-like levels with number agreement (present in their L1).

Research has also shown that acquisition of agreement depends on the agreement domain and syntactic distance. Several studies have investigated the extent to which syntactic distance impacts the establishment of syntactic dependencies in L2 processing (e.g., Keating, 2009, 2010; Foucart & Frenck-Mestre, 2012; Gillon-Dowens et al., 2010, 2011). For example, it was found that gender agreement is acquired earlier with articles than with adjectives, and that accuracy with articles is higher than with adjectives. Moreover, agreement accuracy depends on the type of adjective and its syntactic distance from the target noun. Bruhn de Garavito and White (2002) found that low-proficiency French-speaking learners of L2 Spanish produced more gender agreement errors with predicative adjectives (34.56%) than with attributive adjectives (26.95%). Confirming this pattern of findings, Keating (2009) compared noun-adjective agreement with the noun phrase (attributive position) and across syntactic boundaries (predicative position) in native speakers and L2 learners at three proficiency levels and found that only the advanced learners, and only with attributive adjectives, performed like native speakers. However, as pointed out by Alemán Bañón (2012), many of these studies did not control for the effects of structural versus linear distance, whereas both factors have been found to impact processing in native speakers (O'Rourke & Van Petten, 2011). The findings by Keating (2010) and Morgan-Short et al. (2010), similarly, provide evidence that these two factors can affect L2 processing. However, the unique contribution of syntactic distance to online processing of agreement in an L2 remains an open question.

Furthermore, in contrast to studies demonstrating that gender and number are processed similarly by both native and nonnative speakers at advanced levels of proficiency (e.g., Alemán Bañón, 2012; Dowens et al., 2011; Lukatela et al., 1987; Osterhout & Mobley, 1995; Sagarra & Herschensohn, 2011), some studies found weaker brain responses to number than to gender violations and suggested that number violations may be more difficult to detect than gender violations (O'Rourke & Van Petten, 2011), whereas others suggested that for both native and nonnative speakers, processing gender agreement (gender violations, in particular) may be more cognitively demanding than processing number agreement (e.g., Antón-Méndez, 1999; Antón-Méndez, Nicol, & Garrett, 2002; Barber & Carreiras, 2003; 2005). This cognitive difficulty may be ascribed to grammatical gender being a stem-inherent feature of a noun's lexical representation that "is stored as part of each noun's grammatical description in the mental lexicon" (Schriefer & Jescheniak, 1999, p. 577) and is not computed, in contrast to number, which is considered a morphological feature that combines with the stem of the word (e.g., Franceschina, 2001; White et al., 2004).

Lexical decision to a target that is preceded by a prime, is achieved through a process involving three successive stages: (1) a stage of lexical access, (2) a stage of readout, and (3) a stage of evaluation (Faussart, Jakubowicz & Costes, 1999). During the first stage of lexical access the processor locates the correct lexical entry and proceeded to the state of lexical identifiction (Figure 2). During the second stage of readout, the relevant agreement features of the entry, such as number, gender and case, are made available to the parser (the state of lexical recognition). These two stages form lexical retrieval. After lexical retrieval takes place, the processor evaluates the appropriateness of the target to the context (the state of integration). When the processor encounters gender diagreement, it is forced to return to the lexical identification stage to check if the right word has been selected during lexical access, repeating the stages of readout and evaluation (red arrow in Figure 2). In contrast, number disagreement merely requires the processor to check the final evaluation stage of syntactic processing without forcing it to return to the initial stage of lexical access (blue arrow in Figure 2) (e.g., Domínguez, Cuetos, & Ségui, 1999; Sicuro Correa et al., 2004).

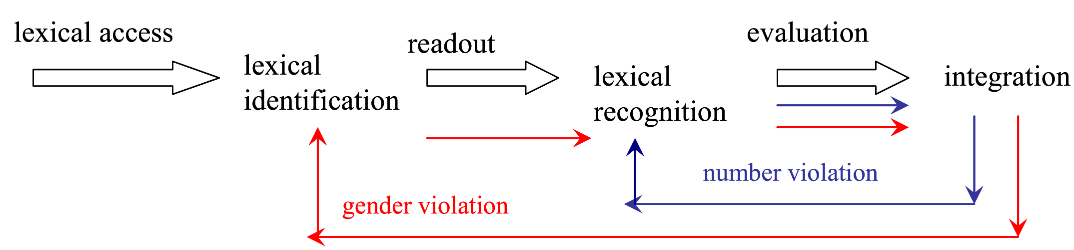

Figure 2. A model of gender and number congruency effect (adapted from Faussart, Jakubowicz & Costes, 1999, p. 97).

In contrast to this view of gender as a lexical feature and number as a syntactic feature, which places them at different levels of representation (syntactic versus. lexical), Picallo (1991) (cited in Alemán Bañón, 2012) proposed that gender, similar to number, projects its own syntactic phrase (below NumP and above NP). Under this proposal, gender and number processing should not be different.

These findings and hypotheses make gender and number agreement interesting categories for linguistic analysis within and across languages to examine both lexical access and syntactic processing (Caroll, 1989; Corbett, 1991). Comparison of gender and number priming between native and nonnative speakers offers an opportunity to examine the extent to which morphosyntactic knowledge is integrated and automatically available to the language processor in real-time reading comprehension (Jiang et al., 2011). For example, it has been pointed out that while native speakers do not rely on gender-ending regularities during gender processing but rather activate inherently stored gender information, this processing is not automatically available to L2 speakers (e.g., Bordag et al., 2006; Guillelmon & Grosjean, 2001; Vatz, 2009). It is clear that more research is needed, using fine-grained and precise measurements to clarify the factors that influence morphosyntactic knowledge acquisition and processing in late L2 learners. It is particularly important to obtain online experimental data from speakers at advanced levels of L2 proficiency to unmask underlying processing differences, which have often been masked in offline tasks.

2.7.3 Overview of the Russian gender and number system

To understand the experiments below, a brief overview of the Russian gender and number systems is required. Russian gender and number agreement is manifested on adjectives, participles, past tense verbs, and numerals, and the agreement controller can either follow or precede its target.

Russian has three genders: masculine, feminine, and neuter. Masculines constitute about 46% of the nominal lexicon, feminines are at 41%, and neuters are at 13% (statistics based on the 34,000-word count; Akhutina et al., 1999). For most (but not all) nouns, their ending in the nominative singular acts as an indicator of their gender. This dissertation focuses only on masculine and feminine genders and, since the nouns used in the experiments were restricted entirely to nouns with transparent morphological marking, the most important correlations for our purposes are the following: (a) nouns ending in a hard, nonpalatalized consonant (with zero-ending) are masculine, and (b) nouns ending in *-a* are feminine if inanimate (Table 2).

Table 2. *Gender agreement in Russian (for masculine and feminine nouns)*

	Noun-Adjective Agreement	**Noun-Verb Agreement**
Masculine	*plox-**oj** fil'm-ø* bad film	*byl-ø fil'm-ø* was film
Feminine	*plox**-aja** muzyk**a*** bad music	*byl-**a** muzyk**a*** was music

Russian has two numbers: singular and plural. The citation form of all nouns is singular. A plural is formed by the attachment of the plural morpheme *–y/-i (*or *–a* for some masculine nouns) to the stem (The process involves the truncation of the *–a* vowel in feminine nouns and *–o* vowel in neuter nouns). To eliminate the additional process of vowel truncation during processing, this study focuses only on the plural form of masculine nouns (Table 3).

Table 3. *Number agreement in Russian (for masculine nouns)*

	Noun-Adjective Agreement	**Noun-Verb Agreement**
Singular	*plox-**oj** fil'm-ø* bad film	*byl-ø fil'm-ø* was film
Plural	*plox**-ije** fil'm-y* bad films	*byl-**i** fil'm-**y*** were films

2.8 Markedness

Important to the acquisition of a morphologically rich language is the notion of markedness, first proposed by Nikolai Trubetzkoy and Roman Jakobson in the 1930s as a means of characterizing binary oppositions and adopted for second language acquisition by Eckman (1977) who proposed to incorporate a notion typological markedness, corresponding to degree of difficulty, into the Contrastive Analysis Hypothesis (CAH). The term *markedness* is polysemous and has 12 different senses that can be grouped into four classes: markedness as complexity, as difficulty, as abnormality, and as a multidimensional correlation (Haspelmath, 2006). In this paper the terms "marked/unmarked" are used in the sense of markedness as overt coding ("formal markedness"). When a category X is said to be unmarked, while a category Y is said to be marked, it means that Y is overtly coded by an affix or auxiliary word, whereas X has no such overt coding ("zero expression"). For instance, whenever a noun has a singular-plural distinction, the singular form is unmarked and the plural form, derived from the singular, is marked and has a special plural marker. Feminine gender is considered to be a marked form in comparison with masculine, because it adds specification for a semantic distinction (often expressed through overt coding). Unmarked categories are assumed to be more frequent, to be acquired earlier, to be more stable than marked ones (Geenberg, 1966; 1975; Eckman, Moravcsic, & Wirth, 1986), which means that they require a lesser processing effort than marked categories.

Akhutina et al. (1999, 2001) posited that the markedness effect in a three-gendered language, such as Russian, is not a simple binary advantage for masculine nouns but reflects a continuum. In their study examining the differences in performance between normal and aphasic Russian listeners, the Markedness Effect found in normals included inhibition exhibited only for masculines (based on the listener's bias for a masculine noun as default), facilitation exhibited only for neuters (based on the low-probability of these nouns), and both facilitation and inhibition for feminine nouns (reflecting their non-default status and the fact that feminines are a very large class even though they are less frequently used than the masculine nouns). Comparing their findings with failure to find gender-priming effects in Bates et al. (2000), Akhutina et al. suggest that this effect may be less likely to emerge in two-gender languages, like Italian, where masculines and feminines are both very common (and neither are zero-marked).

Studies of gender agreement acquisition in L1 showed that Russian children acquire gender agreement by age three (Gvozdev, 1961), and that more agreement errors are produced for marked than unmarked forms. For example, Popova (1973) reported that her oldest participants (aged 3;1–3;6) produced about twice as many past tense verb agreement errors for feminine than for masculine nouns. Similarly, Kempe and colleagues (Kempe et al., 2003) found that gender agreement errors in older Russian children (2;9–4;8) were more common for feminine nouns than for masculine nouns. These findings of superior performance for masculine nouns in older children are in line with the idea that masculine is the unmarked gender in Russian (Akhutina et al., 1999).[6]

Interestingly, the Markedness Effect was not found in aphasic patients (Ahutina et al., 1999), suggesting that its absence may be a general symptom in Russian listeners with sub-optimal language abilities. Hence gender- and number-priming effects may also differ in nature, patterns, and magnitude between native and nonnative speakers.

2.9 Summary

This chapter provided an overview of theoretical models of lexical access and morphosyntactic priming, summarized studies on L1 and L2 agreement processing, and described the Russian gender and number systems. It was shown that, while native speakers demonstrate robust priming effects for gender and number agreement, number seems to exert a weaker effect. Results for L2 speakers are less consistent and, reportedly, depend on various factors, including (but not limited to) language proficiency, grammatical feature, its presence or absence in the first language, and structural distance.

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[6] While younger children (aged 1;10—3;1) in Popova's (1973) study demonstrated reversed gender bias, producing more past tense verb agreement errors for masculine than for feminine nouns, the finding may be explained by overgeneralization of the feminine verb suffix –la in the past tense verbs to masculine nouns at initial stages of acquisition as a more salient past-tense marker rather than a gender agreement marker (Kempe et al., 2003).

What has not been addressed in research so far is the issue whether L1/L2 differences can be traced to the time frame in which relevant grammatical information is activated and remains available until it can be integrated with other information at the controlled integration stage. Even if L2 learners are able to access morphosyntactic information in a native-like manner, such information may decay earlier or its activation may be delayed and, therefore, it may not be available in the critical time frame necessary for normal language processing. As a result, the integration of morphosyntactic information may not proceed in a native-like manner, leading to nonnative-like or inconsistent performance demonstrated by L2 participants in numerous studies.

No study to date has explored differences in L1 and L2 online processing of agreement from the point of view of markedness, role of grammatical category and syntactic distance, while at the same investigating the contribution of underlying attentional mechanisms and the dynamics of accessing morphosyntactic information in memory. The current study, therefore, attempts to investigate these important issues. First, it seeks to identify the mechanisms that underlie native speakers' online processing of agreement dependencies, to examine how different agreement features (gender and number) are retrieved for agreement resolution and whether syntactic distance (agreement operation within or across syntactic boundaries) impacts agreement processing. Second, the study investigates whether morphosyntactic processing in adult L2 learners at an advanced level of proficiency is qualitatively similar to native processing in terms of the processing mechanisms and agreement processing patterns.

CHAPTER THREE: PRELIMINARY STUDIES

The aim of the Main Study was to assess native/nonnative differences at the initial stages of processing of morphosyntax using a priming paradigm in a lexical decision task (LDT). The focus of the study was an examination of priming patterns in number versus gender agreement in two different types of syntactic dependencies. Prior to the Main Study, two preliminary studies were conducted. Preliminary Study 1 characterized the language performance of L2 learners in comparison to native speakers in an offline grammaticality judgment task (GJT) and examined the role of the type of the agreement (within- or across-boundaries) and the type of grammatical feature (number and gender). Preliminary Study 2 developed a priming paradigm that would allow exploration of the time course of morphosyntactic priming and the underlying processing mechanisms in order to answer research questions two and three. Based on the assumptions that lexical access represents an entry stage for effectively every aspect of language processing and that an LDT can permit assessing linguistic function online, an LDT with priming was chosen as the vehicle for gaining insight into the automatic and attentional processes used. In particular, this experiment sought to identify a valid baseline or neutral condition to accurately measure facilitation and inhibition (Neely, 1991) and to dissociate automatic and controlled processes. In order to increase the chances of expectancy-based priming a pairwise paradigm with temporally paired primes and targets rather than a continuous paradigm was chosen (Ober & Shenaut, 1995). In order to circumvent possible auditory processing confounds, the experiment employed visual, rather than auditory, stimuli. It was envisioned that the results of this study would provide a framework for the main study's investigations into the basis of morphosyntactic priming in L2. The study also tested the instrument to ensure that it can capture gender and number priming effects in NA and NV agreement in L1 before using the instrument with L2 participants.

3.1 Preliminary Study 1: Grammaticality judgment task

3.1.1 Aims

The primary aim of Preliminary Study 1 was to characterize the language performance of L2 learners in comparison to native speakers in an offline GJT assessing the end-stage of language processing prior to assessing the initial stage of lexical access. The study examined sensitivities to grammatical agreement violations and the role of the type of agreement (within- or across-phrasal-boundaries) in a grammaticality judgment task that was part of a larger battery of experiments.

3.1. 2 Research questions

The experiment sought to answer the following specific research questions:

1. Do advanced L2 speakers of Russian exhibit native-like sensitivities to grammatical agreement violations in offline processing?
2. Do patterns of L2 performance depend on the type of agreement (whether it operates within phrasal boundaries (NA agreement) or across phrasal boundaries (NV agreement)?
3. Do patterns of L2 performance depend on the type of grammatical feature (number versus gender)?

Furthermore, the study was expected to determine an appropriate level of participants' proficiency needed for participation in the main study by determining a cutoff point for a pre-screening task. [7]

3.1.3 Participants

Participants included 11 native speakers of Russian and 22 English-speaking classroom learners of Russian between the ages of 18 and 38. The native speakers group included 7 females and 4 males (mean age: 28.4). The L2 group included 17 females and 5 males) (mean age: 24.7). All the participants completed a background questionnaire (Appendix A) and a Russian cloze proficiency test (Appendix B). The test was developed by deleting every seventh word from a reading passage of mid-intermediate difficulty from the Reading Comprehension Section of the Standard Test of Russian Proficiency (Level 1) recommended by the Ministry of Education of the Russian Federation (2002, p. 26) and replacing it with a blank of standard length. There were 40 blanks in total. To provide context, two unaltered sentences were supplied: one lead-in sentence at the beginning, and one lead-out sentence at the end of the passage. It took about 10 minutes to complete the test. The responses of a different group of native participants (N = 10) were used to establish a glossary of acceptable responses for scoring L2 participants. Each acceptable answer in a correct form was assigned 1 point. An acceptable answer with an incorrect affix was assigned 0.5 points. Participants scored 0 when their replacement was unacceptable. The total possible score was 40 points.

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[7] A cutoff score is a point on a test score scale that is used to sort examinees into two categories, "masters" and "non-masters," that reflect different levels of proficiency relative to a particular objective measured by a test (Hambleton, 1978).

The test identified two groups at different proficiency levels: the members of the lower proficiency group (=11) scored lower than 50% accuracy on the proficiency test, had pursued three or four semesters of formal Russian studies, and 54.5% of them had study-abroad experience; the members of the higher proficiency group (N=11) scored at a higher than 51% rate of accuracy on the proficiency test, had pursued five or more semesters of formal Russian studies, and 81.8% of them had study-abroad experience. ANOVA run on these scores found a significant difference between the two groups' proficiency scores.

The participants were told that the tasks were solely for the purpose of research regarding the acquisition of Russian grammar but were not told the precise purpose of this research. All the L2 participants received financial compensation for participation.

3.1.4 Materials and design

For each NA and NV agreements there were two grammatical and two ungrammatical conditions for gender and two grammatical and two ungrammatical conditions for number. Grammatical conditions included: the first grammatical gender condition (G1-FF), with a feminine (F) adjective/verb used with a feminine noun (FF); the second grammatical gender condition (G2-MM), with a masculine (M) adjective/verb used with a masculine noun (MM); the third grammatical number condition (G3-SS), with a singular (S) adjective/verb used with a singular (masculine) noun (SS); and the fourth grammatical condition (G4-PP), with a plural (P) adjective/verb used with a plural (masculine) noun (PP). Ungrammatical conditions included: the first ungrammatical gender condition (U1-

MF), with a masculine adjective/verb used with a feminine noun (MF); the second ungrammatical gender condition (U2-FM), with a feminine adjective/verb used with a masculine noun (FM); the third ungrammatical number condition (U3-PS), with a plural adjective/verb used with a singular (masculine) noun (PS); and the fourth ungrammatical number condition (U4-SP), with a singular (masculine) adjective/verb used with a plural (masculine) noun (SP) (Tables 4a and 4b).

Table 4a. *Examples of stimuli using NA agreement, Study 1*

Condition	**Examples**
G1- FF	У твоей подруги очень **добрая улыбка**. Your friend has a very ***kind smile***.
G2-MM	В этом магазине есть **индийский чай**. *There is **Indian tea** in this store.*
G3-SS	По-моему, это довольно **сложный текст**. *This seems to me a rather **complex text.***
G4-PP	**Мужские голоса** уже совсем рядом. ***Male voices** are very close.*
U1-MF	Я знаю, что у тебя **красивый жена.** **I know you have a **beautiful wife**.*
U2-FM	Мы думаем что **деревянная дом** лучше. *We believe that a ***wooden house*** is better.
U3-PS	У его подруги есть **русские самовар**. **His friend has a **Russian samovar**.*
U4-SP	У этого режиссера всегда **интересный фильмы**. **This film director always makes **interesting films**.*

The stimuli list included 48 targets: 24 targets were used in NA dependencies and 24 targets were used in NV dependencies, with 12 nouns for gender agreement (three noun targets per condition) and 12 nound for number agreement (three noun targets per condition. These targets were embedded in simple sentences using words of high frequency and visually controlled for length (4 to 7 words), with half of the target sentences being grammatical and half being ungrammatical. The position of the target in relationship to the controller was not controlled. The type of plural ending (-*y*/-*i* or –*a*) was not controlled.

Table 4b. *Examples of stimuli using NV agreement, Study 1*

Condition	Examples
G1- FF	**Бабушка устала** и хочет хорошо отдохнуть. ***Grandmother is*** *tired and wants to rest well.*
G2-MM	**Кирилл пошел** вперед быстро и уверенно. ***Kirill went*** *forward quickly and confidently.*
G3-SS	**Анжелика** очень хорошо **фотографирует**. ***Angelica takes*** *very good pictures.*
G4-PP	**Друзья решили** встретиться через месяц. ***The friends decided*** *to meet in a month.*
U1-MF	**Максим Горький жила** в Италии долгое время. ***Maxim Gorky lived*** *in Italy for a long time.*
U2-FM	Его **сестра поступил** недавно в институт. ****His sister has recently entered*** *college.*
U3-PS	В выходные **ребята любит** ходить в зоопарк. **On weekends* ***the kids loves*** *going to the zoo*.
U4-SP	**Владислав не опаздывают** никогда и никуда. ****Vladislav are*** *never late anywhere.*

To conceal the focus of the experiment, there were 60 fillers used. Hence, each participant read 108 sentences including 48 target items and 60 fillers. (A full stimuli list is presented in Appendix C.) Two versions of the GJT were prepared to counterbalance the presentation of the grammatical-ungrammatical items: an item was presented in a grammatical condition in one list and in an ungrammatical condition in another. The order of sentence presentation in each list was randomized. The stimuli for gender and number were presented in one list, but the results were analyzed separately for gender and number.

3.1.5 Procedure

Participants met with the researcher at an appointed time online to receive the materials of the experiment and were asked to return them by email as soon as they completed the task. They were asked to decide if the sentences were grammatically correct or incorrect and to highlight grammatical errors in case of ungrammaticality.

3.1.6 Results

The first research question asked whether L2 speakers of Russian exhibit native-like sensitivities to grammatical agreement violations in offline processing. Table 5 shows means and standard deviations of the total number of correct identifications of grammatical violations (collapsed for gender and number and both NA and NV types of dependencies) as a function of group. At advanced levels L2 speakers exhibited native-like sensitivities to grammatical agreement violations: they accurately identified violations in 89% of all cases across conditions (compared to 78% accuracy for the lower-proficiency group and 100% accuracy for the native group).

Table 5. *Mean accuracies (numbers of correct responses) in identifying grammatical violations as a function of proficiency, Study 1*

Proficiency	**Mean**	***SD***
Low-proficiency speakers	18.82	*3.60*
High-proficiency speakers	21.27	*3.13*
Native speakers	24.00	*0.00*

Since all native speakers performed at the ceiling level, there was no variance observed, which violated the assumption of homogeneity of variance, making the *F*-statistic in parametric tests biased and not reliable. Since we were mostly interested to see whether differences between native and high proficiency L2 speakers were not significant and differences between low and high proficiency L2 speakers were significant, an independent *t*-test was used to compare differences between the low- and high-proficiency groups (Levine's test for equality of variance was not significant, p=.313), and the Mann-Whitney *U*-test, the nonparametric alternative to the *t*-test, was used to compare differences between native and high-proficiency L2 speakers. Statistically significant differences were found between native and high-proficiency L2 speakers, U=11, p=.001, but not between the high- and low-proficiency groups, $t(20)$ =1.71, p=104. This could be explained by the small sample size and by a low (50%) cutoff point on the cloze test which allowed the inclusion into the high-proficiency group of some learners who performed close to chance level.

The second research question asked whether the patterns of performance in L2 depended on the type of agreement: whether agreement operated within phrasal boundaries (NA agreement) or across phrasal boundaries (NV agreement). Analyses of L2 speakers' sensitivities to agreement violations in both types of local syntactic dependencies showed higher accuracy on the NA agreement for both groups: 91% versus 87% respectively for the high-proficiency group and 87% versus 70% respectively for the low-proficiency group (Table 6).

In response to the third research question—Do patterns of performance depend on the type of grammatical feature (number versus gender)?—it was found that although gender is not instantiated in L2 participants' native language grammar, while number is, both groups were more sensitive to gender agreement violations (high-proficiency group: 90%; low-proficiency group: 83%) than to number agreement violations (high-proficiency group: 88%; low-proficiency group: 73%); but these differences did not reach significance. Paired samples *t*-tests run on the L2 data showed that (1) for the low-proficiency group, there was no significant difference between sensitivity to number and gender violations, $t(10) = 1.921$, $p = .084$, but there was a significant difference between processing NA and NV dependencies: $t(10) = 2.81$, $p = .018$; and (2) for the high-proficiency group, there were no significant differences found for either gender versus number processing, or for NA versus NV processing: $t(10) = .420$, $p = .684$ and $t(10) = 1.399$, $p = .192$, respectively.

Table 6. *Mean accuracies in identifying grammatical violations as a function of proficiency and grammatical category, Study 1*

Group	Category	Mean	*SD*
LGP	NA	10.5	*1.6*
	NV	8.4	*2.6*
	Gender	10	*1.3*
	Number	8.8	*2.6*
HGP	NA	10.9	*1.8*
	NV	10.4	*1.6*
	Gender	10.8	*1.5*
	Number	10.5	*2.6*
NS	NA	12	*0*
	NV	12	*0*
	Gender	12	*0*
	Number	12	*0*

3.1.7 Discussion and conclusion

The study found that at advanced levels L2 speakers could exhibit native-like sensitivities to grammatical agreement violations, but the significant differences between the native and the high-proficiency groups and the insignificant differences between the high- and low-proficiency groups indicated that a cloze test with a cutoff level set at 50% was not sufficient to identify the level of L2 proficiency necessary for participation in online priming tasks assessing L1/L2 processing differences that may only surface under specific conditions. The results also pointed to a need for a more rigorous scoring system to identify those with a higher level of proficiency.

The finding that L2 speakers were more sensitive to violations of agreement within syntactic boundaries than across syntactic boundaries confirmed the hypothesis, whereas the finding that L2 speakers had more difficulties processing number than gender had not been expected, as this finding contradicts some theories claiming that L2 learners should be less sensitive to morphemes that are not instantiated in their L1 compared to ones that are. This finding also contrasts with studies demonstrating that gender and number are processed similarly, or that gender agreement may be more cognitively demanding than number agreement. One explanation would be that number which is considered a morphological feature triggers more computation than the stem-inherent gender (Lukatela et al., 1987; Osterhout & Mobley, 1995; Sagarra & Herschensohn, 2011). These findings suggest that while L2 learners at high proficiency levels can converge with native speakers when it comes to processing NV dependencies and number agreement, with increased cognitive load, deficits in processing number agreement and NV dependencies may surface.

The study was an important first step before investigating online language processing in L2. First, the results helped identify a new cutoff level on the cloze (raised to 60%) and the need to use a scoring system that focuses more on identifying deficiencies rather than on acknowledging developing knowledge. Using full scores only for correct answers and not giving half points to recognize partially correct answers was deemed appropriate. Additionally, the study identified a need for another measure of proficiency that would help discriminate between "masters," or candidates who have mastered the grammatical categories of interest and who are able to process grammar violations in a native-like manner in an offline grammaticality judgment task, from "nonmasters," i.e., those who have not yet mastered these categories. Previous research (Vatz, 2009) showed that performance on a GJT designed to test acquisition of particular language features could be used as an additional measure of proficiency. The GJT used in Preliminary Study 2 was accepted as an appropriate measure. Based on the Study 2 findings, the cutoff point for accepting participants for the Main Study was set at 85%, a little lower than the score observed in the high-proficiency group in Study 2, which conforms to a standard score cutoff level of < 85 (i.e., > 1 standard deviation below the average standard score of 100) (Aram & Robin, 1993).

3.2 Preliminary Study 2: Lexical decision task

3.2.1 Aims

The purpose of the study was to devise tightly-controlled experimental procedures in order to examine the temporal aspects of morphosyntactic activation and the nature of morphosyntactic processing mechanisms, or routines,[8] in L1, and to identify a valid baseline (or neutral condition) to accurately measure facilitation and inhibition (Neely, 1991). To evaluate the effect of grammatical context on the speed and accuracy of lexical access and to dissociate automatic from controlled processing mechanisms underlying morphosyntactic processing, a morphosyntactic priming paradigm was employed.

Employing the "neutral" condition is the key to the accurate measurement of facilitation and inhibition. According to Jonides and Mack (1984) and Neely (1991), an essential feature of neutral cues is a warning value similar to that offered by informative word primes. In contrast with informative word primes, however, neutral cues must provide no information about upcoming targets. The absence of a baseline condition in many priming studies in most languages has limited their utility. Previous studies that did use

[8] The word "mechanisms" and "routines" in this dissertation are used interchangeably.

the baseline condition in English, have used nonwords, the word "*blank*", the phrase "*The next word is*", and a string of "*xxxx*", but the validity of these primes has only been tested empirically in one study (Arnott, 2001) that identified the string of "*xxxx*" as satisfying criteria for neutrality. The only study that employed a baseline condition in the Russian context used a highly frequent adverb/particle "prosto" (simply), similar in frequency and meaning to the word "just" or "simply" in English (Akhutina et al., 1999) but did not assess its validity empirically.[9]

The use of the word "*blank*" (in translation) in a Russian priming study is not appropriate because an adjective will require an inflection marked for gender and number, and the use of the adverb "*pusto*" before the noun or the verb is not permitted in Russian and may introduce the ungrammaticality bias rather than serve the purpose of providing a gender- and number-neutral context. Using a nonword without adjectival endings may introduce a different confound: nouns ending in a consonant typically belong to the masculine gender (singular), and nouns ending in a vowel are either feminine (-*a*), or neuter (-*o*/-*e*). Furthermore, nouns ending in *–y*/*–i* may be plural forms of masculine or feminine nouns. The phrase "*The next word is*" is translated into Russian with a zero copula, which may introduce another confound and cause a slowdown in processing the targets. Therefore, in this preliminary investigation, the validity of two remaining baseline conditions, the word "*prosto*" ("simply") and the string "*xxxx*," was investigated.

3.2.2 Research questions and hypotheses

The study was designed to answer the following three research questions:

[9] The study investigated the effect of grammatical gender agreement on lexical access in Russian.

1. What priming patterns exist in native online processing of number and gender agreement, and in processing of agreement within phrasal boundaries (NA) and across phrasal boundaries (NV)?

Research suggests that patterns of performance may be different for the two types of dependencies and the two grammatical features. It was predicted that gender agreement would produce larger priming effects than number agreement and that agreement within phrasal boundaries would produce larger priming effects than agreement across phrasal boundaries.

2. Which prime— the word "*prosto*" ("simply") or the string of "*xxxx*"—can be used as a valid baseline condition for measuring the costs and benefits of grammatical priming?

Following Neely (1991), the "neutral" condition was operationalized as a condition that makes it possible to observe facilitatory and/or inhibitory components of priming. Facilitation is defined as faster reaction times, RTs, or recognition of target words following a congruent prime relative to a neutral prime, and inhibition is defined as slower RTs, or recognition of targets following an incongruent prime relative to a neutral prime (Neely,1991). Following Arnott (2001), at short SOAs (250 ms), neutral primes were expected to yield facilitatory effects in grammatical contexts, but at long SOAs (1000 ms), they were expected to give rise to facilitation in grammatical contexts and inhibition in ungrammatical contexts. That is, at short SOAs,

$$\boldsymbol{RTs\ G < RTs\ N\ =\ RTs\ U},$$

while at long SOAs,

***RTs G* < *RTs N* < *RTs U*,**

where "*G*" and "*U*" mean grammatical and ungrammatical contexts, respectively. Thus, it was predicted that RTs to nouns following *prosto* and *xxxx* would be significantly slower than RTs following a grammatical version of the prime (thus, providing evidence for facilitation in the grammatical condition), and significantly faster than responses following an ungrammatical version of the prime (thus, providing evidence for inhibition in the ungrammatical condition).

3. What are the locus and the nature of the processing routines underlying morphosyntactic priming effects in native speakers of Russian across a normal range of SOAs?

Prelexical processing (automatic or attentional), being time-dependent, would be represented by an interaction of SOA and prime. Fast, automatic activation of grammatical information would be reflected at short SOAs by priming effects with a facilitatory component only, whereas slower, attentional prelexical mechanisms would be represented by priming effects with an inhibitory component (with or without facilitation) at longer SOAs. While postlexical processing, like prelexical strategic processing, can also give rise to both faciliation and inhibition, these processes occur after both prime and target have been accessed. So, postlexical processes are less dependent on SOA than prelexical processes, which is reflected in the failure of SOA to interact with prime or in the finding of inhibition at even the shortest SOA employed.

Thus, it was hypothesized that, if prelexical automatic and attentional mechanisms contribute to grammatical priming effects, only automatic processing routines would operate at the short SOA of 250 ms and would be reflected in morphosyntactic priming effects due to facilitation, whereas at longer SOAs of 1000 ms and 2000 ms, expectancy-based processing would be engaged and would be reflected in priming effects with both facilitatory and inhibitory components. If, on the other hand, morphosyntactic priming effects are the result of postlexical processing routines, priming effects with inhibitory components would be identified irrespective of SOA.

3.2.3 Participants

Participants included 20 native speakers of Russian: 10 females and 10 males (mean age: 37.95 (range: 19-52). The participants at the time of experiment resided in Russia or had recently moved to the USA. They were randomly assigned to one of the SOA groups (250ms, 500 ms, 1000 ms, or 2000 ms), with five participants in each group, and were naïve as to the purpose of the study.

3.2.4 Materials and design

Experimental stimuli consisted of prime/target word pairs representing local syntactic dependencies within and across syntactic phrase boundaries featuring gender and number agreement in grammatical, ungrammatical, and two neutral conditions. Since prime frequency may have a significant impact on target processing in two-word priming studies (Liu, Bates, Powell, & Wulleck, 1997), in order to control for characteristics of the prime, masculine and feminine forms of the same adjective prostoj ("simple") and the same verb byt’ (“to be”) were used in the experiment. It was expected that the use of the same primes, instead of a variable set of adjectives and verbs, while requiring minimal semantic processing, will ensure that the processing of subsequent target words will begin at the same time (Akhutina et al., 1999). Thus, primes included: (1) the masculine singular adjective *prostoj* ("simple"); (2) the feminine singular adjective *prostaja* ("simple"); (3) the masculine singular past form of the verb *byt’ (“to be”)—byl* (“was”); (4) the feminine past form of the verb *byt’ (“to be”)—byla* (“was”); (5) the plural adjective *prostyje* ("simple"); (6) the plural form *byli* (“were”); (7) adverb “*prosto”* and (8) *“xxxx*”.

These primes were combined with 5 real nouns with a frequency range between 30 and 300 occurrences per million words, and 5 nonce nouns based on real words with the same frequency, all in transparent disyllabic forms, to form grammatical (10x6) and ungrammatical (10x6) conditions (total: 120). The two neutral primes were combined with 15 real and 15 nonce words each (30x2). This resulted in a stimulus list with 200 prime-target pairs (Table 7). The same masculine singular noun targets were used for separate analyses of gender and number processing. The prime-target pairs, therefore, formed two grammatical and two ungrammatical NA conditions, two grammatical and two ungrammatical NV conditions, and two neutral conditions. The same stimulus list was used in each SOA group, with stimuli pairs randomized for each presentation, and with each target appearing in the list in the same condition only once (Appendix C).

Nonce words comprised 50% of each list. To discourage participants from responding before reading the entire nonword letter string, half of the nonwords were derived by taking real word stems and adding inappropriate endings (Blumstein et al., 1991). The remaining nonwords were created by randomly changing one or two phonemes in real word stems that were not used in the experiments.

Although the stimuli for gender and number were presented in one list, the results were analyzed separately for gender [design: 4 (SOA group: 250 ms, 500 ms, 1000 ms, and 2000 ms) x 4 (prime condition: grammatical, ungrammatical, *prosto*, and x*xxx*) x 2 (gender: masculine, feminine) x 2 (dependency: NA, NV)] and for number [design: 4 (SOA group: 250 ms, 500 ms, 1000 ms, and 2000 ms) x 4 (prime condition: grammatical,

Table 7. *Study 2 design*

Target/ Prime	Fem Adj: Prostaja	Masc Adj: Prostoj	Fem Verb: Byla	Masc Verb: Byl	Neutral 1: Prosto	Neutral 2: xxxx	Plural Adj: Prostyje	Plural Verb: Byli
FEM	NA G	NA U	NV G	NV U	N1	N2	n/a	n/a
real	5	5	5	5	5	5	0	0
nonce	5	5	5	5	5	5	0	0
MASC/SING	NA U	NA G	NV U	NV G	N1	N2	NA U	NV U
real	5	5	5	5	5	5	5	5
nonce	5	5	5	5	5	5	5	5
PLURAL	n/a	NA U	n/a	NV U	N1	N2	NA G	NV G
real		5		5	5	5	5	5
nonce		5		5	5	5	5	5

ungrammatical, *prosto*, and *xxxx*) x 2 (number: singular, plural) x 2 (dependency: NA, NV)].

3.2.5 Procedure

The experiment was constructed to be run online on DMDX (Forster & Forster, 2003) (remote testing mode). Prior to the study, the experimental materials had been calibrated carefully and the remote testing mode had been tested with multiple volunteer participants (friends and relatives of the researcher). All the problems were fixed before the commencement of the experiment, so at the time of the experiment no problems in accessing and using the experimental materials were reported.

Participants received a letter with detailed instructions that contained a link to the folder with experimental materials they were to download to their computers (e.g., ftp://lexicaldecision:dmdx@ftp.drivehq.com/experiment/native/250). There were four sets of instructions and four folders prepared for each experimental group. An example of instructions for participants in group SOA250 is presented in Appendix E. Upon completion of the experiment an e-mail with the participant's responses was automatically sent to the experimenter.

Experimental trials in each group were randomized for each participant such that each participant in a group saw the same 200 stimuli in a different random order. Each trial began with a preparatory cue ("+") in the center of the computer screen visible for 500 ms. After a blank screen interval of 1000 ms, the first word, the prime, was displayed and remained visible for the entire duration of the SOA (which, depending on the group was either 250, 500, 1000, or 2000 ms). This continuous display of the prime was meant to encourage participants to create expectancies and to invoke the facilitatory effect with the inhibitory component (Balota et al., 1992). The second word, the target, was then displayed and remained on the screen for 4000 ms or until the participant depressed the response button. The next trial was activated 1500 ms after the previous target disappeared from the screen (Figure 3).

Participant reaction times, or the time from presentation of the target to depression of the response button, for word targets correctly identified as words was recorded. Errors were also recorded for both *yes* responses to nonword targets and the failure to respond to word targets. Experimental stimuli were presented via 10 blocks of 20 trials (200 trials total). After each block, participants were given the opportunity to rest. A set of 16 practice trials preceded each experiment. The practice primes included 12 grammatical pairs (6 real words and 6 nonce words—one for each type of grammatical feature in both types of dependencies) and four pairs in the neutral grammatical conditions (two in N1 and two in N2, with one real and one nonce target in each). The grammatical proportion of the stimuli in the practice list was covertly manipulated to encourage creation of expectancies (Milberg, Blumstein, Katz, Gershberg, & Brown, 1995).

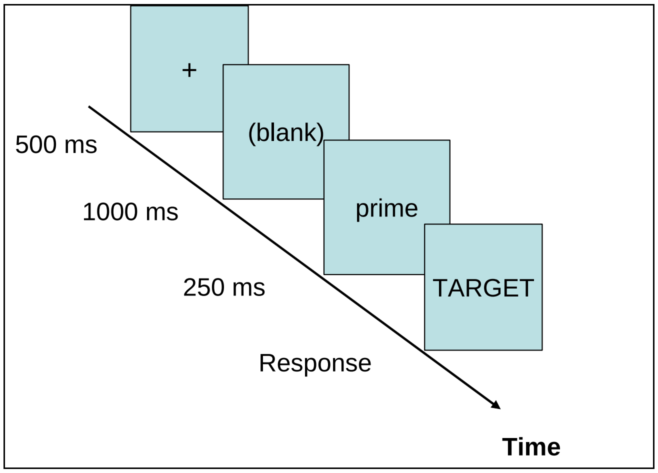


Figure 3. Outline of the priming procedure for SOA250 ms, Study 2.

3.2.6 Analysis

Since Study Two was a pilot study in nature, it was not treated as a stand-alone study, and the analysis of the results was mainly descriptive, according to recommendations for any type of pilot study (Lancaster et al., 2004). It was not considered appropriate to place undue significance on results from hypothesis tests with such small numbers of participants in each group. The four groups' mean response latencies and priming effects were compared in order to identify trends and possible sources of variance in preparation for the Main Study. The difference in RTs between the grammatically correct condition, *G*, and the morphosyntactically incorrect condition, *U*, was considered representative of "morphosyntactic priming":

Gender Priming Effects = RTs U - RTs G

Number Priming Effects = RTs U - RTs G.

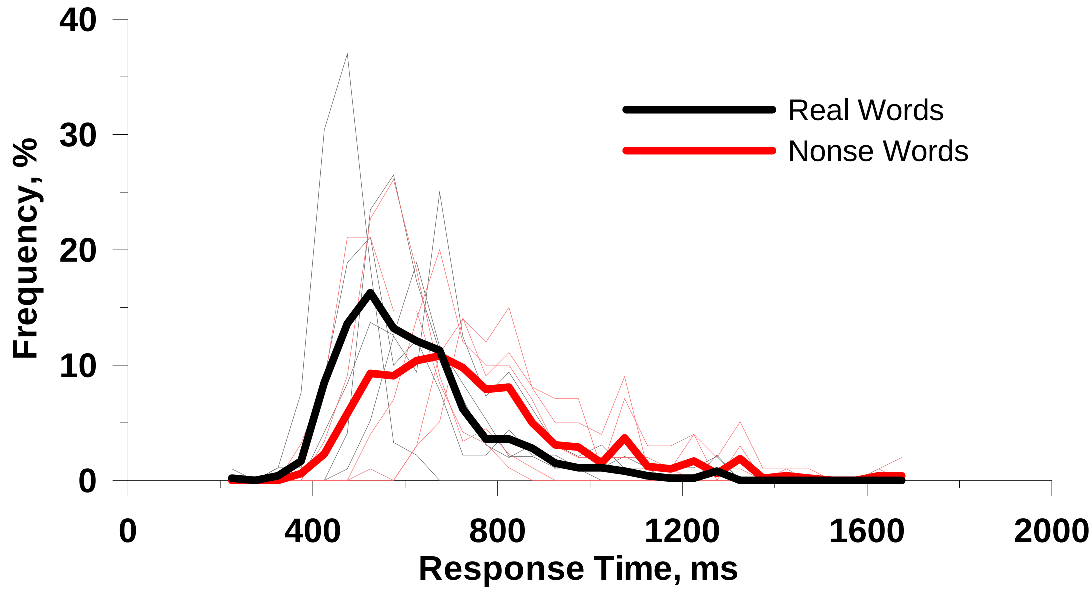
RTs for the G and U conditions were compared to identify gender and number priming effects and were contrasted with each of the baseline conditions, N1 and N2, to determine the facilitatory and inhibitory components of observed priming effects:

Facilitation* = *Mean RTs G < Mean RTs N

Inhibition* = *Mean RTs U > Mean RTs N.

3.2.7 Results and discussion

Participants made errors in 3.6% of word trials and in 3.5% of nonword trials. Accordingly, error data were not subjected to further analysis. Responses to word targets were then cleaned by eliminating reaction times that were greater than 1500 ms. This resulted in the elimination of 1.91% of all responses. Figure 4 shows frequencies of distribution of RTs for the SOA500 group (selected as an example) for real and nonce words and for grammatical and ungrammatical conditions. While confirming that the curve has a near-to-normal distribution, the figure demonstrates the variability of individual responses signifying a need for more participants before it would be possible to identify reliable patterns of responses. The figure also shows that there is a tendency to respond longer to ungrammatical items and nonce words compared to grammatical and real words, respectively. The clustering of mean reaction times of each participant in groups of 50 ms and graphed as a function of percentage of total responses represents a gradation of response intensity over time and, as suggested by Butler, McNamara, & Durso (2010) and Butler et al. (2011), can be assumed to reflect patterns of spreading activation. Thus, it can be suggested that at medium SOAs, activation in native speakers is delayed, is lower, and lasts longer for nonce words relative to real words and for words in the ungrammatical condition relative to the grammatical condition.



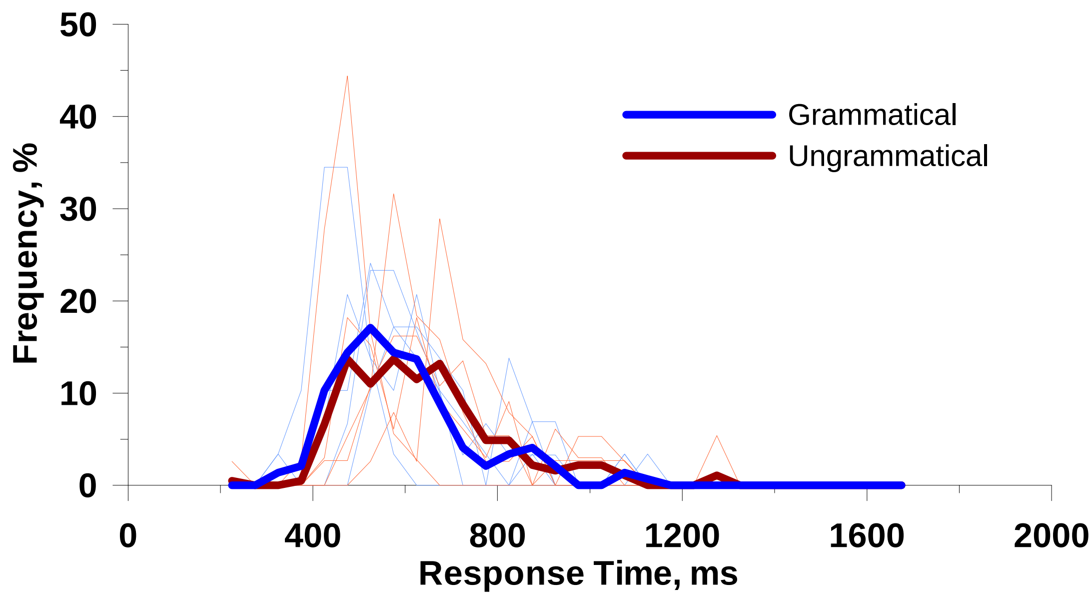


Figure 4. Frequency distributions of RTs at SOA500, Study 2.

Note: Thin lines represent mean RTs of five individual participants in the SOA500 group. Thick lines represent combined RTs for the SOA500 group.

The first research question asked what patterns of performance exist in native online processing of number and gender agreement within phrasal boundaries (NA agreement) and across phrasal boundaries (NV agreement). To answer this question, the RT means for grammatical, ungrammatical, and both neutral conditions were collapsed across the four SOAs and calculated as a function of prime condition to allow the researcher to determine whether morphosyntactic priming effects can be captured by the study's instrument. A comparison of reaction-time differences between conditions demonstrates that priming effects exist, and, with the RTs in the neutral condition falling mid-way between the *G* and the *U* conditions, this comparison also demonstrates that there is facilitation for targets in the congruent condition and inhibition for targets in the ungrammatical condition (Figure 5).

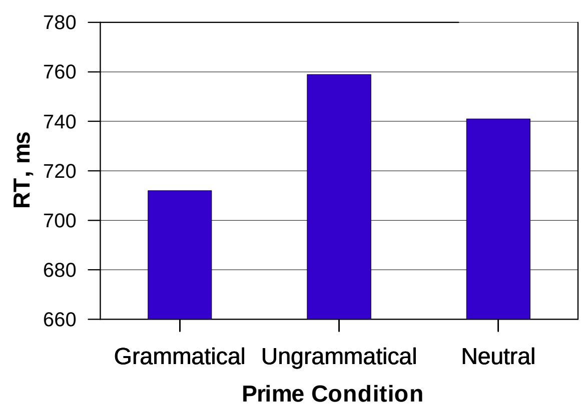
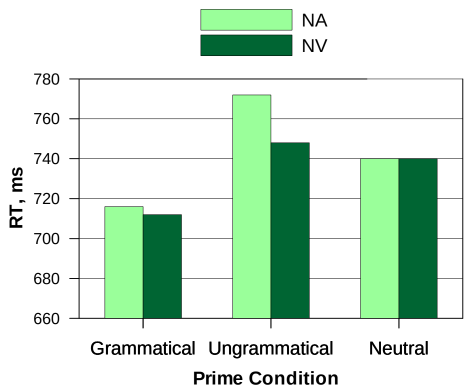


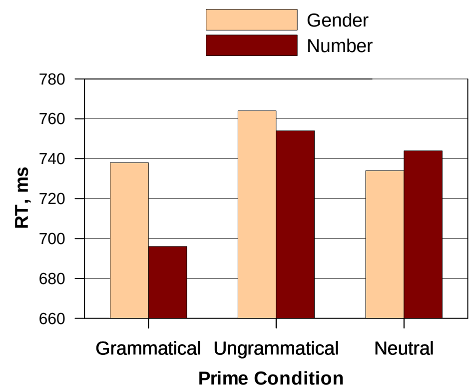
Figure 5. Mean RTs as a function of prime condition, Study 2.
Note: The base line of the bar graphs is shifted to 660 ms.

A closer examination of the data revealed differences in the processing between the two dependencies and two grammatical features and confirmed the hypothesis that NA agreement produced larger priming effects compared with NV agreement (60 ms versus

39 ms) (Figure 6a) and that gender agreement produced larger priming effects than number agreement (57 ms versus 27 ms) (Figure 6b).



(a)



(b)

Figure 6. Mean RTs for *(a)* NA & NV dependencies and *(b)* for gender and number, Study 2.
Note: The base line is shifted to 660 ms.

The second research question was concerned with identifying a valid baseline condition for measuring the costs and benefits of grammatical priming. To answer this question the "neutrality" of two conditions, namely the adverb "*prosto*" ("simply") and the string "*xxxx,*" was examined by analyzing group mean RTs as a function of SOA and the nature and magnitude of priming effects invoked by these two primes. For this finer-grained analysis, more trimming was deemed necessary, and reaction times that were greater than 1500 ms and lower than 300 ms were removed (Zevin & Balota, 2000), resulting in the elimination of 4.7 % of all responses.

As seen from the graph in Figure 7, the cleaned data demonstrate virtually no difference between the RTs to nouns in both neutral conditions, with differences emerging only at 500 ms: prime *"prosto"* was processed as fast as nouns in the grammatical condition, thus underestimating facilitation and overestimating inhibition. However, due to the small number of participants, the effect could have occurred due to extraneous factors. Both neutral conditions were examined against the criteria for neutrality, and both primes met the criteria: at short SOAs (250 ms) they yielded facilitatory effects in grammatical contexts (with minimal inhibition for targets in ungrammatical contexts), and at long SOAs (1000 ms and 2000 ms) they gave rise to both facilitation in grammatical contexts and inhibition in ungrammatical contexts. RT values for both neutral primes were collapsed for the subsequent analyses of the findings.

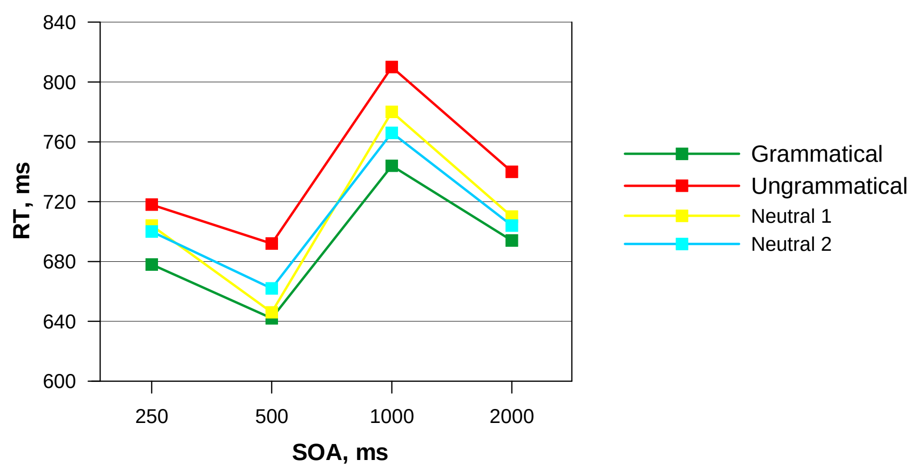


Figure 7. Mean response times as a function of SOA , Study 2.
Note: The base line is shifted to 600 ms.

Although, based on these results, either prime could provide a valid baseline condition for the purposes of examining the temporal aspects of grammatical priming, the word prime *"prosto"* was selected over the string "*xxxx*" because, unlike a word prime, "*xxxx*" is a "nonlinguistic" event (e.g., Antos, 1979, cited in Neely, 1991) and may, as such, interact with targets in a different way.

The last research question was concerned with identifying the locus of the priming effects and the nature of the processing routines underlying these effects in native speakers of Russian across a range of SOAs while simultaneously charting the time course of morphosyntactic priming. Process dissociation was based on the three-process model of information processing—prelexical automatic, prelexical attentional, postlexical attentional processing (Neely & Keefy, 1989; Neely, 1991). Consistent with the process dissociation procedure outlined earlier, the priming effects exhibited by the study's native participants were expected to change as a function of SOA if prelexical processing mechanisms (automatic spreading activation and expectancy-based mechanisms) were engaged. Automatic routines would be reflected at short SOAs by priming effects with a facilitatory component only, whereas attentional mechanisms would be represented by priming effects with an inhibitory component (with or without facilitation) at longer SOAs. If, on the other hand, morphosyntactic priming effects are the result of postlexical processing routines, priming effects with inhibitory components would be identified irrespective of SOA.

The group priming effects were analyzed as a function of SOA and were found to be robust across the range of SOAs employed. As seen from the graph in Figure 8, priming effects increase with increase in SOA and are the largest at 1000 ms, dropping in size at 2000 ms. These effects were statistically significant at 500, 1000, and 2000 ms (*p<.05*).

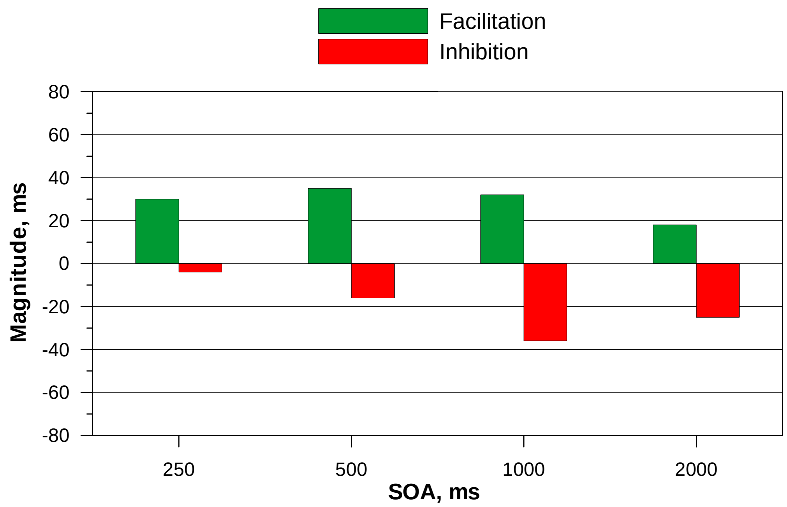


Figure 8. Time course of facilitation and inhibition, Study 2.

Since priming is due to both facilitation and inhibition (Neely, 1991), the nature of these effects was examined by looking at these components of priming. Figure 9 demonstrates that at the short SOA250 the priming effect was primarily faciltatory (30 ms), with very small inhibition (5ms) in the ungrammatical condition, which typically reflects the engagement of automatic routines. With the increase of SOA, there was a significant growth in the magnitude of priming (*p*<.05) due to increased facilitation (34ms) in the grammatical condition, as strategic expectancy-based processes got engaged, and inhibition (16 ms) in the ungrammatical condition when these expectancies were not met. At SOA1000, priming was dominated by the inhibitory component (36 ms), with facilitation remaining robust (32 ms). As priming diminished at SOA2000, the pattern continued, with inhibition (25 ms) dominating over facilitation (19 ms). This analysis confirms the engagement of both automatic and attentional routines.

To see if the same priming patterns operated in both types of syntactic dependencies, the same analysis was carried out for the NA and NV dependencies separately. Figure 8 shows that the magnitude of priming for NA dependencies remained the same at 250, 500, and 1000 ms and then increased at 2000 ms with a longer SOA, whereas the magnitude of priming for NV dependencies grew from 250 ms to 1000 ms and then dropped sharply to no priming at 2000 ms. A closer examination of the components of priming revealed that (1) for NA dependencies the inhibitory component gradually grew in magnitude with growth of SOA, whereas the facilitatory component diminished ($r=-.7$) until it picked up again at 2000 ms; and (2) for NV dependencies both facilitation and inhibition grew in magnitude up to 1000 ms, when they both dropped ($r = .8$). More specifically, the findings were as follows.

(1) At 250 ms, priming in NA dependencies occurred due to facilitation only (46 ms), reflecting automatic processing, whereas less priming in NV dependencies (25 ms) was almost equally represented by facilitation (15 ms) and inhibition (10 ms), suggesting the involvement of strategic processes.

(2) At 500 ms, priming in NA was represented by dominating facilitation (29 ms) accompanied by inhibition (14 ms). The same pattern was present in NV dependencies, with priming effect reaching significance (55 ms, $p<.05$; facilitation: 38 ms; inhibition: 17 ms). This indicates that strategic processes were evoked for processing both types of dependencies.

(3)	At 1000 ms, there was a reversal in dominance between facilitation and inhibition for NA dependencies, and priming was represented mostly by the inhibitory component (44 ms versus 10 ms). Priming was significant in NV dependencies (83ms, $p<.5$), with facilitation prevailing over inhibition (54 ms versus 28 ms).

(4)	At 2000 ms, significant priming in NA dependencies (96 ms, $p<.05$) was dominated by inhibition (73 ms versus 23ms), whereas no significant priming was found in NV dependencies.

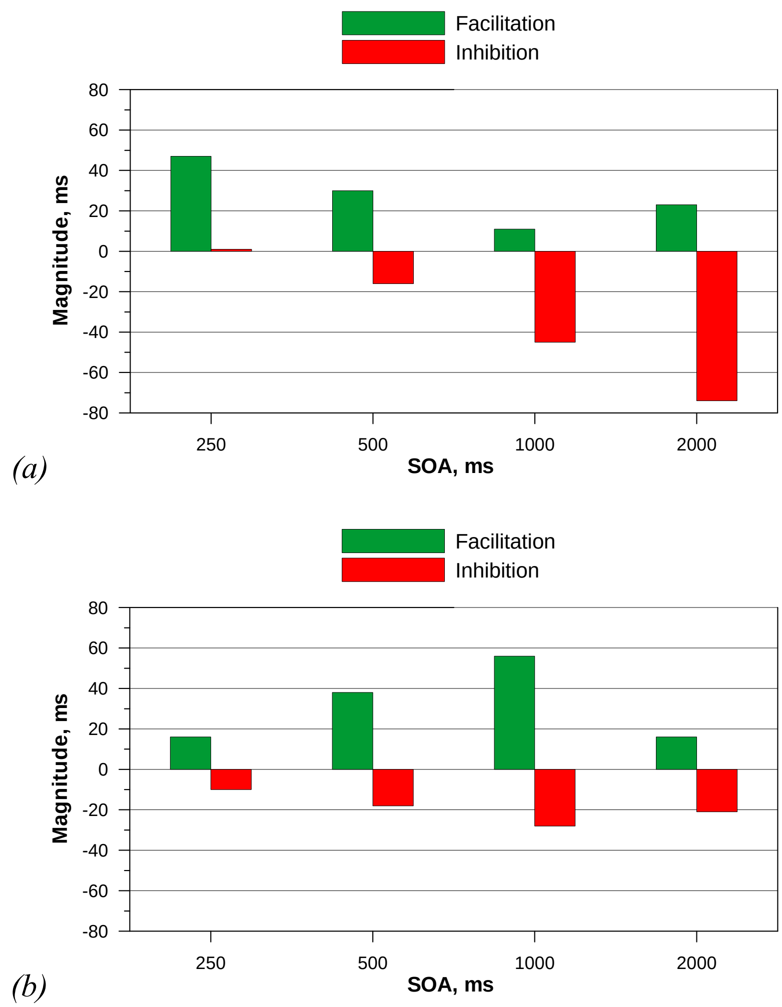


Figure 9. Priming effects for (a) NA and (b) NV dependencies, Study 2.

To summarize, local dependencies within and across phrasal boundaries invoked time-dependent prelexical processing mechanisms. However, while NV dependencies that crossed phrasal boundaries invoked priming patterns indicative of only strategic mechanisms, NA dependencies within phrasal boundaries invoked both automatic mechanisms at 250 ms and strategic mechanisms that emerged at 500 ms and increased over time, being most robust at the longest SOA of 2000 ms. It is not clear, however, why NA processing was dominated by inhibition at longer SOAs, whereas NV processing was dominated by facilitation. It was expected that results from more participants would show whether this was a stable or a random effect. The finding that no priming was observed for NV dependencies at 2000 ms suggests that grammatical information about NV agreement may decay more quickly than information about NA agreement.

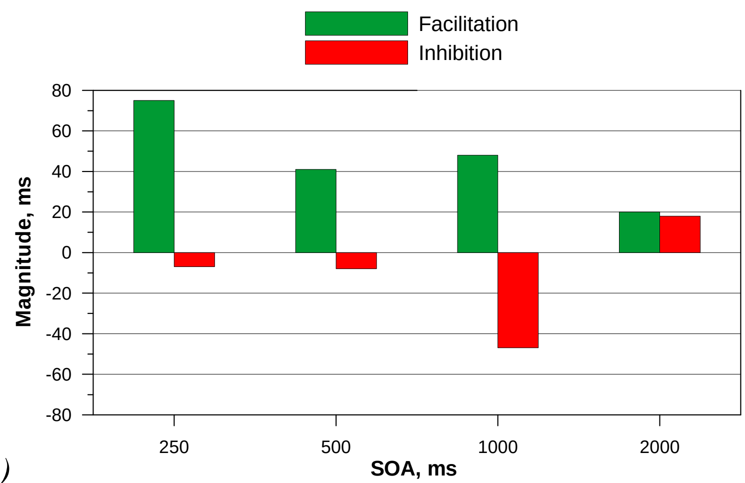
Collapsing RTs for both types of dependencies to compare priming effects for gender and number revealed the following trends (Figure 10).

(1) At the short SOA of 250 ms, significant priming for gender (81 ms, $p<.05$) was reflected in marginally significant facilitation (75 ms, $p=.06$) with no or little (7 ms) inhibition, in contrast with priming for number, which reflected only the inhibitory component (8 ms), along with inhibition of grammatically congruent targets.

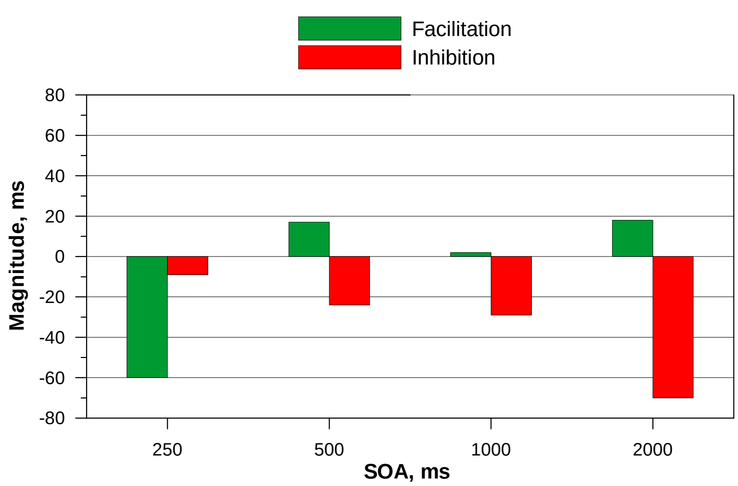
(2) At 500 ms, the significant priming for gender (51 ms, $p<.05$) included facilitation (42 ms) and was accompanied by a little growth in inhibition (9 ms). There was also a significant priming effect for number (41 ms, $p<.05$) which was almost equally represented by facilitation and inhibition (17 ms versus 24 ms, respectively).

(3) At 1000 ms, priming for gender reached its maximum (94 ms, $p < .05$) and was equally represented by facilitation and inhibition (48 ms versus 46 ms), whereas for number priming was reflected only in inhibition (29 ms).

(4) At 2000 ms, gender was not primed (some facilitation and negative inhibition were caused by longer processing of the neutral prime), but number was primed significantly (88 ms, $p<.05$), due to a significant inhibitory component (69 ms, $p<.05$; facilitation: 19 ms).



(a)



(b)

Figure 10. Priming effects for (a) gender and (b) number, Study 2.

To summarize, gender and number demonstrated diametrically different priming patterns: while gender seemed to invoke both automatic and strategic processes, number evoked strategic processes. Gender evoked facilitation at 250 ms, whereas the presence of inhibition in the absence of facilitation in number processing at short SOAs is indicative of postlexical re-evaluation. Further, gender-processing was consistent with expectancy-based processes, whereas the relatively low magnitude of facilitation across the range of SOAs in number processing suggests that number may have been processed postlexically.

3.2.8 Conclusions

The present study aimed to (1) to develop online priming procedures for examining the nature of the processes used to activate and integrate grammatical information in L1 and L2, and (2) compare the morphosyntactic priming in L1 and L2. The study provided a framework for subsequesnt investigations by

(a) showing that the instrument can capture priming effects for gender and number in two types of dependencies, and that these priming effects are larger for NA dependencies than for NV dependencies and for gender than for number;

(b) identifying a semantically and grammatically neutral baseline condition for the accurate measurement of the facilitatory and inhibitory components of morphosyntactic priming effects; and

(c) suggesting that the locus of priming effects may depend on the grammatical feature processed: while it appears that gender information is activated prelexically—using automatic mechanisms or expectancy, number information seems to be accessed after the agreement controller has been accessed.

While the study provided evidence of the use of both automatic and strategic routines in native speakers, further design modifications were deemed necessary to more actively encourage the engagement of prelexical processing routines in the main experiment. One way to dissociate automatic and attentional (expectancy-based) mechanisms is to use stimulus lists with high- and low-grammaticality proportions to encourage ASA on the low-grammaticality proportion lists and expectancy-based mechanisms on the high-grammaticality proportion lists (Neely, 1991). Crossing these lists with a range of SOAs would provide additional evidence of the time course of priming to further dissociate different processing mechanisms. The Main Study, based on the findings of preliminary Studies 1 and 2, was intended to replicate the findings in native speakers and to extend the findings in order to examine the locus of the underlying processes in native speakers and to explore their engagement in second language learners.

CHAPTER FOUR: METHOD (THE MAIN STUDY)

4.1 Aims, research questions, and hypotheses

The aim of the current research was to explore whether highly proficient second language speakers of Russian are able to exhibit native-like sensitivities to morphosyntactic structure. To this end, the study investigated native and second language online processing of local syntactic dependencies governed within and across phrasal boundaries to determine whether the nature of these dependencies contributes to the patterns of performance for both native and L2 participants. It was also important to determine the nature and the locus of the processes that are invoked at the initial stage of lexical access. The study also examined the processing of gender and number agreement in native and L2 speakers of Russian to determine whether gender and number morphological cues can facilitate lexical access in native and nonnative processing. More specifically, the study sought to find answers to the following general research questions:

1. What mechanisms for lexical access underlie the processing of morpholosyntactic information in native and nonnative online processing of agreement? Are native and nonnative speakers similarly sensitive to the syntactic distance between the elements in local syntactic dependencies within phrasal boundaries (NA agreement) and local syntactic dependencies across phrasal boundaries (NV agreement)?
2. What priming patterns characterize native and nonnative processing of gender and number? Are native and nonnative speakers similarly sensitive to gender and number agreement?

In order to answer the first question, I analyzed the processing of two types of dependencies within and across phrasal boundaries (NA and NV agreement) collapsing responses across the two grammatical categories (gender and number). In order to answer the second question, I analyzed patterns of gender agreement and number agreement separately, with mean RTs collapsed across NA and NV dependencies. The inclusion of two SOAs was expected to dissociate automatic and strategic (prelexical and postlexical) routines. Prelexical processing (automatic or attentional), being time-dependent, was expected to be represented by an interaction of SOA and prime (Neely, 1991) based on these assumptions:

- A short SOA (250 ms) evokes fast, automatic mechanisms reflected in priming effects with a facilitatory component only;
- A long SOA (1000 ms) evokes slower, attentional mechanisms reflected in priming effects with an inhibitory component (with or without facilitation) and attributed to either prelexical expectancy generation or postlexical congruency checking strategies (Neely, 1991).

Participants were expected to show facilitation in both long and short SOA condition, with greater facilitation occurring in the long SOA condition owing to the influence of both automatic and cotrolled orocessing. They are also expected to show inhibition in the long SOA condition. Postlexical processing, on the other hand, being time-independent, was expected to be represented by lack of interaction of SOA and prime (De Groot, 1984; McNamara, 2005), as well as in the finding of inhibition at the short SOA of 250 ms.

To further dissociate two types of prelexical processing, i.e., automatic and attentional, the experiments manipulated the grammaticality proportions (GP)[10] (Goodman et al., 1981; Neely, 1991), or the proportion of grammatically related versus unrelated targets. A low-grammaticality proportion (LGP) was expected to evoke prelexical automatic processing (ASA), whereas a high-grammaticality proportion (HGP) was expected to actively encourage prelexical strategic (expectancy-based) processing routines. During prelexical expectancy generation, participants were expected to use the prime word to generate an expectancy set of possible target words that are grammatically related to the prime word. Lexical decisions would be subsequently faster to related target words that were included within the expectancy set than to those that were not, and priming with increased facilitation and increased inhibition would be expected in response to high GP relative to low GP. In contrast, postlexical semantic matching involves retrospectively checking for a relationship between the prime and the target after the grammatical information has been accessed. When there is grammatical congruency between the prime and the target, a participant is more likely to offer a "*yes/word*" response, and the lexical decision, thus, is faster. When there is no congruency, a participant is more likely to offer a "*no/nonword*" response, and lexical decisions are inhibited, because this incongruency must be overcome to clear the way for a "yes" response to real word targets.

In order to examine the time course of the processing routines, the low and high GP versions of each experiment were crossed with each of the two SOAs (250 ms and 1000

[10] Grammaticality proportion is defined as the number of grammatically congruent real word trials divided by the total number of grammatically congruent and incongruent real word trials (Arnott, 2005; Blumstein et al, 1991).

ms).[11] Automatic activation was expected to occur at shorter SOAs and when the GP was low, and controlled expectancy-based processes were expected to occur at longer SOAs and when the GP was high. Table 8 summarizes predicted processing effects for attentional mechanisms based on the following assumptions (discussed in detail in chapter 2):

1. Automatic spreading activation (ASA) has an effect only when the prime and the target are grammatically congruent.

2. ASA produces only facilitatory effects and no inhibitory effects.

3. ASA decays (unless the participant makes a conscious effort to maintain it via rehearsal). Thus, the facilitatory effect of ASA decreases as SOA increases (in our case, it dissipates at the long SOA, which is assumed to be long enough that there will be a complete decay of ASA (Loftus, 1973; Neely, 1977, 1991; MacNamara, 2005).

4. Strategic expectancy-based processes produce a facilitatory effect when the target is an exemplar of the grammatical category expected by the participant (it appears in a high GP list).

5. The effects of prelexical strategic attention increase with increasing SOA. It is assumed that the short SOA is too short for the prelexical routines to be committed, as they require somewhere between 400 and 7000 ms to affect performance in lexical decision (McNamara, 2005).

6. In contrast to prelexical processing reflected in the interaction between SOA and priming condition, postlexical mechanisms are expected to operate independent of SOA and are reflected in the presence of facilitation for grammatically congruent

[11] This range of SOAs was chosen as it incorporated SOAs both shorter and longer than 400 ms, identified as being the point at which attentional processes become activated (Chertkow et al., 1994).

targets and inhibition for grammatically incongruent targets at any SOA. Accordingly, the failure of SOA to interact with prime or the finding of inhibition at even the shortest SOA employed would be indicative of postlexical congruency-checking routines.

Table 8. *Predicted processing effects of automatic spreading activation, expectancy-based prelexical, and coherence-checking postlexical processes as a function of prime condition, GP, and SOA*

Condition	**Example**	**GP**	**SOA**	**ASA**		**Expectancy**		**Coherence-checking**	
				F	**I**	**F**	**I**	**F**	**I**
Grammatical	*Prostoj kozel*	Low GP	250	+		-		+	
	Simple (MASC)goat	Low GP	1000	-		-		+	
	(MASC)	High GP	250	+		-		+	
		High GP	1000	-		+		+	
Ungrammatical	*Prostaja kozel*	Low GP	250		-		-		+
	Simple (MASC) goat	Low GP	1000		-		-		+
	(FEM)	High GP	250		-		-		+
		High GP	1000		-		+		+

Note: Facilitatory effects are represented by F, and inhibitory effects are represented by I. Facilitation is assumed to emerge in reponse to grammatical condition, whereas inhibition is assumed to emerge in response to grammatical incongruency. Therefore, '+' and '-' indicate the presence or absence of a particular process in conditions where their emergence is expected.

The current study's manipulation with the two critical variables—grammaticality proportion and SOA— was expected not only to test these predictions but to more clearly dissociate automatic and strategic processes evoked by the processing of morphosyntactic information in prime-target word pairs in native and L2 speakers of Russian.

The other variables of interest were two types of local syntactic dependencies and grammatical categories of gender and number. The current study, therefore, examined whether number and gender is processed similarly, and whether gender- and number-marked primes would evoke similar priming patterns in native and nonnative speakers of Russian. The study also examined whether there are differences in agreement between nouns and adjectives located within the same noun phrase (e.g., *prostoj kozjol* "simple-MASC-SG goat-MASC-SG") and between nouns and verbs located across phrasal boundaries (e.g., *byl kozjol* "was-MASC-SG goat-MASC-SG").

Preliminary Study 2 demonstrated differences in native speakers' priming patterns that were interpreted in the following way:

1. When data were collapsed across gender and number, NA dependencies within phrasal boundaries invoked both prelexical and postlexical mechanisms, whereas NV dependencies across phrasal boundaries invoked only postlexical mechanisms;
2. When data were collapsed across dependencies, gender processing invoked both prelexical and postlexical mechanisms, whereas number was processed postlexically.

Thus, based on the findings of Study 2, on previous research discussed in chapter 2, and on the assumptions for process dissociation listed above, the study sought to test the following hypotheses:

1. L1 and L2 participants would exhibit differences in engaging attentional mechanisms when accessing morphosyntactic information.

    a. L1 participants would be able to evoke both prelexical (automatic or controlled) routines and postlexical controlled mechanisms depending on the type of dependency (syntactic distance):

    - NA dependencies, due to their short syntactic distance, would encourage prelexical processing routines;
    - NV dependencies, due to their longer syntactic distance, would be processed postlexically.

    b. L2 participants would exhibit differences in both the automatic and controlled processes underlying lexical access compared to L1 participants.

2. L1 and L2 speakers would exhibit the following similarities and differences in the patterns of processing gender and number agreement and in the underlying mechanisms.

    a. Gender agreement and number agreement would be processed differently by both native and nonnative speakers:

    - gender agreement violations would be more disruptive than number agreement violations

- L2 participants would exhibit reduced sensitivity to gender agreement (not instantiated in their L1) than to number agreement (instantiated in their L1).

b. L1 participants and L2 participants would exhibit the Markedness Effect (Akhutina et al, 1999) displaying asymmetries between feminine and masculine nouns and between singular and plural nouns:

- masculines and singulars would be processed faster and would produce larger priming than feminines and plurals;
- agreement violations for masculine singular nouns would lead to inhibition; agreement violations for feminine nouns would lead to facilitation (with or without inhibition); markedness effects for agreement violations for plural nouns would be accompanied by the effects produced by their greater morphological complexity and would be reflected in the presence of both facilitation (due to their non-default status) and inhibition (due to an additional process of decomposition).

c. Both L1 and L2 participants would demonstrate similar sensitivity to the syntactic distance effect that would be evident in slower RTs for and smaller size of priming for NV dependencies (across syntactic boundaries) than for NA dependencies (within syntactic boundaries).

d. L1 participants would be able to evoke both automatic and expectancy-based mechanisms in processing gender agreement, but number agreement (plurals, in particular) would only evoke postlexical controlled routines (due to the additional process of morphological decomposition). L2 participants would only rely on postlexical controlled mechanisms in processing both categories.

4.2 Participants

4.2.1 Pre-screening

Forty Russian-speaking participants residing in Russia and 40 English-speaking participants residing in the USA filled out a background questionnaire covering general information (age,[12] sex, etc.), language history (native language, number of years of language learning experience, participation in study-abroad or intensive summer programs, etc.), visual acuity, handedness, and some logistical questions (in particular, access to a PC[13]). The participants were prescreened by using a web-based survey created at https://docs.google.com (Appendix A).

In the native speakers group, three participants withdrew from the study before taking language proficiency tests. Thirty seven participants took the proficiency tests, and one participant withdrew from the study before starting the main experiment. The remaining 36 participants completed all the experimental tasks. At the analysis stage, one participant's mean accuracy rates were found to fall outside the accuracy scores frequency distribution and this participant's data were excluded from the analysis. In order to preserve a balanced design, with 9 participants per testing condition, one more

[12] Since there is strong evidence for normal age-related overall slowing of RT in LD tasks and less semantic priming in older than in younger controls (Ober & Shenaut, 1995), care was taken not to include participants older than 50.
[13] The DMDX program used in the study to measure reaction times to linguistic stimuli is a Windows-based display system and does not run on Mac computers.

participant was added to the study as a replacement. A randomly selected subgroup of 10 NS participants also completed a gender-monitoring task and a number-monitoring task as controls.

In the L2 group, five students could not participate in the study because of technical difficulties (lack of access to a PC that is required by the DMDX software), two participants withdrew during the screening stage due to changes in circumstances, and 14 did not pass the screening: their scores were below the cutoff points (identified in Study 1) indicating a lower proficiency level than needed for the current study. Seventeen more participants were recruited to yield a total of 36 participants. At the analysis stage, three participants' mean accuracy rates were found to fall outside the accuracy scores frequency distribution, these participants' data were excluded from the analysis, and three replacements were found to keep the number of English-speaking participants in the L2 group at 36.

All the participants were 18 years of age or older, had over 13 years of formal education, and had normal or corrected-to-normal vision (Table 9). All L2 participants were speakers of English as the native language, and all had extensive practice with Russian either through study-abroad, living and/or working in Russia or attending intensive summer programs in the US. As seen in Table 9, the difference in age between the NS and the L2 groups was significant: $t(35)=3.57$, $p=.001$. However, selecing of younger L2 participants would have entailed recruiting participants at a lower level of proficiency, which was not desirable for the purposes of the current study, whereas selection of participants in Russia was determined by an easier access to university students than to working adults.

Table 9. *Participants' demographics*

	Native Speakers	**L2 Speakers**
Mean Age (years)	21.81 (range: 18—33)	26.97 (range: 20—49[14])
Sex (N)	Females: 26 Males: 10	Females: 17 Males: 19
Handedness	Right-handed: 35 Left-handed: 1	Right-handed: 35 Left-handed: 1
Mean years of formal education (years)	14.7	16.8

4.2.2 Screening

Further, the participants took two online proficiency tests—the cloze test (Appendix B) and the GJT that were used in study 1 (Appendix C). Both tests were created in the Canvas learning management system (https://canvas.instructure.com) and were completed online under time pressure (the participants were allowed 30 minutes for the cloze test and 20 minutes for GJT, with the timer on the screen showing the time left). The scoring procedure for the cloze test was made more rigorous in comparison with the scoring procedure used in Study 1: participants received 1 point for semantically acceptable and grammatically correct responses and 0 points for either semantically unacceptable responses or incorrect grammatical forms. Over 50% of native speakers'

[14] Two participants in the L2 group were over 40 years of age (to be specific, one was 42 and the other was 49). Although there was no significant difference in the processing speed between these and younger participants, the older participants were assigned to different testing groups.

responses for one item in the test were semantically unacceptable, and this item was removed from the analysis for both NS and L2 groups.

All Russian-speaking volunteers and those L2 volunteers who scored above 60% on the cloze test and above 85% on the GJT were invited to participate in the main study. Results of both groups' performance on each test are presented in Table 10.

Table 10. *Participants' performance on the screening tests*

	Native Speakers	**L2 Speakers**
Cloze test		
Accuracy (%)	96 (84—100)	76 (62—95)
Average time (min)	8 min	17 min
Grammaticality		
judgment test	95 (88—100)	95 (85—100)
Accuracy (%)	11 min	17 min
Average time (min)		

4.3 The Lexical decision study

4.3.1 Design

The overall design of the LDT study was based on study 2, but there were the following design modifications. The current study used a within-subjects design, in which each participant was exposed to all the experimental conditions. To dissociate two types of prelexical processing, i.e., automatic and expectancy-based processing, each participant was exposed to different (high and low) grammaticality proportions (GP) (as defined above) (Goodman et al., 1981; Neely, 1991). In accordance with the aims of the study and to allow the time course of the processing routines to be charted, different SOAs needed to be used. The four SOAs used in the pilot study would have required eight different tests featuring different stimuli, which was deemed unpractical. Therefore, two SOAs considered to be most representative for the purposes of the investigation (namely 250 ms and 1000 ms), were selected for the current study.

Since the complete morphosyntactic priming battery for each participant consisted of four lexical decision tests, Low GP-SOA250, Low GP-SOA1000, High GP-SOA250, and High GP-SOA1000, four different lists of targets were created. Manipulations with grammaticality proportion resulted in two versions of each target: a high GP (HGP, or HP) version with GP of 0.7 and a low GP (LGP, or HP) version with GP of 0.3. These 8 stimuli lists (4 x 2) were crossed with two SOAs (250ms and 1000ms) (8 x 2), which, in turn, resulted in 16 tests (Figure 11). These 16 tests were distributed among participants in such a way that each participant encountered different targets in each of the four experimental conditions, but across participants each target appeared in all GP and SOA experimental conditions (Figure 12). It was not possible to counterbalance all the items in the priming condition without disturbing the desired grammaticalilty proportion. Hence, with the change in GP from high to low, the nouns appearing in the high GP lists in the grammatical condition appeared on the low GP list in the ungrammatical condition, and the nouns that were used in the high GP lists the ungrammatical condition were used on the low GP lists in the grammatical condition.

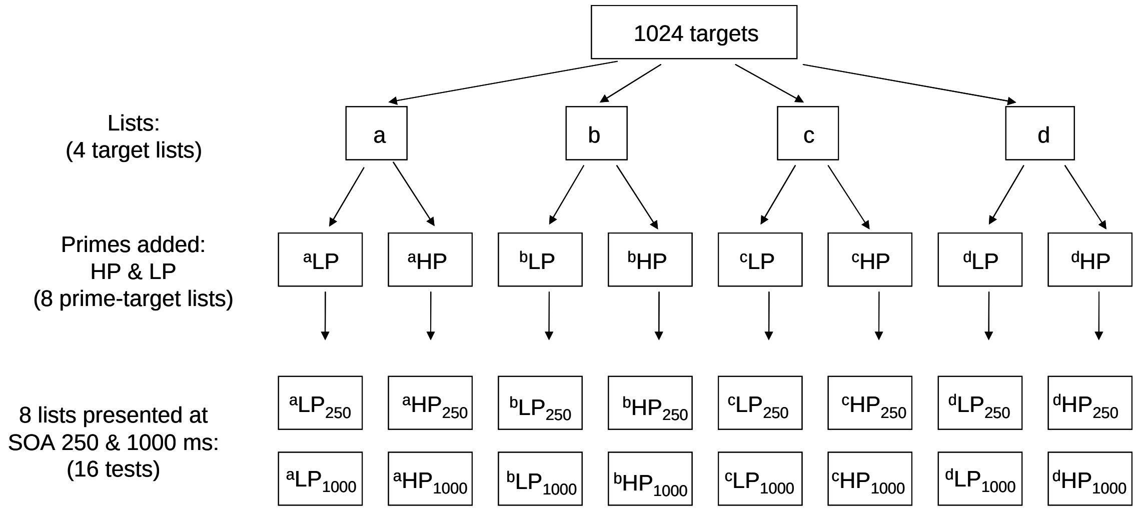


Figure 11. Design of the experiment.

Participant	Test set taken	Tests taken
1.	1	${}^{a}LP_{250}$ ${}^{b}LP_{1000}$ ${}^{c}HP_{250}$ ${}^{d}HP_{1000}$
2.	2	${}^{b}LP_{250}$ ${}^{c}LP_{1000}$ ${}^{d}HP_{250}$ ${}^{a}HP_{1000}$
3.	3	${}^{c}LP_{250}$ ${}^{d}LP_{1000}$ ${}^{a}HP_{250}$ ${}^{b}HP_{1000}$
4.	4	${}^{d}LP_{250}$ ${}^{a}LP_{1000}$ ${}^{b}HP_{250}$ ${}^{c}HP_{1000}$
5.	1	${}^{a}LP_{250}$ ${}^{b}LP_{1000}$ ${}^{c}HP_{250}$ ${}^{d}HP_{1000}$
6.	2	${}^{b}LP_{250}$ ${}^{c}LP_{1000}$ ${}^{d}HP_{250}$ ${}^{a}HP_{1000}$
7. …	……	…………..
…..		
9.	1	${}^{a}LP_{250}$ ${}^{b}LP_{1000}$ ${}^{c}HP_{250}$ ${}^{d}HP_{1000}$
…	……	…………
36.	4	${}^{d}LP_{250}$ ${}^{a}LP_{1000}$ ${}^{b}HP_{250}$ ${}^{c}HP_{1000}$

Figure 12. Tests rotation across participants.

4.3.2 Stimuli

The target list used in preliminary Study 2 (Appendix D) served the basis for creating the current study's master list consisting of 1024 targets (Appendix F). Besides increasing the number of stimuli from 800 to 1024 (see explanations below), there were two key changes to the stimuli used in Study 2. First, the three neutral prime conditions used in that study were collapsed to create one neutral condition. For this condition, the prime "*prosto*," identified as being semantically and syntactically neutral, was employed. Second, since the present experiment examined the effect of GP on morphosyntactic priming, the stimulus lists used in Study 2 were modified to create lists with two different GPs—low and high.

Experimental stimuli consisted of prime/target word pairs representing syntactic dependencies within and across syntactic phrase boundaries featuring gender and number agreement in a grammatical (G) condition, an ungrammatical (U) condition, and a neutral (N) condition. Since the study examined gender and number agreement, primes needed to be marked for gender (masculine and feminine) and number (singular and plural). Therefore, primes included: (1) the masculine singular adjective *prostoj* ("simple"); (2) the feminine singular adjective *prostaja* ("simple"); (3) the plural adjective *prostyje* ("simple"); (4) the masculine singular past form of the verb *byt'* ("to be")—*byl* ("was"); (5) the feminine form of the verb *byt'* ("to be")—*byla* ("was"); (6) the plural form *byli* ("were"); and (7) the adverb "*prosto*."

These primes were combined with targets to form three experimental conditions: grammatical (G), ungrammatical (U), and neutral (N). Table 11 demonstrates the experimental design detailing the distribution of targets across priming conditions.

Table 11. *Experimental design*

(a) High-grammaticality proportion: GP: .7

Target/ Prime	Fem Adj: Prostaja	Masc/Sing Adj: Prostoj	Plural Adj: Prostyje	Fem Verb: Byla	Masc/Sing Verb: Byl	Plural Verb: Byli	Neutral: Prosto
FEM	NA G	NA U	n/a	NV G	NV U	n/a	N
real	13	5	0	13	5	0	5
nonce	10	5	0	10	5	0	10
MASC/SING	NA U	NA G	NA U	NV U	NA G	NV U	N
real	5	13	5	5	13	5	5
nonce	5	10	5	5	10	5	10
PLURAL	n/a	NA U	NA G	n/a	NV U	NV G	N
real	0	5	13	0	5	13	5
nonce	0	5	10	0	5	10	10

(b) Low-grammaticality proportion, GP: .3

Target/ Prime	**Fem Adj: Prostaja**	**Masc/Sing Adj: Prostoj**	**Plural Adj: Prostyje**	**Fem Verb: Byla**	**Masc/Sing Verb: Byl**	**Plural Verb: Byli**	**Neutral: Prosto**
FEM	NA G	NA U	n/a	NV G	NV U	n/a	N
real	5	10	0	5	10	0	5
nonce	5	8	0	5	8	0	10
MASC/SING	NA U	NA G	NA U	NV U	NA G	NV U	N
real	10	5	10	10	5	10	5
nonce	8	5	8	8	5	8	10
PLURAL	n/a	NA U	NA G	n/a	NV U	NV G	N
real	0	10	5	0	10	5	5
nonce	0	8	5	0	8	5	10

The targets included real nouns with a frequency range between 10 and 320 occurrences per million words and nonce nouns based on real nouns, drawn from other frequency ranges, all in transparent disyllabic forms. The same nouns were used as targets in the masculine and singular categories, and they were compared once with feminine nouns and once with plural nouns during analysis. The mean lemma frequency across all categories was 75.11 (*SD*=59.8). A one-way ANOVA run on raw frequencies and word length, with word category (feminine, masculine/singular, and plural) as a factor did not find significant differences among word categories in word frequency. The difference in word length between feminine, masculine/singular and plural nouns, however, was shown to be significant, $F(2,514)=59.89$, $p<.001$, $\eta\rho^2=.189$. However, it proved impossible to achieve a satisfactory balance for word length in letters. A great care was, therefore, taken to maintain the same average word length for each block of nouns in each condition in each list and across lists (Table 13). A later analysis of mean RTs as a function of word length showed that in word length did not modulate RTs in either group of participants. The mean word length was 5.1 (*SD*=.9). Word frequencies (including surface frequency for plural nouns) were also carefully balanced across blocks of feminine, masculine, and plural targets used in each prime condition (see Appendix F for a complete list of targets). ANOVA did not find significant differences in either word length or lemma frequencies among stimuli lists.

Table 12. *Mean length and frequency of word stimuli*

	Word category	Mean	SD	Min	Max
Word length (letters)	Feminine	4.79	0.73	3	7
	Masculine/Singular	5.55	0.86	4	8
	Plural	4.80	0.65	3	6
Word frequency (ipm)	Feminine	72.31	59.10	20	318
	Masculine/Singular	76.87	58.52	21	303
	Plural	75.45	61.90	12	254

To meet different GP requirements, the GP for each list was calculated according to the following formula:

$$\frac{\textbf{All real words in the G condition}}{\textbf{All real words (grammatical) + All real words (ungrammatical)}}$$

Each high GP list had the GP of .7 (i.e., 70% of all real words used in the G and U conditions formed grammatical prime-target stimuli, and 30% formed ungrammatical pairs), and each low GP stimulus list had the GP of .3 (i.e., 30% of all real words used in the G and U conditions formed grammatical prime-target stimuli, and 70% formed ungrammatical pairs).

Thus, careful balancing of the number of the stimuli in each experimental condition yielded 133 real word targets in each HGP list and 125 real word targets in each LGP list. These word targets were distributed across the three prime conditions in the following manner: 78 G, 40 U, and 15 N word trials in the HGP lists, and 40 G, 70 U, and 15 N word trials in the LGP lists (Tables 11a and b).

As common in the literature, the study employed about 50% of nonwords: 130 nonwords in the HGP list: 60 G, 40 U, and 30 N) and 124 nonwords in the LGP list: 36 G, 58 U, and 30 N. To discourage participants from responding before reading the entire nonword letter string, half of the nonwords were derived from real word stems by adding inappropriate endings (Blumstein et al., 1991). The remaining nonwords were created by randomly changing one or two letters in real word stems that were not used in the experiments. Care was taken to ensure that newly constructed nonwords did not use low-frequency bigrams and orthographic or phonological sequences that are illegal in Russian. The list was checked by ten native speakers of Russian, who did not participate in the study, with the aim of identifying any low-frequency real words that could have inadvertently been created by manipulations with real words. As a result, 5.18% of nonce words were replaced or reconstructed.

Thus, the total number of targets used the experiment was 1024 (263 words in each of the two HGP lists and 249 words in each of the two LGP lists), with a total of 516 real word targets and 508 nonword targets.

4.3.3 Procedure

The investigations were carried out in remote testing mode using the DMDX software developed by K. I. Forster and J. C. Forster at the University of Arizona (2003).

Participants signed a consent form electronically and received detailed instructions by email for each testing session.[15]

The L2 participants and a subgroup of NS participants, who completed the gender and number monitoring tasks, completed the experiment in three testing sessions held on three different days, with two tests featuring the same GP but different SOAs completed on the same day. The procedure is presented in Figure 13. All the participants started testing with the LGP lists because starting with the high GP lists could have created an expectation that the pairs of words are grammatically congruent that could have interfered with subsequent processing of the stimuli in the low GP lists that was designed to trigger automatic activation (facilitation of grammatical targets in the absence of inhibition of ungrammatical targets). Upon completion of each test an e-mail with the participant's data was sent to the experimenter automatically.

[15] Although the study participants were unsupervised when performing the experimental tasks, an examination of their accuracy scores and the percentage of ouliers in the reaction time data showed that the performance indices were within the boundaries expected in lab conditions (see section 5.1).

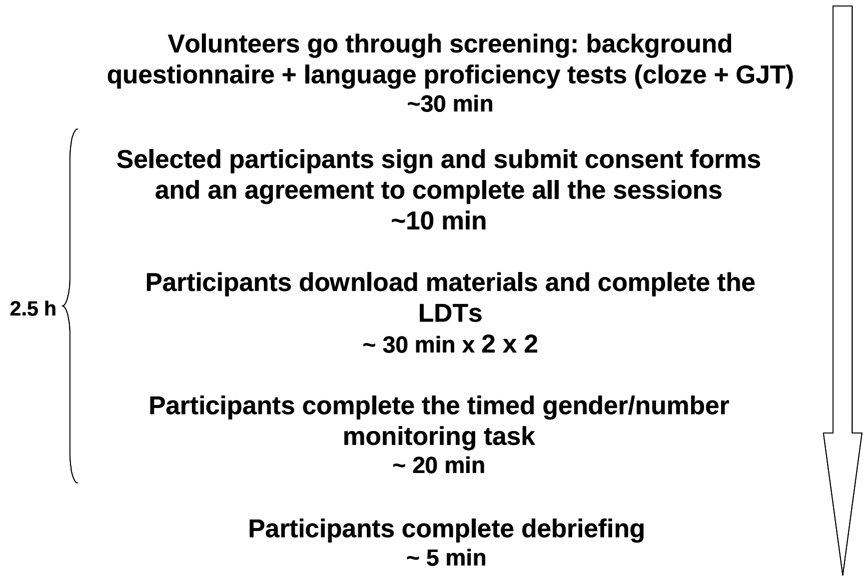


Figure 13. The experimental procedure.

Experimental stimuli were presented via 12 blocks of 20-22 trials. There were 263 trials in each HGP list and 249 trials in each LGP list. After each block, participants were given an opportunity to rest. A set of 14 practice pairs preceded each experiment. The practice primes included 14 prime-target pairs (7 real words and 7 nonce words—one for each type of grammatical feature in both types of dependencies) presented in different priming conditions (6 grammatical, 6 ungrammatical, and 2 neutral). The participants were instructed to take a longer break between the two tests that were completed on the same day. All the sessions were completed on different days.

Participant reaction times, or the time from the presentation of the target to depression of the response button, were recorded to the nearest millisecond for correct responses to word and nonword targets. Errors were also recorded for both *yes* responses to nonword targets and the failure to recognize the word targets. Studies vary in whether feedback is given or not. Since the main dependent variables in the current experiment were reactions latencies and accuracy, it was decided to provide direct feedback to participants in the form of RTs in milliseconds after each correct response. If their response was incorrect, they received negative feedback (*Wrong*) without RT information. This not only reminded participants of accuracy instructions but discouraged them from pressing the response keys randomly (Wentura & Degner, 2010).

4.4 The Gender/Number monitoring task

After completing the four tests of the main experiments, L2 participants and a randomly selected subgroup of native participants also completed a gender-monitoring task (GMT) and a number-monitoring task (NMT) to assess the probability that observed priming effects in L2 speakers were influenced by incorrect gender or number assignment and to determine the ratio of errors made due to motor effects. The stimuli incorporated all the 516 real nouns used in the LDT experiment, with half of the masculine singular nouns used in the NMT and the other half in the GMT. Thus, the GMT included 152 feminine nouns and 106 masculine singular nouns, and the NMT included 152 plural nouns and 106 masculine singular nouns.

The two tasks were completed after the main experiment and involved a dual-choice response mode. Stimuli were presented visually using DMDX software remote response mode. Participants were asked to decide as quickly as possible whether the word they saw belonged to the feminine or masculine gender in the GMT and to singular or plural number in the NMT. They depressed the right control button for masculine and singular nouns and the left control button for feminine and plural nouns. They had four seconds to respond. Six practice trials were presented before each task, and the order of the stimuli was randomized for each participant. The presentation of the tasks was counterbalanced across participants.

4. 5 Debriefing

All the participants completed an online debriefing questionnaire which fulfilled educational and ethical functions (Appendix G). In the questionnaire they could share their thoughts about the purpose of the experiment, evaluate its difficulty, procedures, and the amount of remuneration, as well as express any concerns and indicate whether they would like to be contacted for future studies.The results of the debriefing were not analyzed, but an informal examination showed that most participants expressed their interest in the purpose of the study, satisfaction with the procedures, and a desire to participate in future experiments. Afterwards the participants received a letter, in which the researcher thanked them for participation and provided a description of the true purpose of the experiment. The letter also informed the participants that if they would like any information about the results of the study once it is completed, they should feel free to contact the researcher.

CHAPTER FIVE: RESULTS

5.1. Data preparation

5.1.1 Word versus nonword discrimination

The first step in the experimental data analysis consisted in examination of the accuracy of real and nonce word discrimination by native and L2 speakers. To justify the use of the collected data in the further analysis of priming effects it was critical to demonstrate that the probability of correct discrimination of real and nonce words by participants was well above chance, or in other words, that the word categorization accuracy (ranging from 0% for all incorrect classifications to 100% for all correct classifications) was significantly larger than 50% corresponding to at-chance performance.

According to the signal detection theory (SDT) (Macmillan & Creelman, 1991), that attributes responses to a combination of sensitivity and bias, the behavior of an observer, when responding ‘‘*yes*’’ or ‘‘*no*’’ regarding the presence or the absence of the signal against a background of noise, has at least two dimensions. One dimension is determined by the sensitivity of the observer (i.e., how well the observer discriminates the signal from noise); a second dimension is referred to as the observer’s response bias, or the inclination to judge in one direction as opposed to the other (e.g., to indicate that the signal is present rather than absent).

In order to analyze the participants’ discrimination performance, a typical line of analysis of the results of binary classifications used in the SDT was followed. All results were categorized into true positives (TP), or correct identifications of real words, or hits; true negatives (TN), or correct identifications of nonce words; false negatives (FN), or incorrect classification of real words as nonce words, or misses; and false positives (FP), or incorrect classification of nonce word as real words, or false alarms. For the convenience of presentation, the number of responses in each category was converted into a corresponding fraction (f) by dividing this number by the total number of targets. For example,

N = TP+TN+FP+FN is the total number of all stimuli or responses;

f(TP) = TP/N is the fraction of true positive classification results;

f(TN) = TN/N is the percent fraction of true negative classification results;

f(FP) = FP/N is the percent fraction of false positive classification results;

f(FN) = FN/N is the percent fraction of false negative classification results.

The overall accuracy of the binary classification experiment is estimated as the sum of the true positive and true negative fractions:

Accuracy = f(TP)+f(TN)

The overall error rate is the sum of all false classification fractions:

Error = f(FP)+f(FN)

There are four other parameters characterizing the classification accuracy that are frequently used in the literature, hit rate (r) or rate of true positives r(TP), correct rejection rate or rate of true negatives r(TN), miss rate or rate of false negatives, r(FN), and false alarm rate or the rate of false positives, r(FP):

r(TN) = TN/(FP+TN)

r(TP) = TP/(FN+TP)

r(FN) = FN/(FN+TP)

r(FP) = FP/(FP+TN)

The rate of false negatives, r(FN) presents the probability of attributing a real word to the nonce-word category, whereas the rate of false positives, r(FP) presents the probability of classifying a nonce word as real.

Table 13 shows real/nonce word discrimination by all participants for the four tests (LGP1000, LGP250, HGP1000 and HGP250) of both experiments. The results are presented in the form of fractions f(TP), f(TN), f(FP), f(FN) as defined above.

Table 13. *Real and nonce word discrimination by native and L2 participants*

	Native Speakers		**L2 Learners**	
	Responses			
Stimuli	**Real words**	**Nonce words**	**Real words**	**Nonce words**
Real words	0.479	0.029	0.443	0.050
Nonce words	0.032	0.460	0.049	0.458

Note: Values in the table present the number of responses in each category as the fraction of the total number of all responses (or stimuli) for all tests.

As shown in Table 14, the overall accuracy of real/nonce word discrimination was high for both groups (0.94 for native speakers and 0.90 for L2 speakers). In both groups, errors of two types were well-balanced: the fraction of false positives and false negatives in all responses in the native speaking group was equal, correspondingly, to 0.032 and 0.029. Corresponding error fractions in the L2 speakers were 0.049 and 0.050.

Table 14. *Mean classification accuracy for native and L2 participants*

	Native Speakers	**L2 Speakers**
Accuracy	0.939 (0.832—1.0)	0.901 (0.973—0.713)
Error	0.062 (0.0—0.168)	0.099 (0.027—0.287)
Hit Rate	0.944 (0.838—1.0)	0.898 (0.725—0.970)
Miss Rate	0.056 (0.0—0.162)	0.102 (0.030—0.275)
Correct Rejection Rate	0.934 (0.822—1.0)	0.904 (0.700—0.977)
False Alarm Rate	0.066 (0.0—0.178)	0.096 (0.023—0.300)

Note: Values in the brackets represent the range of corresponding accuracy characteristics for individual participants.

One-sample *t*-test was used to check whether the mean accuracy rate for both groups was significantly larger than 0.5. The probability of correct real/nonce word discrimination was found to be well above chance for both groups. For L2 speakers: M=0.901, SD=0.061, $t(35)$=41.1, p<0.001, and for native speakers: M=0.939, SD=0.047, $t(35)$=55.8, p<0.001. Therefore, it was concluded that responses given by both groups were not based on chance.

D-prime analysis was also conducted to examine the participants' ability to discriminate signal from noise. D-prime values were calculated as the difference of z-sores of hit and false alarm rates using the results of all four tests:

$$\mathbf{d' = Z(r(TP)) - Z(r(FP))}$$

Overall d-prime value for native speakers was equal to 3.09 and ranged from 1.91 to 4.26 for individual participants (for four participants in this group d' values could not be calculated because their hit rate was 1.0). Overall d-prime value for L2 speakers was equal to 2.59 and ranged from 1.12 to 3.87 for individual participants.

One sample *t*-test was carried out on the mean d-prime values in order to check the difference from chance level (d'=0). The one-sample *t*-tests revealed a significant difference from 0 for d' values of both the native and the L2 groups: $t(35)=24.3$, $p<0.001$ (two-tailed) and $t(35)=25.1$, $p< 0.001$ (two-tailed), respectively.

Diependaele et al. (2012), who have for the first time analyzed the level of internal noise associated with response choice and RTs in the LDT, showed that responses for nonword and word choices for words with a frequency above 10 per million are very consistent, indicating a high validity of RT for these stimuli with the LDT. Since all the words used in the current experiment had a mean frequency of 75 wpm and, according to the results of a debriefing questionnaire, all the L2 participants were familiar with 90% or more of all the words, which was reflected in a very small number or errors, RT data used in the analyses are deemed reliable.

5.1.2 Reliability and data cleaning

Correct responses to word targets were analyzed. The internal consistency of the tests was assessed by computing the split-half reliability for the RT data using the Spearman-Brown formula. Reliability coefficients, with r=1.00 for native participants and r=.99 for L2 speakers (Table 15), were very high overall. However, the neutral condition was characterized by lesser consistency of responses in both groups, in particular in the L2 group, as evidenced in lower reliability coefficients and suggesting more processing difficulties caused by the neutral primes. Furthermore, there was a drop in the magnitude of reliability coefficients in L2 participants in LP1000 grammatical and HP250 neutral conditions, possibly caused by these participants' lesser familiarity with individual items in the list.

Table 15. *Reliabilities for all the tests for native and L2 participants prior to data cleaning*

Participants/Tests	**Grammatical Condition**	**Ungrammatical Condition**	**Neutral Condition**	**All**
		Native		
LP250	0.96	0.97	0.87	0.98
LP1000	0.97	0.99	0.91	0.99
HP250	0.98	0.98	0.91	0.99
HP1000	0.98	0.96	0.95	0.99
All	0.99	0.99	0.98	1.00
		L2		
LP250	0.92	0.95	0.89	0.98
LP1000	0.76	0.97	0.87	0.98
HP250	0.94	0.88	0.63	0.98
HP1000	0.94	0.90	0.84	0.96
All	0.96	0.99	0.93	0.99

As is customary in priming studies, native speakers' values greater than 1500 ms were considered extreme and were removed from the data. They constituted .86% of all responses, which falls at the 99th percentile of all responses. In order to maintain consistency of the filtering process across the two groups of participants, the threshold value for filtering outliers in L2 data was set at 99th percentile as well and was equal to 2000 ms. Values, or response times, greater than 2000 ms were considered extreme and eliminated. All the remaining responses fell within two standard deviations from the mean. The internal consistency of the tests was reassessed showing higher values of reliability coefficients in the conditions where the coefficients were lower in the first test (Table 16).

Table 16. *Reliabilities for all the tests for native and L2 participants after data cleaning*

Participants/Tests	Grammatical Condition	Ungrammatical Condition	Neutral Condition	All
		Native		
LP250	0.96	0.97	0.87	0.98
LP1000	0.96	0.99	0.94	0.99
HP250	0.99	0.98	0.90	0.99
HP1000	0.98	0.98	0.93	0.99
All	0.99	0.99	0.96	1.00
		L2		
LP250	0.94	0.96	0.86	0.98
LP1000	0.80	0.97	0.88	0.98
HP250	0.95	0.93	0.71	0.98
HP1000	0.94	0.88	0.81	0.97
All	0.97	0.99	0.93	0.99

Reliability coefficients were also calculated for each type of dependency and for each grammatical category across the four tests. Perusal of Table 17 shows that, in particular for L2 participants, the distribution of coefficients is more across the grammatical categories than across the tests, with more variability in the neutral condition but with high coefficient values across all categories as well as overall.

To identify targets used in the LDT in which L2 participants may have assigned gender/number incorrectly, responses to the gender- and number-monitoring tasks were analyzed. The analysis revealed that L2 participants' mean accuracy in both gender and number assignment was high: it was 97.3% (range: 90.1%-100%) on the GM task and 96.7% (range: 90.4%-100%) on the NM task. The mean accuracy scores of the subgroup of Russian participants (N=10), who also performed the tests, were 96.9% (range: 90.2%-100%) on the GMT and 95.8% (range: 90.1%-100%) on the NMT.

Table 17. *Reliabilities for syntactic dependencies and grammatical features for native and L2 participants after data cleaning*

Participants/Tests	**Grammatical Condition**	**Ungrammatical Condition**	**Neutral Condition**	**All**
		Native		
NA dependencies	0.99	0.99	0.92	1.00
NV dependencies	0.99	0.99	0.95	1.00
Gender	0.98	0.98	0.96	0.99
Number	0.98	0.98	0.96	1.00
All	0.99	0.99	0.96	1.00
		L2		
NA dependencies	0.97	0.97	0.90	0.99
NV dependencies	0.96	0.98	0.90	0.99
Gender	0.93	0.98	0.93	0.99
Number	0.97	0.96	0.93	0.99
All	0.97	0.98	0.92	0.99

Errors among native participants on the gender and number monitoring tasks were obviously due to errors in motor responses and constituted 3.6% of all responses. Errors among L2 participants constituted 3%. Because of L2 participants' high proficiency level and native-like error rate on the monitoring tasks, it was decided not to remove these words from their LDT RT data for reasons of consistency in data cleaning between the NS and the L2 groups.

Performance of native speakers and L2 participants was further compared by blocks used in the presentation. Figures 14 and 15 demonstrate that error rates and reaction times across blocks for both the native and the L2 groups were relatively stable, with the exception of the first two blocks where the participants made more errors and responded slower as they were getting used to the routine.

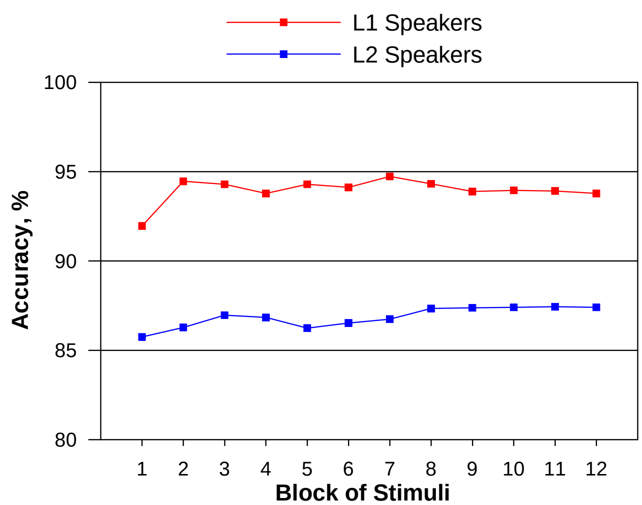


Figure 14. Accuracy rates across blocks for the L1 and L2 groups.

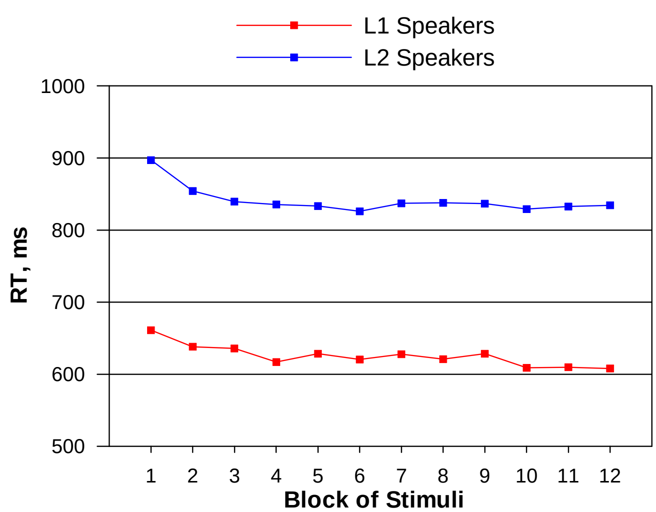


Figure 15. Reaction times across blocks for the L1 and L2 groups.

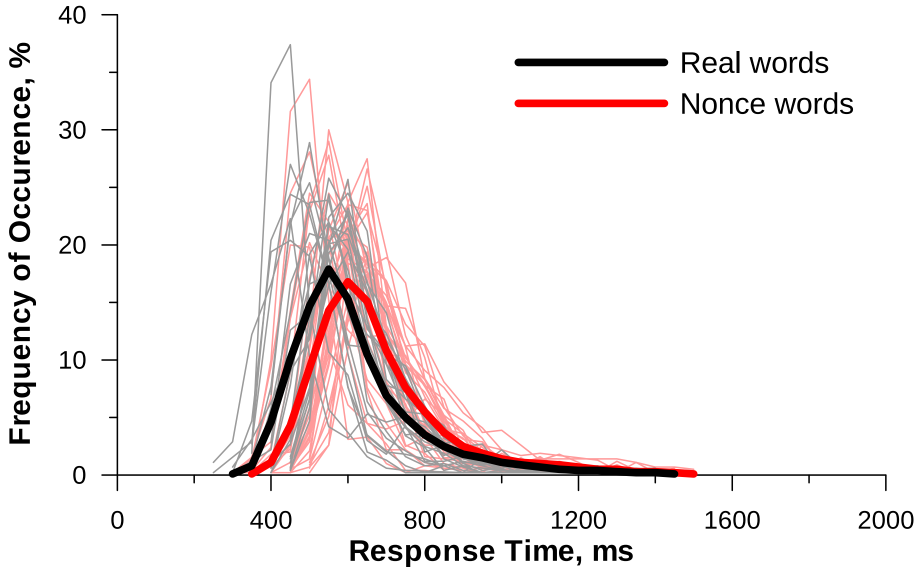
The stimuli presentation was randomized for each participant, so these minor fluctuations were not considered in the analysis.

5.2 Lexical decision task

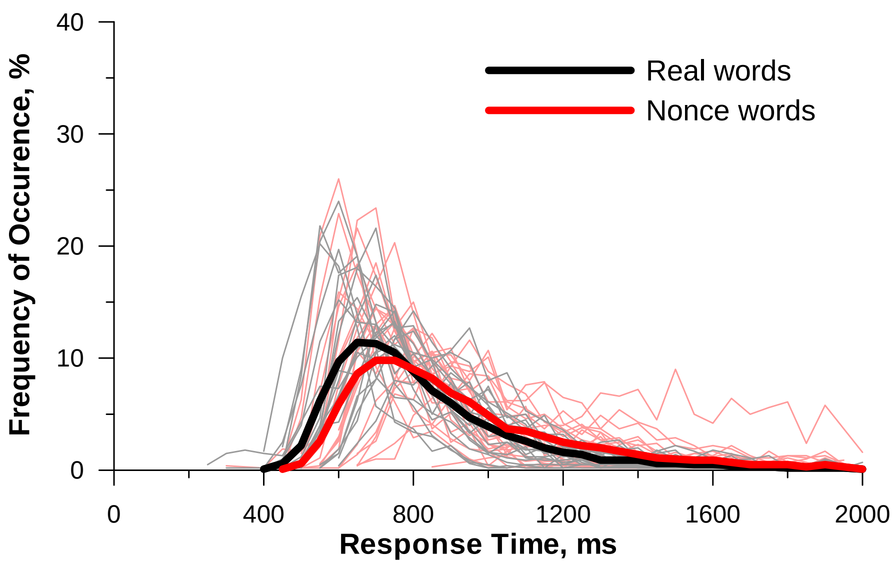
5.2.1 Preliminary analysis

The average response latencies in native and L2 groups were calculated for real and nonce words for each participant collapsed over items across multiple trials for each condition.[16] Figures 16a and 16b show native and L2 frequencies of distribution of each participant's RTs for real and nonce words as a function of percentage of total responses across conditions, and Figure 17 compares native and L2 frequencies of distribution for real words. As the graphs demonstrate, the curves of the distribution, although close to normal, are positively skewed, as are virtually all empirical RT distributions (e.g., Luce, 1986). Both groups took longer to recognize nonce words than real words. The curves of the means distribution for L2 RTs of both real and nonce words collapsed across all cells of the design are flatter and wider than the curves of the native speakers' means distribution reflecting slower response latencies and a larger variance among L2 speakers (RTs for real words: M_{NS}=618.5, *SD*=170.8; M_{L2}=830.17, *SD*=258.6). The mean RTs for native speakers are compatible with values reported by Arnott et al (2005) for English-speaking controls' morphosyntactic priming in a similar experiment averaged over the means reported for the same conditions as the ones used in the current study.

[16] The data obtained in this study were analyzed with subjects as the unit of analysis, and only F_1 is reported, following McNamara's recommendation (2005): "Joint reporting of F_1 and F_2 is never correct; one should report either F_1 or the appropriate quasi-F ratio (or its approximation, *miniF'*)" (p.56).



(a)



(b)

Figure 16. Frequency distributions of RTs for real and nonce words across conditions and experiments for L1 *(a)* and L2 *(b)* participants.

Note: Thin lines represent mean RTs of individual participants. Thick lines represent combined RTs for all participants.

It thus seems fair to conclude that the morphosyntactic priming method (applied for the first time to Russian) yields reaction times well within the range needed in order to draw conclusions about online priming effects.

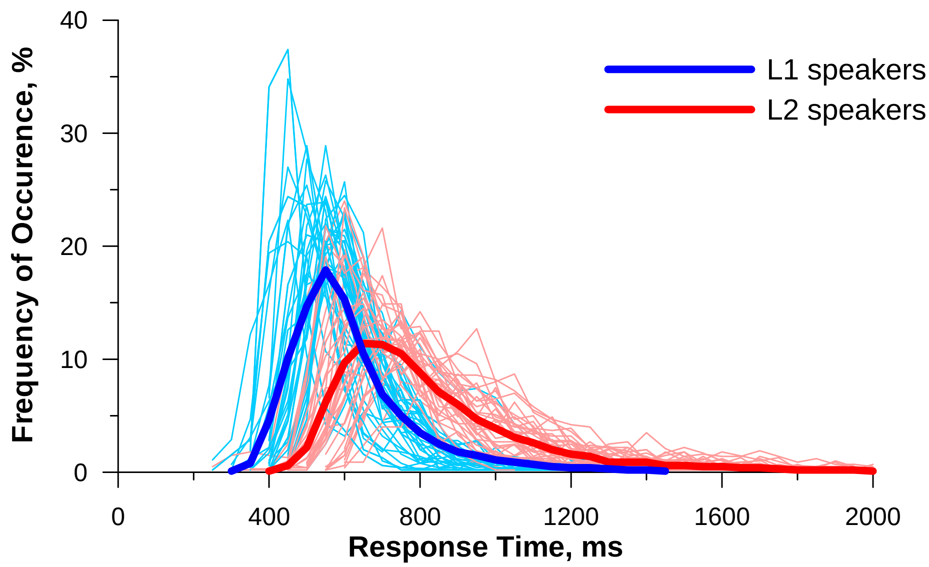


Figure 17. Frequency distributions of RTs for real words across conditions and experiments.

Note: Thin lines represent mean RTs of individual participants. Thick lines represent combined RTs for all participants.

If viewed as a representation of a gradation of response intensity over time (Milberg, November, 2011, personal correspondence), we can assume that the frequency distribution may reflect patterns of spreading activation in NS and L2 participants (Butler, McNamara, & Durso, 2010; Butler et al. 2011). Activation of morphosyntactic information in L2 speakers appears to be delayed, to be lower in intensity, and to last longer in comparison to native speakers.

The average response latencies and accuracy rates calculated for real words for each participant were submitted to a one-way ANOVA. Significant differences between the two groups were found in RTs: $F(1,71)=66.04$, $p<.001$, $\eta\rho^2 = .482$[17] and in accuracy rates: $F(1,71)=33.56$, $p<.001$, $\eta\rho^2 = .321$. Levene's Test of Homogeneity of Variances indicated that group comparisons failed to meet the assumption of homogeneity of variance: $F(1,71)=3.11$, $p<.05$, $\eta\rho^2=.042$, and $F(1,71)= 3.83$, $p<.05$, $\eta\rho^2=.051$. Accordingly, the L2 and L1 groups' data were not compared directly. Instead, the groups' data were analyzed independently. Since the study did not consider the role of language proficiency, the L2 group was relatively homogenous in proficiency, and proficiency was not used as a covariate. Further, the use of the same primes in each condition eliminated the need for analyses of variance over items, so that all statistical analyses were conducted only over participants. Guided by the research questions, the following sections present detailed analyses of each group's data, first comparing agreement in syntactic dependencies, then focusing on gender and number agreement.

5.2.2 Syntactic dependencies

5.2.2.1 Noun-adjective versus noun-verb dependencies

Based on Blumstein et al.'s (1991) findings that priming differed according to whether prime–target constructions operated within phrasal boundaries or across phrasal boundaries, it was predicted that native speakers would process NA and NV dependencies differently. Two-way within-subjects ANOVAs with dependency (NA, NV) and prime condition (grammatical, ungrammatical) as factors run on each group's

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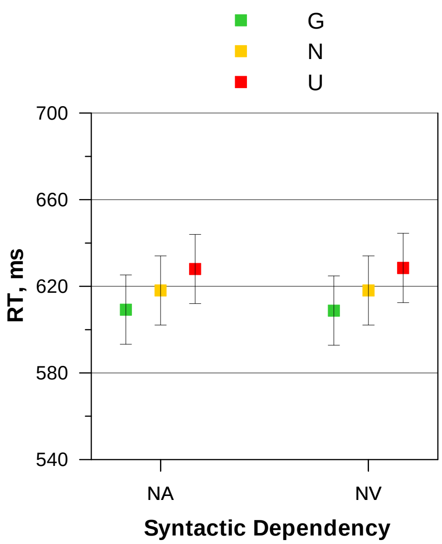
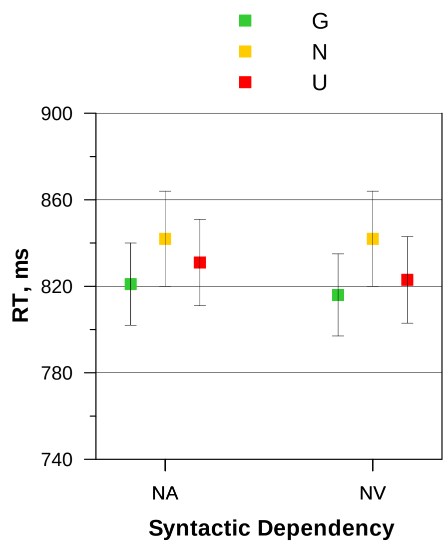
[17] Here and henceforth $\eta\rho^2$ is calculated from an F ratio and its degrees of freedom: $\eta\rho^2=(df \text{ effect x } F \text{ effect})/(df \text{ effect x } F \text{ effect})+df \text{ error}$
.

responses found no significant effect of dependency or interaction of dependency and prime condition in native speakers, $F(1,35)=.333$, $p=.57$, $\eta\rho^2=.009$, with $M=618.46$ ($SE=16.58$) in NA dependencies and $M=618.46$ ($SE=17.41$) in NV dependencies. In contrast, the effect of dependency was significant for L2 speakers, $F(1,35)=6.38$, $p=.016$, $\eta\rho^2=.154$, reflecting longer processing of agreement in NA dependencies than agreement in NV dependencies: $M=831.60$ ($SE=20.01$) and $M=821.49$ ($SE=20.11$), respectively (Figure 18).



(a)



(b)

Figure 18. Native *(a)* and L2 *(b)* participants' RTs as a function of syntactic dependency. *Note: In this graph and throughout the text the letters G, N, U in the legend correspond to a grammatical, neutral, or ungrammatical prime condition.*

The following sections examine the nature of routines underlying syntactic processing in NA and NV dependencies separately following the analysis pattern of Arnott et al (2005). We will return to the comparison of the mechanisms underlying the processing of agreement in each dependency in the end of section 5.2.

5.2.2.2 Noun-adjective dependencies

Each group's data were submitted to a repeated-measures analysis of variance (ANOVA) with three within-subjects factors, namely GP (low, high), SOA (250 ms, 1000 ms), and prime condition (grammatical, neutral, ungrammatical). Measures of morphosyntactic priming effects, facilitation and inhibition, were of particular interest. Within each ANOVA procedure, therefore, planned within-subject contrasts were conducted to determine the presence of morphosyntactic priming. To provide measures of priming, mean reaction times in the G condition were compared with mean reaction times in the U condition. Morphosyntactic priming effects were defined as the reaction time (RT) difference between the U and G conditions. That is,

$$\textbf{Priming effect} = \textbf{RTs}_{\textbf{ungrammatical}} - \textbf{RTs}_{\textbf{grammatical}}$$

Reaction times for the G and U conditions were also compared with the N condition to determine the facilitatory and inhibitory components of observed priming. Facilitation was defined as significantly shorter reaction times in the G condition than in the N condition. Conversely, significantly longer reaction times in the U condition than in the neutral condition, represented inhibition. That is,

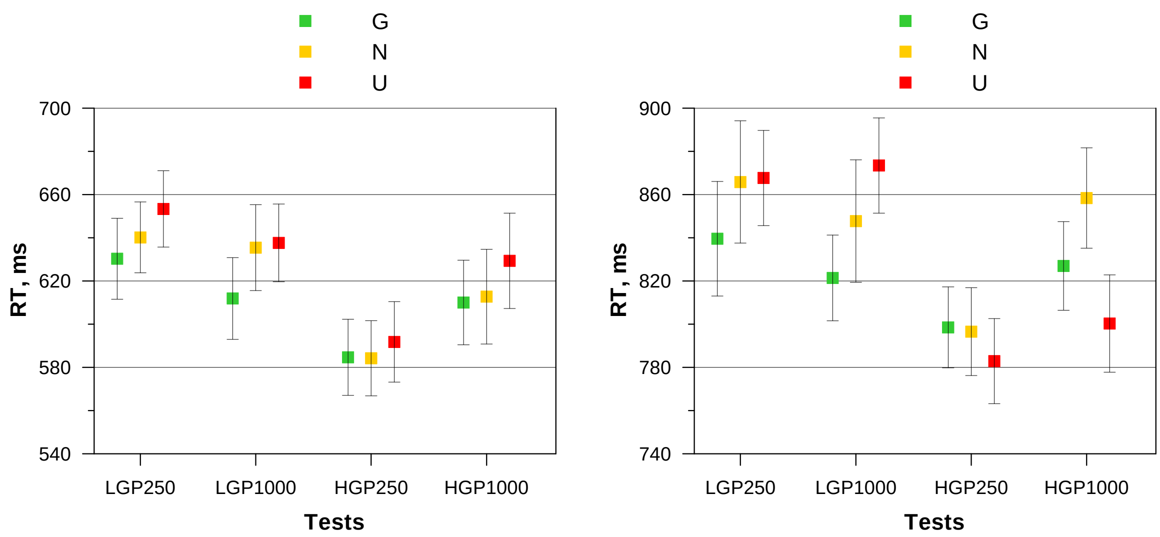
Facilitation = Rts N > Rts G

Inhibition = Rts UG > Rts N

Mean reaction time data for NA agreement dependencies in each of the four tests are displayed as a function of grammaticality proportion, SOA, prime condition, and group in Table 18 and presented for easier review in Figures 19 a and b.

Table 18. *Mean reaction times in NA dependencies as a function of GP, SOA, prime condition and group (in ms)*

	SOA250		**SOA1000**	
	NS group	**L2 group**	**NS group**	**L2 group**
Low GP				
Grammatical	630.28 (112.23)	839.55 (158.21)	611.88 (113.31)	821.39 (118.87)
Neutral	640.18 (97.84)	865.83 (168.37)	635.43 (118.00)	847.74 (169.85)
Ungrammatical	653.36 (105.59)	857.69 (127.37)	637.61 (106.84)	873.49 (132.79)
High GP				
Grammatical	584.65 (105.82)	798.49 (112.27)	609.10 (117.48)	826.95 (122.06)
Neutral	584.23 (105.25)	796.53 (120.28)	612.75 (130.05)	858.41 (139.72)
Ungrammatical	591.78 (109.16)	782.87 (117.78)	629.33 (133.01)	800.26 (134.97)



(a) *(b)*

Figure 19. Native *(a)* and L2 *(b)* participants' RTs in NA dependencies as a function of SOA, GP, and prime condition.

Note: The base line is shifted to 540 ms for native and 740 ms for L2 participants.

Native speakers

For the native speakers group, the results of the RM ANOVA revealed significant main effects for GP, $F(1,35)=6.35$, $p=.016$, $\eta\rho^2=.154$, and for prime condition, $F(2,70)=12.37$, $p< .001$, $\eta\rho^2=.281$. Sensitivity to the GP was reflected in significantly faster reaction times when grammaticality proportion was high than when it was low: *M*=635 ms (*SE*=17.5) in response to low GP and *M*=602 ms (*SE*=18.0) in response to high GP. The effect of the prime condition was reflected in significantly faster responses to grammatically correct noun targets (*M*=609 ms, *SE*=16.6) than to grammatically incorrect noun targets (*M*=628 ms, *SE*=16.70), with response times to the neutral prime "*prosto*" falling in between response times to grammatical and ungrammatical targets (*M*= 618 ms, *SE*=16.9). SOA, on the other hand, did not modulate response latencies in native speakers: *M*=614 ms (*SE*=16.3) at SOA250 and *M*=622 ms (*SE*=17.6) at SOA1000.

Significant two-way interaction was identified for GP x SOA, $F(1,35)=8.32$, $p=.007$, $\eta\rho^2=.192$. Two-way interactions between GP and priming condition and between SOA and prime condition, and the three-way GP x SOA x prime condition interaction, however, failed to reach statistical significance.

The study aimed to investigate the influence of GP and SOA on morphosyntactic priming. The two interactions for GP x prime condition and SOA x prime condition were not significant (Figures 20 and 21), and planned within-subject contrasts within the ANOVA procedure were used to examine priming effects at each GP and at each SOA independently, first by collapsing reaction time data across SOA and then by collapsing reaction time data across GP.

At the low GP, native speakers' reaction times in the G condition were significantly faster than in the U condition, $F(1,35)=28.45$, $p< .001$, $\eta\rho^2 =.448$, with a priming effect of 24 ms, and significantly faster than in the N condition, $F(1,35)=9.59$, $p=.004$, $\eta\rho^2=.215$, with facilitation of 17 ms. The 7 ms difference between reaction times in the U condition and in the N condition was too small to reach significance. The results clearly indicate that, as expected, native priming in the low GP condition was due to facilitation. With respect to the high GP, there was a significant difference between the G and the U conditions, $F(1,35)=8.94$, $p=.05$, $\eta\rho^2=.204$ (priming effect of 13 ms). While there was almost no difference between the G and the N conditions and insignificant difference between the U and the N conditions, and, hence, no facilitation and insignificant inhibition (12 ms). $F(1,35)=3.23$, $p=.07$, $\eta\rho^2=.085$, indicating that in the high GP condition priming was due to inhibition. Hence, in native participants, low GP evoked morphosyntactic priming effects due to facilitation, and high GP, conversely, evoked priming effects due to inhibition.

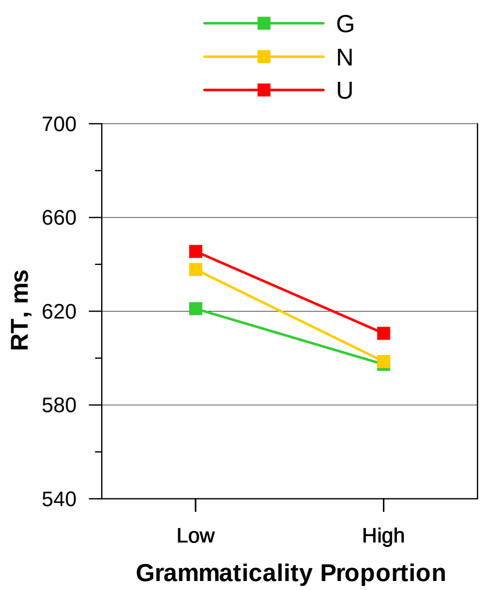


Figure 20. Grammatical priming reaction times in NA dependencies as a function of GP and prime condition for native participants.
Note: The base line is shifted to 540 ms.

As shown in Figure 20, for native participants the decrease in priming between low and high GP was not significant. Further within-subjects contrasts for facilitatory and inhibitory priming effects, this time with GP as a factor, showed that while the increase in inhibition was not significant (although the inhibitory component of priming at high GP became significant), increasing the GP led to a significant decrease in facilitation, $F(1,35)=4.71$, $p=.037$, $\eta\rho^2=.119$.

Within-subject contrasts revealed that at the short SOA of 250 ms, reaction times for the G condition were significantly faster than for the U condition (priming effect of 15 ms), $F(1,35)=13.41$, $p< .001$, $\eta\rho^2=.277$, but there was no significant facilitation recorded, whereas inhibition of targets recorded in the U condition was marginally significant (10 ms), $F(1,35)=3.79$, $p=.06$, $\eta\rho^2=.098$. At the long SOAs of 1000 ms, the magnitude of priming (23 ms), $F(1,35)=23.45$, $p<.001$, $\eta\rho^2=.401$, was composed of significant facilitation (13 ms), $F(1,35)=6.54$, $p=.015$, $\eta\rho^2=.157$, and insignificant inhibition (9 ms).

As revealed by repeated within-subject contrasts, while the magnitude of priming between 250 ms and 1000 ms changed significantly, $F(1,35)=7.0$, $p=.012$, $\eta\rho^2 =.167$, changes in either inhibition or facilitation were not, as evidenced by the absence of a significant main effect for SOA and a non-significant SOA x prime interaction in the omnibus RM ANOVA.

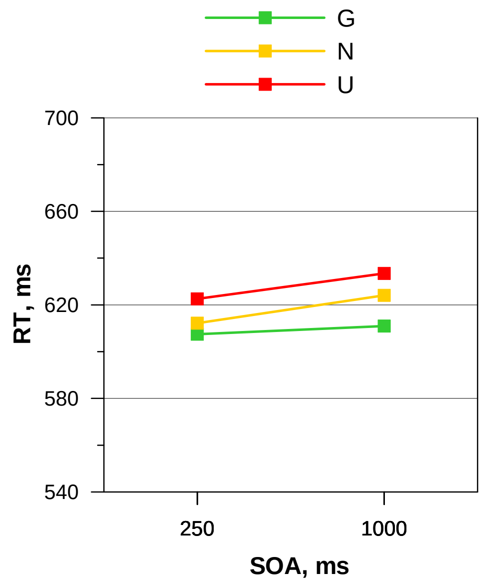


Figure 21. Grammatical priming reaction times in NA dependencies as a function of SOA and prime condition for native participants.
Note: The base line is shifted to 540 ms.

L2 speakers

For L2 participants, the RM ANOVA revealed a significant main effect for GP, $F(1,35) = 13.2$, $p = .001$, $\eta\rho^2 = .306$, and for prime condition $F(2,70) = 4.36$, $p = .016$, $\eta\rho^2 = .117$. The higher GP evoked significantly faster RTs to the targets in the grammatically congruent condition, $M = 811$ ms ($SE = 18.9$), whereas low GP slowed down responses to the targets the ungrammatical condition, $M = 853$ ms ($SE = 22.6$). Similar to native speakers, SOA did not modulate response latencies in L2 speakers: $M = 825$ ms ($SE = 20.29$) at SOA250, and $M = 838$ ms ($SE = 20.57$) at SOA1000.

Significant two-way interactions were identified for GP x SOA, $F(1,35)=11.82$, $p=.002$, $\eta\rho^2=.253$, and for GP x prime condition, $F(1.58, 55.36)=10.15$, $p<.001$, $\eta\rho^2=.225$.[18] Both the three-way interaction for GP x SOA x prime condition and the two-way interaction for SOA x prime condition, as in the native group, failed to attain statistical significance. Hence, L2 priming, similar to native priming, changed as a function of GP rather than SOA.

Analysis of the mean RTs showed that the L2 speakers' response latencies were longer overall and exhibited larger variability than response latencies in native speakers, but their means seemed native-like, with targets in the G condition recognized faster than targets in the U condition, M=822 ms (SE=19.5) and M=831 (SE=19.8), respectively. Unlike native speakers, however, who exhibited consistent priming effects across the four tests, with response times for targets in the ungrammatical condition being longer than targets in the grammatical and neutral conditions, L2 speakers demonstrated an unexpected reverse priming effect, when grammatical targets were processed slower than ungrammatical targets. This effect was only observed in tests with high GP. Besides, L2 mean results for targets in the baseline "*prosto*" condition were longer than for targets in the grammatical or ungrammatical conditions, M=842 ms (SE=21.9), which artificially inflated facilitation and reduced inhibition effects. The analysis of facilitation and inhibition for L2 speakers, therefore, was not considered informative.

[18] Mauchly's test indicated that the assumption of sphericity had been violated for GP x prime interaction, $\chi^2(2)=7.67$, $p<.05$, therefore degrees of freedom were corrected using Huynh-Feldt estimates of sphericity ($\varepsilon=.87$). The same correction will apply in other statistical tests henceforth.

The analyses described in this section were performed for consistency with the analyses performed for the native data. However, because of the reverse priming observed in response to high GP, collapsing data across GPs was not useful. Hence, in order to examine the priming effects that cancelled each other out when collapsed, additional analyses for the L2 data were performed for each GP condition separately.

Figure 22 displays mean reaction times for each prime condition as a function of GP. Examination of the GP x prime condition interaction revealed that, in response to low GP, L2 speakers recorded significant priming (40 ms): $F(1,35)=24.28$, $p< .001$, $\eta\rho^2=.412$, and significant facilitation (26 ms), $F(1,35)=4.61$, $p=.04$, $\eta\rho^2=.116$, whereas inhibition was not significant (14 ms). In contrast, reaction times in response to the high GP were significantly faster in the U condition than in the G condition (significant reverse priming of 21 ms), $F(1,35)=8.69$, $p=.01$, $\eta\rho^2=.197$, as ungrammatical targets exhibited significant facilitation relevant to the grammatical condition. This facilitation of ungrammatical targets in the high GP condition, along with the unexpected delayed processing of the neutral prime, distorted measures of facilitation and inhibition in response to high GP, demonstrating artificially inflated reverse inhibition (36 ms): $F(1,35)=20.7$, $p<.001$, $\eta\rho^2=.360$, and facilitation (15 ms), $F(1,35)=5.4$, $p=.026$, $\eta\rho^2=.134$.

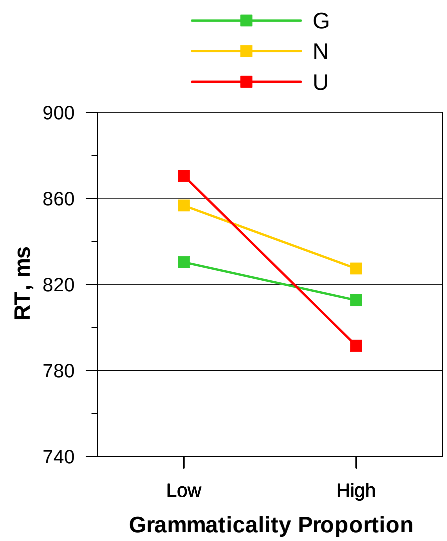
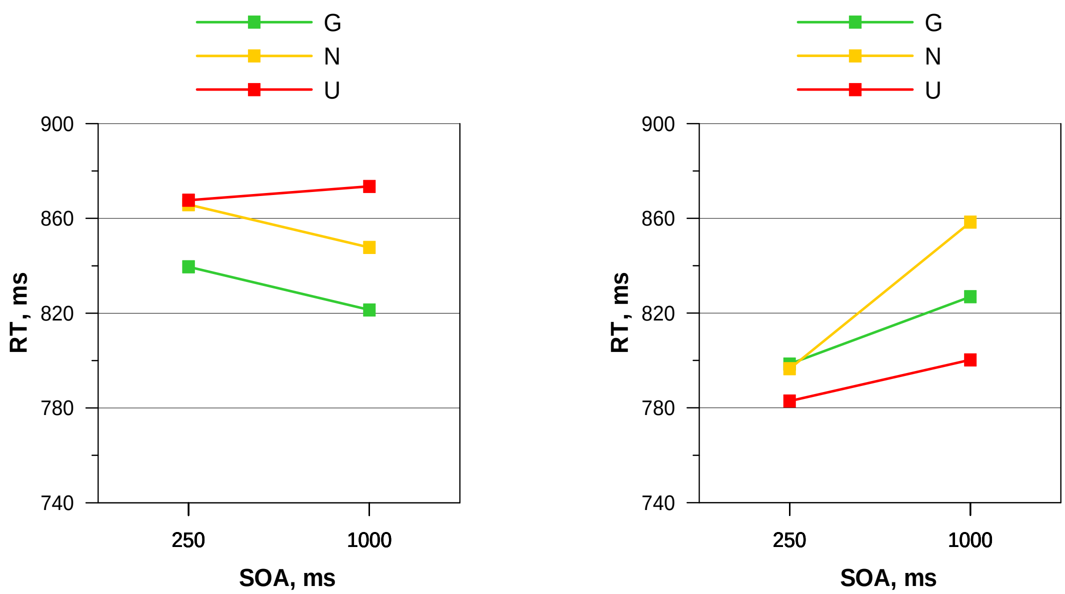


Figure 22. Grammatical priming reaction times in NA dependencies as a function of GP and prime condition for L2 participants.
Note: The base line is shifted to 740 ms.

Although the SOA x prime condition interaction was not significant, planned within-subject contrasts within the ANOVA procedure were used to examine priming effects at each SOA by collapsing reaction time data across GP. It was found that targets in the baseline condition at SOA1000 (in response to high GP) were processed longer than targets in other conditions, which distorted measures of facilitation and inhibition. Besides, because of marginally significant reverse priming observed at high GP at SOA250, $F(1,35)=2.9$, $p=.09$, $\eta\rho^2=.077$, and SOA1000, $F(1,35)=8.69$, $p=.007$, $\eta\rho^2=.198$, priming effects in data collapsed across GPs, 6 ms at SOA250 and 13 ms at SOA1000, were diminished due to the opposite direction of priming.

Priming effects were analyzed for each GP separately (Figures 23a and b). The analysis showed that only priming in response to low GP was marginally significant (28 ms) at

SOA250, $F(1,35)=3.86$, $p=.06$, $\eta\rho^2=.099$, and significant (52 ms) at SOA1000, $F(1,35)=22.6$, $p<.001$, $\eta\rho^2=.392$. Reverse priming in response to high GP was not significant: 16 ms at SOA250 and 27 ms at SOA1000. Changes in the size of priming over time examined for each GP were not significant.



(a) *(b)*

Figure 23. L2 participants' grammatical priming reaction times in NA dependencies as a function of SOA and prime condition in response to *(a)* low GP and *(b)* high GP.
Note: The base line is shifted to 540 ms for native and 740 ms for L2 participants.

Summary and discussion

Table 19 presents a summary of the findings for NA dependencies. As shown by the table, both native and L2 groups were sensitive to morphological markers of agreement when processing syntactic dependencies within phrasal boundaries, as reflected in the existence of priming effects. There were important similarities and differences identified between the two groups.

Table 19. *Priming, facilitation, and inhibition for NA dependencies (in ms)*

	Native speakers			**L2 speakers**		
	Priming	**Facilitation**	**Inhibition**	**Priming**	***Facilitation***	***Inhibition***
low GP	24.40***	16.73**	-7.67	40.12***	*26.32**	*-13.80*
high GP	13.24**	1.17	-12.07	-21.15**	*14.75**	*35.90****
SOA250	15.11***	4.74	-10.36	*6.26*	*12.16*	*5.90*
SOA1000	22.53***	13.15*	-9.38	*12.70*	*28.90***	*16.20*

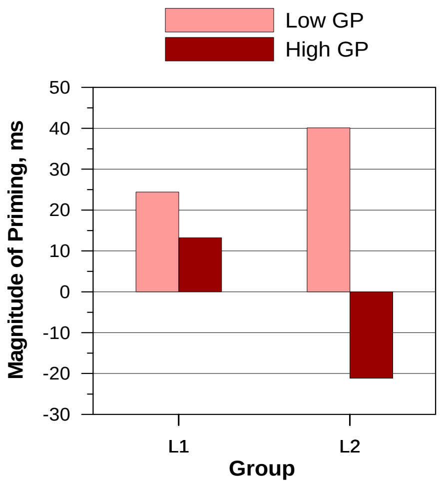
Notes:

1. *Overall priming effect, facilitation and inhibition are reported in milliseconds.*
2. *Morphosyntactic priming effect = ungrammatical – grammatical condition;*
   facilitation = neutral – grammatical condition;
   inhibition = neutral – ungrammatical condition.
   Based on the assumption that G<U, negative values in priming indicate reverse priming. Based on the assumption that N<U, inhibition is expected to have a negative value, hence, lack of the negative sign indicates reverse inhibition.
3. ** = p<.05; ** = p<.01; *** = p<.001*
4. *L2 measures of priming, faciliatation, and inhibition collapsed over SOA (and presented in italics) are reported but are not considered informative for the purposes of the study.*

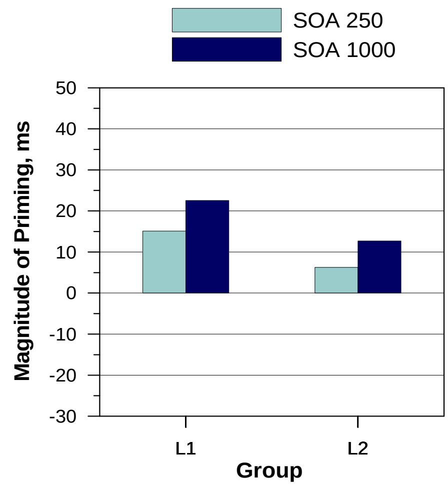
When collapsed across SOA, priming patterns of the two groups demonstrated the following differences. The size of priming in response to both low and high GP was larger in nonnative participants compared to native participants. However, while the native participants consistently recognized noun targets faster when they formed an agreement dependency, in which noun and adjective agreed in terms of gender and/or number, than when they formed a morphosyntactically incorrect agreement dependency, in which noun and adjective disagreed in gender and/or number, the L2 speakers recorded reverse priming (facilitation of grammatically incorrect targets relative to grammatically correct targets) in response to high GP.

Interestingly, they demonstrated native-like priming patterns in response to low GP. The unexpected finding suggests that under conditions encouraging expectancy of grammatical targets, L2 speakers were able to recognize words in ungrammatical NA agreement constructions faster than in grammatical ones, i.e., were mentally more ready for violations of agreement than for coherence. As was shown, while the size of the priming effect for native participants did not change significantly with increase in GP, the difference was statistically significant for L2 participants.

An examination of the time course of priming effects revealed the following patterns: both native and L2 participants showed an increase in the magnitude of priming with increase of SOA. However, the increase in priming over time was only found significant for the native group.



(a)



(b)

Figure 24. Priming effects for NA dependencies for native and L2 groups as a function of *(a)* GP and *(b)* SOA.

With respect to the nature and locus of the morphosyntactic priming effects in NA dependencies, the native group recorded morphosyntactic priming effects with significant facilitation and insignificant inhibition in reponse to low GP, which is consistent with automaticity (McNamara, 2005; Neely, 1976, 1991; Posner & Snyder, 1975). On the other hand, marginally significant inhibition without facilitation observed at SOA250 argues for the presence of postlexical processing. Further, increased priming observed with an increase of SOA (reflecting a basic tenet of attentional processing, namely, that controlled mechanisms take time to engage), as well increased priming in response to an increase in GP pointed to the emergence of prelexical expectancy-based processes, also evidenced by the presence of inhibition of ungrammatical targets. The observed absence of facilitation of grammatical targets relative to the baseline is surprising, however, and will be addressed in the General Discussion. Thus, according to the three-process model of priming (Neely & Keefy, 1989), native speakers demonstrated the engagement of different mechanisms, rather than one mechanisms.

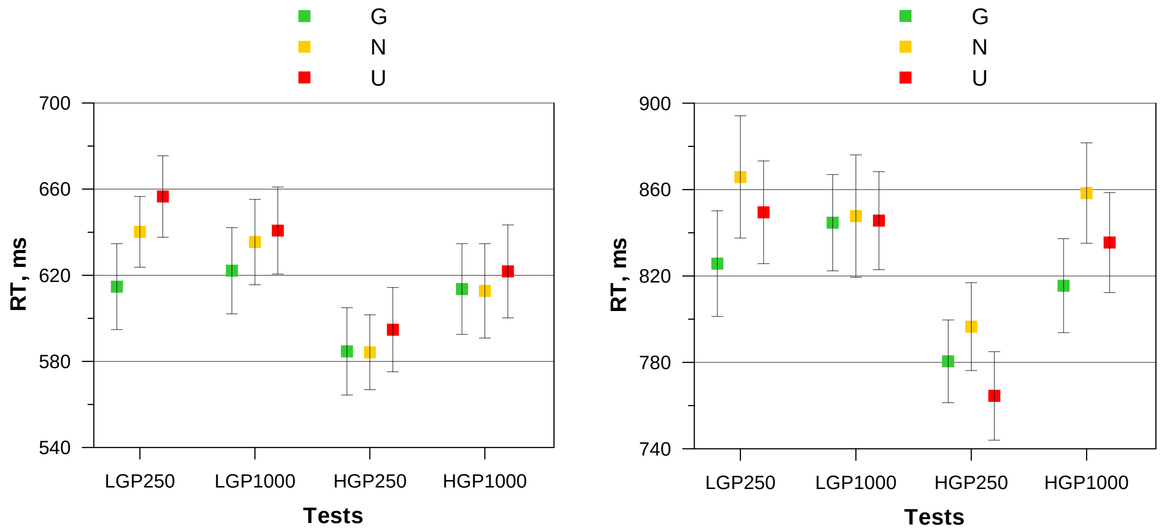
As for L2 speakers, it can be concluded that their performance was primarily consistent with priming mechanisms operating postlexically (Neely & Keefy, 1989; Neely, 1991; McNamara, 2005), as reflected in their slowdown in the neutral condition and speeding up in the ungrammatical condition in response to high GP, no record of significant priming at the short SOAs, and no interaction between SOA and priming. I will return to this issue in the general discussion.

5.2.2.2 Noun-verb dependencies

L2 participants' mean reaction time data for NV agreement dependencies that cross phrasal boundaries are displayed as a function of grammaticality proportion, SOA, prime condition and group in Table 20 and presented for easier review in Figures 25a and b. The groups' data were submitted to repeated measures ANOVA with three within-subjects factors, namely GP, SOA, and prime condition. Within each ANOVA procedure, therefore, planned within-subject contrasts were conducted to determine the presence of morphosyntactic priming, inhibition, and facilitation.

Table 20. *Mean reaction times in NV dependencies as a function of grammaticality proportion, SOA, prime condition and group (in ms)*

	SOA250		**SOA1000**	
	NS group	**L2 group**	**NS group**	**L2 group**
Low GP				
Grammatical	614.74 (120.07)	825.69 (146.96)	622.12 (120.38)	844.64 (130.89)
Neutral	640.18 (97.84)	865.73 (168.37)	635.43 (118.00)	847.74 (169.85)
Ungrammatical	656.56 (111.78)	849.5 (136.30)	640.74 (119.72)	845.58 (133.36)
High GP				
Grammatical	584.68 (121.37)	780.5 (116.21)	613.6 (126.12)	815.49 (130.41)
Neutral	584.23 (105.25)	796.52 (120.28)	612.75 (130.05)	858.41 (139.72)
Ungrammatical	594.73 (116.82)	764.47 (119.16)	621.79 (133.72)	835.46 (125.39)



(a) *(b)*

Figure 25. Native (a) and L2 (b) participants' RTs in NV dependencies as a function of SOA, GP, and prime condition.

Note: The base line is shifted to 540 ms for native and 740 ms for L2 participants.

Native speakers

Native participants recorded significant main effects for GP, $F(1,35)=5.97$, $p=.02$, $\eta\rho^2=.146$, and for prime condition, $F(2,70)=16.81$, $p<.001$, $\eta\rho^2=.325$. Significant two-way interactions were identified for GP x SOA, $F(1,35)=4.55$, $p=.04$, $\eta\rho^2=.115$, and for GP x prime condition, $F(2,70)=4.67$, $p=.013$, $\eta\rho^2=.118$. The main effect for SOA, the two-way interaction for SOA x prime condition, and the three-way interaction between GP, SOA, and prime condition failed to reach statistical significance.

The GP effect was reflected in their significantly faster response latencies to targets in high GP condition, M=602 ms (SE=18.97), than in low GP condition, M=635 ms (SE=18.38). The prime effect was demonstrated in the finding of morphosyntactic priming effects, facilitation, and inhibition. Native speakers responded to grammatically correct noun targets, *M*=609 ms (*SE*=17.75), faster than to incorrect targets, *M*=629 ms (*SE*=17.94). Responses to neutral targets, *M*=618 ms (*SE*=16.87), fell mid-way between grammatical and ungrammatical targets. SOA, on the other hand, did not seem to significantly modulate response latencies in NS: *M*=613 ms (*SE*=17.18) at SOA250, and *M*=624 ms (*SE*=18.4) at SOA1000.

The GP x prime interaction was investigated by collapsing reaction time data across SOA. Figure 26 displays mean reaction times for each prime condition as a function of GP. Using planned within-subject contrasts, the two GP conditions, low and high, were analyzed independently. At low GP, native speakers demonstrated significant priming effect (30 ms), $F(1,35)=32.12$, $p<.001$, $\eta\rho^2=.479$, and significant facilitation (19 ms), $F(1,35)=8.59$, $p=.006$, $\eta\rho^2=.197$. However, inhibition of 11 ms did not reach significance. At high GP, priming effects only included an insignificant inhibitory component (10 ms).

In response to high GP, priming effects decreased significantly from 30 to 9 ms, which was confirmed statistically by repeated within-subject contrasts for GP: $F(1,35)= 9.01$, $p=.005$, $\eta\rho^2 =.205$. This decrease in the magnitude of priming was caused by a significant decrease in facilitation (from significant to absent), $F(1,35)=5.28$, $p=.028$, $\eta\rho^2= .131$, whereas inhibition did not change significantly in response to high GP (remaining insignificant).

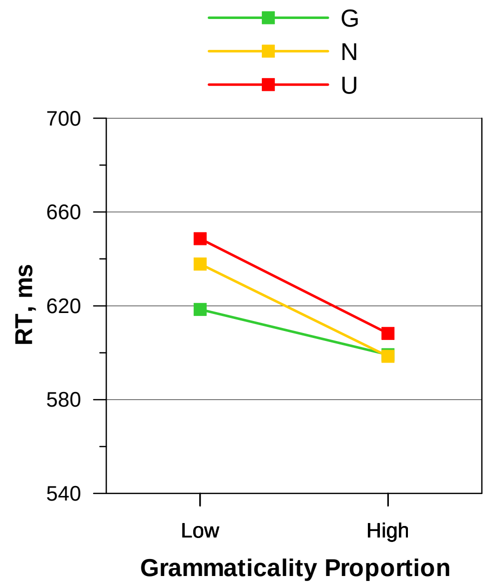


Figure 26. Grammatical priming reaction times in NV dependencies as a function of GP and prime condition for native participants

Note: The base line is shifted to 540 ms.

Figure 27 shows mean reaction times per prime condition as a function of SOA. Tests of within-subject contrasts revealed the following effects. At the short SOA of 250 ms, reaction times for the G condition were significantly faster than for the U condition (priming effect of 26 ms), $F(1,35)=24.07$, $p<.001$, $\eta\rho^2=.408$, and significantly faster than in the N condition (facilitation of 12 ms), $F(1,35)=4.05$, $p=.05$, $\eta\rho^2=.10$. Reaction times in the U condition were significantly slower than RTs in the N condition (inhibition of 14 ms), $F(1,35)=9.73$, $p<.004$, $\eta\rho^2=.218$. At the long SOAs of 1000 ms, priming effect (13 ms) remained significant, $F(1,35) = 10.27$, $p=.003$, $\eta\rho^2=.227$, whereas both facilitation (6 ms) and inhibition (7 ms) were insignificant. These results indicate that native speakers primed at both 250 and 1000 ms, and, despite some reduction in the magnitude of priming over time due to a slowdown of responses in the N and G conditions, priming effects over time were did not change significantly as a function of SOA.

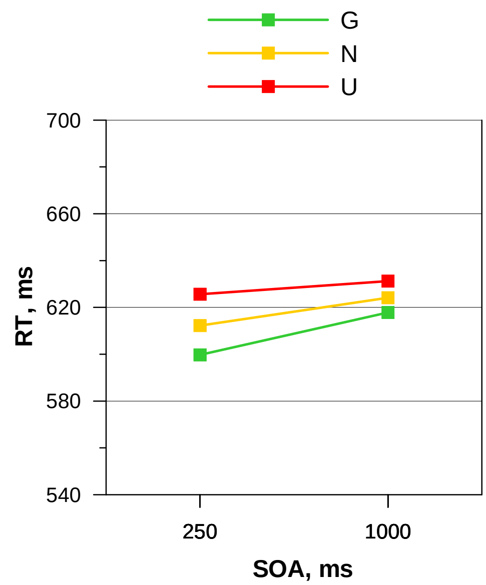


Figure 27. Grammatical priming reaction times in NV dependencies as a function of SOA and prime condition for native participants.
Note: The base line is shifted to 540 ms.

L2 speakers

As evidenced by the graphs in Figures 25a nd b (and similar to results obtained for NA dependencies), L2 speakers' response latencies when processing NV dependencies were longer overall than response latencies in native speakers, M=827.5 (SE=20.11). The RM ANOVA revealed significant main effects for GP, SOA, and for prime condition, $F(1,35)=9.68$, $p=.002$, $\eta\rho^2=.212$, $F(1,35)=7.36$, $p=.019$, $\eta\rho^2=.174$, and $F(1.7,59.92)=7.03$, $p=.001$, $\eta\rho^2=.166$, respectively. A significant two-way interaction was identified for GP x SOA, $F(1,35)=12.07$, $p=.003$, $\eta\rho^2=.256$. The three-way interaction for GP x SOA x prime condition was also significant, $F(1,35)= 3.55$, $p=.034$, $\eta\rho^2=.092$. The two-way interactions for SOA x prime condition and GP x prime condition failed to attain statistical significance, suggesting that while RTs in L2 changed as a function of GP and SOA, the time course of priming effects in L2 was not modulated by either. The statistical analyses showed that, like native speakers, L2 participants were sensitive to grammaticality proportion, responding faster to high GP than to low GP: *M*=809 ms (*SE*=19.48) and *M*= 847 ms (*SE*=22.44), respectively, and to SOA, responding faster at SOA250 than at SOA1000: *M*=814 ms (*SE* =20.24) and *M*=841 ms (*SE*=21.21). L2 participants were also sensitive to the prime condition. RT means collapsed across GP and SOA showed that they responded faster to targets in the G condition, M=817 ms (*SE*=19.26), than in the U condition, *M*=824 ms (*SE*=20.30), but the U condition was faster than the N condition, *M*=842 ms (*SE*=21.89). Similarly to their performance on NA dependencies, the L2 paticipants recorded reverse priming effect in response to high GP at SOA250, but, in contrast to NA dependencies, this effect was not observed at SOA1000.

Planned within-subject contrasts within the ANOVA procedure were used to examine priming effects at each GP and at each SOA independently, first by collapsing reaction time data across SOA and then by collapsing reaction time data across GP.

As reflected in Figure 28, priming of 12 ms in response to low GP was not significant. In response to high GP, L2 participants' reverse priming at SOA250 and normal priming at SOA1000 cancelled each other out, when collapsed across SOA, which necessitated additional analyses at each GP separately. Besides, the longer processing of the neutral prime in response to both low and high GP did not yield reliable measures of facilitation and inhibition. Therefore, the components of priming were not analyzed further.

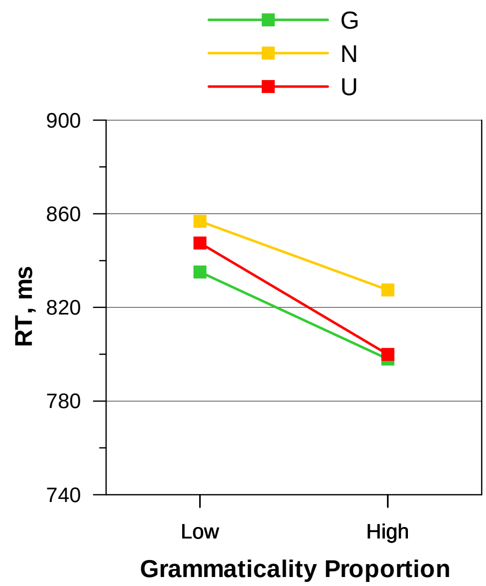
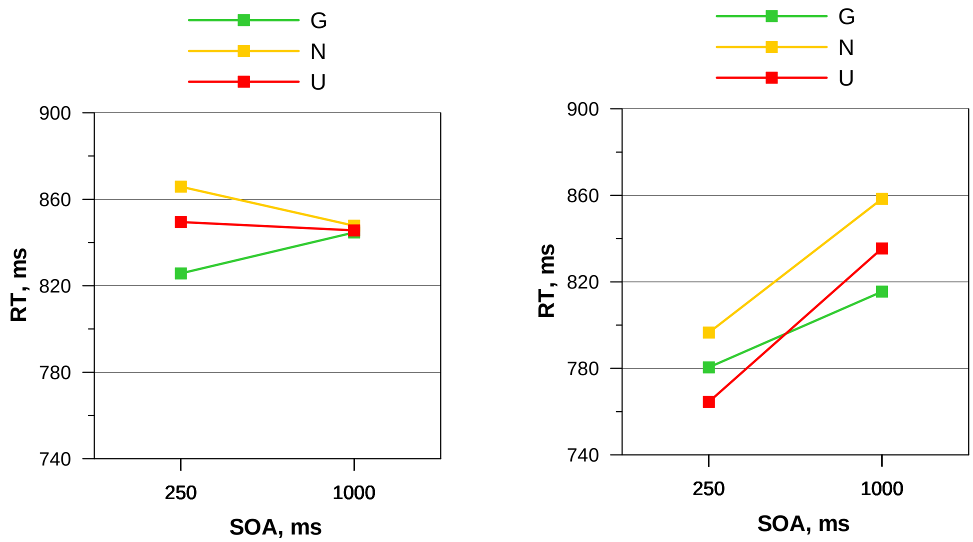


Figure 28. Grammatical priming reaction times as a function of GP and prime condition for L2 participants in NV dependencies.

Note: The base line is shifted to 740 ms.

Analysis of the SOA x prime condition interaction in response to low GP (Figure 29a) revealed marginally significant priming effects at SOA250 ms (24 ms), $F(1,35)=3.6$, $p=.07$, $\eta\rho^2 =.093$, and absence of priming at SOA1000. Responses to high GP showed insignificant reverse priming at SOA250 (16 ms), and significant priming at SOA1000 (20 ms), $F(1,35) =3.57$, $p=.07$, $\eta\rho^2=.093$ (Figure 29b). L2 participants' priming effects did not change between SOAs of 250 and 1000 ms in response to low GP, but changed significantly in response to high GP, due to the reversal of priming effects, $F(1,35)=6.76$, $p=.014$, $\eta\rho^2 =.162$.



(a) *(b)*

Figure 29. L2 participants' grammatical priming reaction times as a function of SOA and prime condition in response to (a) low GP and (b) high GP in NV dependencies.
Note: The base line is shifted to 540 ms for native and 740 ms for L2 participants.

Summary and discussion

Table 21 presents a summary of the findings for NV dependencies. As seen from the table, both native and L2 groups were sensitive to morphological markers of agreement when processing syntactic dependencies across phrasal boundaries, as demonstrated by the existence of priming effects. However, similar to NA agreement, patterns of NV agreement in L2 speakers differed from those in native speakers.

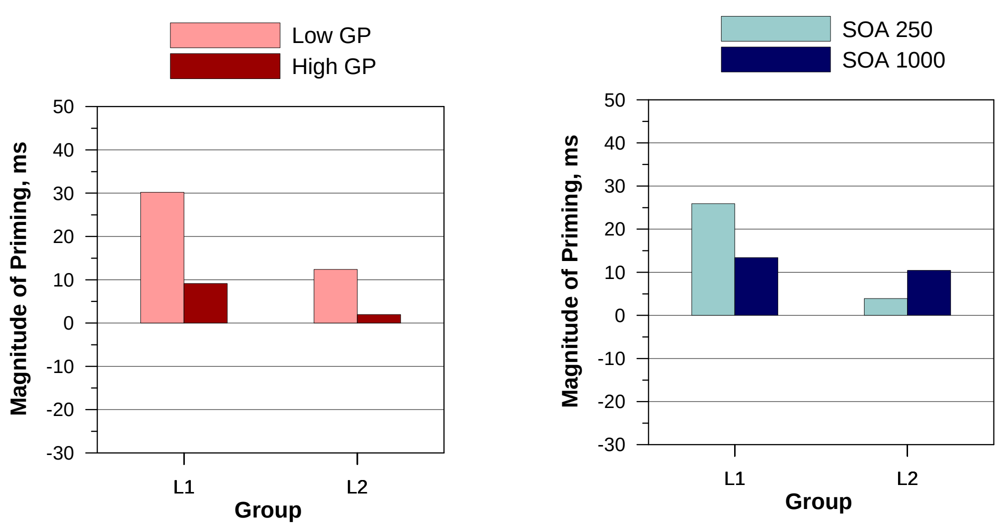
Table 21. *Priming, facilitation, and inhibition for NV dependencies (in ms)*

	Native speakers			**L2 speakers**		
	Priming	**Facilitation**	**Inhibition**	**Priming**	***Facilitation***	***Inhibition***
low GP	30.22***	19.38**	-10.84	12.37	*21.62*	*9.24*
high GP	9.12	-0.65	- 9.77	1.97	*29.47****	*27.5***
SOA250	25.93***	12.49*	-13.44**	*3.89*	*28.08***	*24.18****
SOA1000	13.41**	6.23	-7.18	*10.45*	*23.01***	*12.56*

Notes:

1. *Overall priming effect, facilitation and inhibition are reported in milliseconds.*
2. *Morphosyntactic priming effect = ungrammatical – grammatical condition;*
   facilitation = neutral – grammatical condition;
   inhibition = neutral – ungrammatical condition.
   Based on the assumption that G<U, negative values in priming indicate reverse priming. Based on the assumption that N<U, inhibition is expected to have a negative value, hence, lack of the negative sign indicates reverse inhibition.
3. * = p<.05; ** = p<.01; *** = p<.001
4. *L2 measures of priming, faciliatation, and inhibition collapsed over SOA (and presented in italics) are reported for consistency but are not considered informative for the purposes of the study.*

When collapsed across SOA, priming patterns of the two groups demonstrated the following differences. The size of priming in response to both low and high GP was larger in native participants compared with nonnative participants, and the priming effects in both groups decreased in magnitude with growth in GP (Figure 30a). The L2 group exhibited longer RTs to the neutral prime in response to high GP, which, similar to their performance in response to NA dependencies, pointed to difficulties with the "*prosto*" structure (the neutral prime) and obscured the examination of the contribution of facilitation and inhibition to the priming effect. However, while in NA dependencies this effect was only observed at SOA1000, in NV dependencies the neutral condition was processed longer than the U condition across GPs and SOAs. An examination of the time course of priming effects revealed the following patterns: the native participants showed an insignificant decrease in the magnitude of priming with increase of SOA. The L2 participants' results showed a similar pattern in respose to low GP and reverse priming at the short SOA in response to high GP. The finding suggests that high GP trigerred sensitivity to violations of agreement that emerged at the short SOA as reflected in faster response times to incongruent primes. At SOA1000 priming changed direction at the long SOA but was only marginally significant, $F(1,35)=3.6$, $p=.07$, $\eta\rho^2=.093$ (Figure 30b).



(a) *(b)*

Figure 30. Priming effects for NV dependencies for native and L2 participants as a function of (a) GP and (b) SOA

Examination of the nature and the locus of the morphosyntactic priming effects in NV dependencies revealed that the native participants recorded morphosyntactic priming effects with significant facilitation and insignificant inhibition in response to low GP, suggesting the engagement of ASA. However, at the short SOA250, they recorded both significant facilitation and inhibition, which is inconsistent with the notion of automaticity (Neely, 1976; 1991) and points to the involvement of postlexical mechanisms. An examination of the time course of priming shows that increasing the SOA resulted in a marginally significant decrease in the size of priming, accompanied by decrease in facilitation and inhibition, which indicates the presence of prelexical mechanisms (McNamara, 2005; Neely, 1991) or suggests that the peak of activation may have occurred earlier. Increasing the proportion of grammatical prime-target pairs also reduced the magnitude of priming, pointing to a complex interplay of processing mechanisms in native speakers that will be addressed in the general discussion.

As for L2 participants, their longer responses in the neutral condition compared to grammatical and ungrammatical conditions distorted measures of facilitation and inhibition, which, along with the finding of reverse priming, can be interpreted as evidence of their reliance on controlled postlexical mechanisms. Delayed L2 processing of the target in the neutral prime condition may have reflected an increased level of ambiguity of this condition for L2 participants as a result of the lower prime frequency and/or due to its use in a different syntactic structure, which could have created an ungrammaticality bias that L2 participants had to overcome. Further, the lack of interaction between SOA and prime in L2 participants (reflected in the finding that priming effects did not change significantly in magnitude between 250 and 1000 ms) also indicates the involvement of postlexical strategic mechanisms.

5.2.3 Priming effects in NA versus NV dependencies

To examine the impact of SOA and GP on priming effects in NA and NV dependencies, a three-way ANOVA was run on the RTs for each dependency, with dependency, GP, and SOA as factors. It was found that native speakers exhibited differences in the time course of priming effects between the two types of dependencies: with increase in SOA, priming increased in NA dependencies and decreased in NV dependencies, which was reflected in a significant dependency by SOA interaction, $F(1,35) = 8.6$, $p < .001$, $\eta\rho^2 = .197$. Dependency by GP interaction was not significant. L2 speakers, in contrast, only demonstrated significant dependency by GP interaction, $F(1,35) = 14.24$, $p < .001$, $\eta\rho^2 = .289$, and no dependency x SOA interaction.

To summarize, priming patterns in L1 were consistent with the involvement of both automatic and strategic mechanisms, but some findings seemed contradictory. L2 processing, in contrast, seemed to have mostly relied on strategic routines. Neither L1, nor L2 participants, however, demonstrated a clear role of syntactic distance in evoking a particular processing routine, indicating that the dissociation of the underlying mechanisms could have been obscured by the conjoint use of two different grammatical categories of gender and number, that can evoke different processing routines, in the stimuli lists. Therefore, it was important to examine the mechanisms of priming in gender and number agreement separately. In the following section I compare the processing of gender and number agreement in native and L2 participants first by collapsing RTs across SOAs and GPs in order to examine the role of markedness and syntactic dependency, and then return to the analysis of the attentional mechanisms underlying the processing of gender and number agreement.

5.3. Gender and number agreement

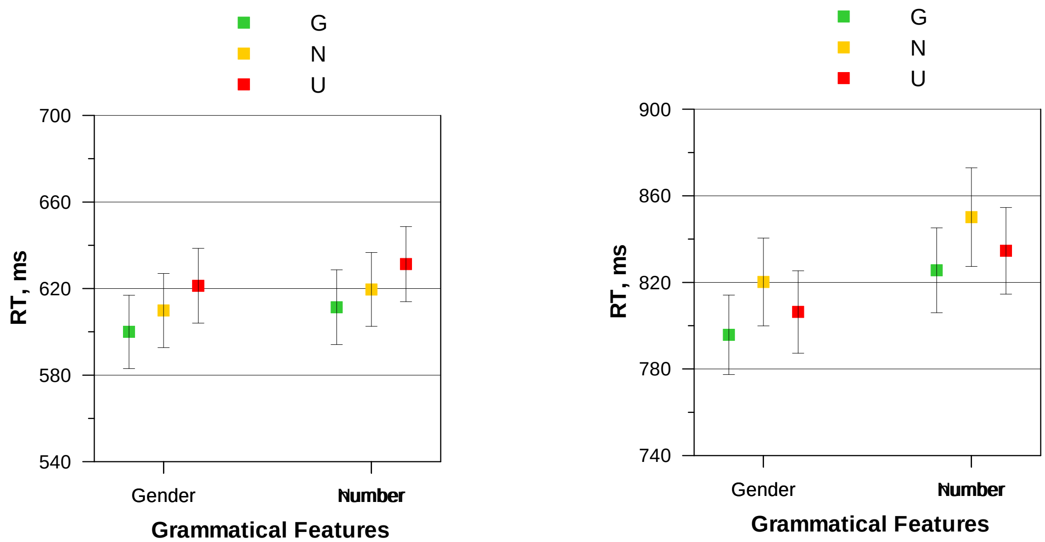
5.3.1 Gender versus number

The study's hypotheses predicted that both native and L2 speakers would process gender and number agreement differently, evoking different priming patterns for each category. To test these predictions, a two-way within-subjects ANOVA, with grammatical category (gender, number) and prime condition (grammatical, ungrammatical, neutral) as factors, was run on each group's responses collapsed over syntactic dependencies, SOAs, and GPs. Significant effects for grammatical category and prime condition were found in both groups of speakers. In particular, the effect for grammatical category confirmed statistically the observation that both groups process gender significantly faster than number: native speakers, $F(1,35)=27.9$, $p<.001$, $\eta\rho^2=.444$, with $M=610$ ms ($SE=17$), and $M=621$ ms ($SE=17.1$), respectively; and L2 speakers, $F(1,35)=76.08$, $p<.001$, $\eta\rho^2=.685$, with $M=807$ ms ($SE=18.9$), and $M=837$ ms ($SE=20.4$), respectively. The main effect of prime condition reflected significant overall differences in priming effects, $F(2,70)=22.6$, $p<.001$, $\eta\rho^2=.392$ in native speakers, and $F(1.59, 55.67)=9.17$, $p<.001$, $\eta\rho^2=.208$, in L2 speakers. Using planned within-subject contrasts gender and number were analyzed independently to determine the magnitude and patterns of priming effects.

For gender, the native speakers demonstrated a significant main effect of prime condition, $F(1.6,55.9)=17.45$, $p<.001$, $\eta\rho^2$ .615, which reflected the following findings: grammatical targets were recognized faster than ungrammatical targets (priming of 21 ms), $F(1,35)=66.05$, $p<.001$, $\eta\rho^2=.654$, and components of priming recorded both significant facilitation (10 ms), $F(1,35)=6.80$, $p=.01$, $\eta\rho^2=.163$, and inhibition (11 ms), $F(1,35)=7.49$, $p=.01$, $\eta\rho^2=.176$. In L2 speakers, the main effect for prime condition, $F(1.6, 56.6)=7.39$, $p=.003$, $\eta\rho^2=.173$, was reflected in significant priming (11 ms), $F(1,35)=5.85$, $p=.021$, $\eta\rho^2=.143$, and significant differences between the G and the N conditions (25 ms) and between the U and N conditions (14 ms). However, these measures were not true measures of facilitation or inhibition (due to longer processing of the neutral prime), $F(1,35)=11.5$, $p=.002$, $\eta\rho^2=.247$, and $F(1,35)=3.78$, $p=.060$, $\eta\rho^2=.097$, respectively, and they were not considered in further analysis.

For number, the native speakers, demonstrated a significant main effect of prime condition, $F(1.8,61.7)=14.03$, $p<.001$, $\eta\rho^2=.290$, reflected the following findings: grammatical targets were recognized faster than ungrammatical targets (priming of 20 ms), $F(1,35)=39.17$, $p<.001$, $\eta\rho^2=.528$, and components of priming recorded a marginally significant facilitation (8 ms), $F(1,35) =3.32$, $p=.08$, $\eta\rho^2=.087$, and significant inhibition (12 ms), $F(1,35)=7.49$, $p=.01$, $\eta\rho^2=.176$. In the L2 speakers, the main effect for prime condition, $F(1.6, 57.1)= 5.93$, $p=.007$, $\eta\rho^2=.143$, was reflected in marginally significant priming (9 ms), $F(1,35)= 3.18$, $p =.06$, $\eta\rho^2 =.083$. Measures of facilitation (25 ms) and inhibition (16 ms) were inflated due to longer processing of the neutral prime,

$F(1,35)=9.9$, $p=.003$, $\eta\rho^2=.221$, and $F(1,35)=3.46$, $p=.07$, $\eta\rho^2=.09$, respectively, and were disregarded in the analysis of L2 data.



(a) *(b)*

Figure 31. Native *(a)* and L2 *(b)* participants' RTs for gender and number agreement as a function of grammatical category and prime condition.

Note: The base line is shifted to 540 ms for native and 740 ms for L2 participants.

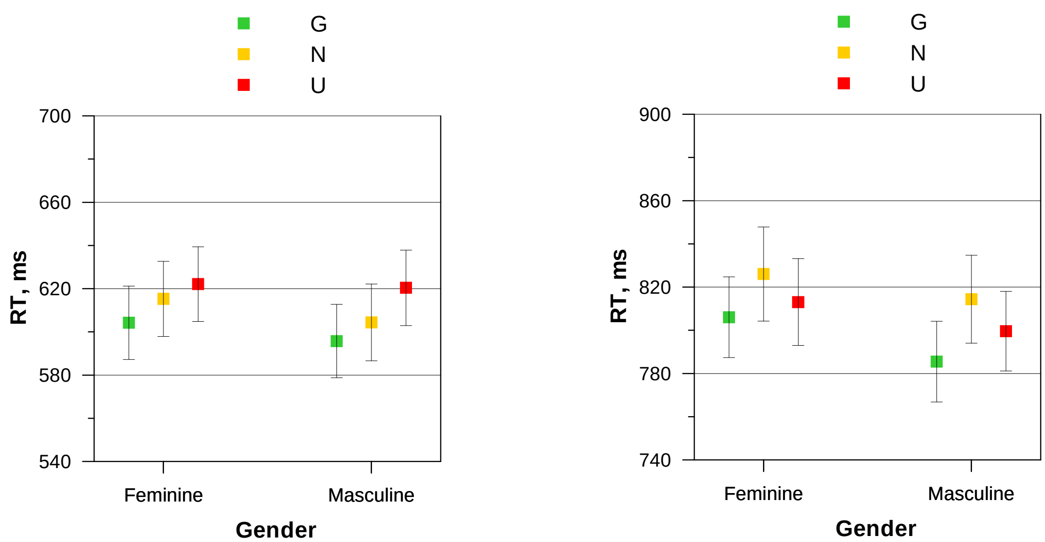
Thus, it was found that gender was processed faster than number by both groups, and that priming patterns observed for gender an number reflected similar trends, with the exception of the NV condition producing larger priming effects for gender in L2 speakers than the NA condition (besides the reported above finding that the neutral condition caused L2 speakers processing difficulties, distorting measures of facilitation and inhibition). In the following sections, I describe analyses of data collapsed across dependencies and performed for each category separately, examining the role of markedness, syntactic distance, and the nature of the underlying processing mechanisms. Table 22 presented in the end of the section summarizes the main findings.

5.3.2 Processing of feminine and masculine nouns in gender agreement

The following series of analyses compared processing patterns for feminine and masculine nouns.

Native speakers

Figure 32a presents the mean RTs for feminine and masculine genders for native speakers. A 2 x 3 within-subjects ANOVA, with the factors of gender (masculine, feminine) and prime condition (grammatical, ungrammatical, neutral) yielded a significant main effect for gender, $F(1, 35)=4.6$, $p=.04$, $\eta\rho^2=.116$, reflected in the fact that feminines were processed significantly longer than masculines, M_F =614 ms (SE=16.9), and M_M = 607 ms (SE=17.2), although they were, on average, a little shorter and a little more frequent (see Table 12). A significant effect for prime condition, $F(2,70)=17.45$, $p< .001$, $\eta\rho^2=.333$, reflected significant overall priming effects that were obtained for gender in an earlier analysis (21 ms of priming that included 11 ms of inhibition and 10 ms of facilitation). However, no significant gender x prime condition interaction was found, suggesting insignificant differences in priming effects between the two genders. Within-subjects contrasts were conducted separately for masculine and feminine nouns in order to examine the direction of priming effects. The tests showed significant priming for both feminine nouns $F(1,35)=29.36$, $p< .001$, $\eta\rho^2=.633$, and masculine nouns $F(1,35)=50.73$, $p< .001$, $\eta\rho^2=.592$. Priming was insignificantly greater for masculines (25 ms) than for feminines (18 ms), and the effect in masculines was largely due to significant inhibition of 16 ms, $F(1,35)=11.05$, $p=.002$, $\eta\rho^2=.24$, with insignificant facilitation (9 ms), whereas in feminines the effect was primarily due to significant facilitation (11 ms), $F(1,35)=4.98$, $p=.032$, $\eta\rho^2=.125$, in the presence of insignificant inhibition (7 ms).



(a) *(b)*

Figure 32. Native *(a)* and L2 *(b)* participants' mean RTs for masculine and feminine nouns.

Note: The base line is shifted to 540 ms for native and 740 ms for L2 participants.

L2 speakers

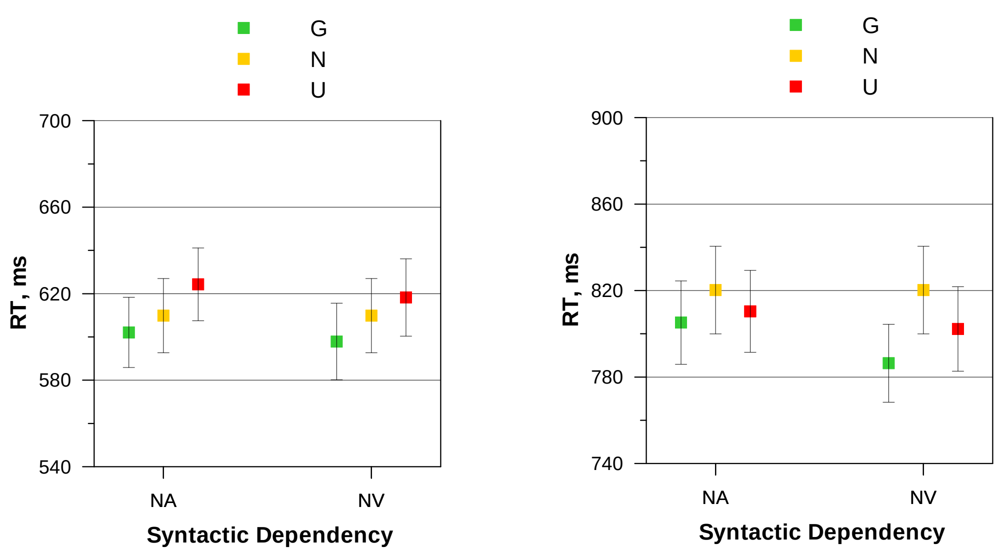
Figure 32b presents mean RTs for feminine and masculine genders for L2 speakers. A 2 x 3 within-subjects ANOVA, with gender (masculine, feminine) and prime condition (grammatical, ungrammatical, neutral) as factors yielded a significant main effects for gender, $F(1, 35)=9.87$, $p=.003$, $\eta\rho^2=.22$, reflected in that feminines were overall processed significantly longer than masculines, M=815 ms (SE=19.5) and M=800 ms (SE=18.6), and a significant effect for prime condition, $F(1.62,56.6)=7.39$, $p=.003$, $\eta\rho^2=.175$, reflected in significant overall priming effects that were obtained for gender in an earlier analysis (11 ms of priming that consisted of 25 ms of facilitation inflated by delayed processing of nouns in the neutral condition and 14 ms of reverse inhibition due to the same reason). The gender x prime condition interaction was not significant, suggesting insignificant differences in priming effects between the two genders. Since measures of both facilitation and inhibition were distorted, an examination of the direction of priming effects was not possible, and further tests of within-subjects contrasts only focused on the magnitude of priming, excluding the neutral condition. The tests showed that, while the small priming of 7 ms for feminine nouns was not significant, priming of 14 ms in masculine nouns was: $F(1,35)=5.17$, $p=.029$, $\eta\rho^2=.129$.

5.3.3 The role of syntactic distance in gender agreement

To examine gender agreement as a function of syntactic dependency, within-subjects ANOVA with dependency (NA, NV) and prime condition (grammatical, ungrammatical, neutral) as two factors were run on response times for gender for both groups of participants.

Native speakers

Analysis showed that native speakers processed targets in NA dependencies, on average, 3 ms slower than targets in the NV dependency, M=612 ms (SE = 16.5), and M=609 ms (SE=17.5), respectively: $F(1,35)=3.83$, $p=.058$, $\eta\rho^2=.099$. Importantly, while priming effects were significant for each dependency, F_{NA} (1,35)=37.29, p<.001, $\eta\rho^2$=.516, and F_{NV}(1,35)=44.66, p<.001, $\eta\rho^2$=.561, there was no significant priming condition by dependency interaction, thus no significant differences in priming effects between the two dependencies (22 ms in the NA condition and 20 ms in the NV condition). According to Figure 33a, priming in NA dependencies seemed dominated by inhibition of 15 ms (in comparison with 8 ms of facilitation), whereas priming in NV dependencies seemed dominated by facilitation of 12 ms (in comparison with 8 ms of inhibition).



(a) *(b)*

Figure 33. Native *(a)* and L2 *(b)* participants' mean RTs for gender as a function of syntactic dependency

Note: The base line is shifted to 540 ms for native and 740 ms for L2 participants.

Tests of within-subjects contrasts run for each dependency confirmed the dominance of inhibition in the NA dependency statistically [significant inhibition, F(1,35) =7.82, p=.008, $\eta\rho^2$=.183, versus marginally significant facilitation, F(1,35)=3.4, p=.07,

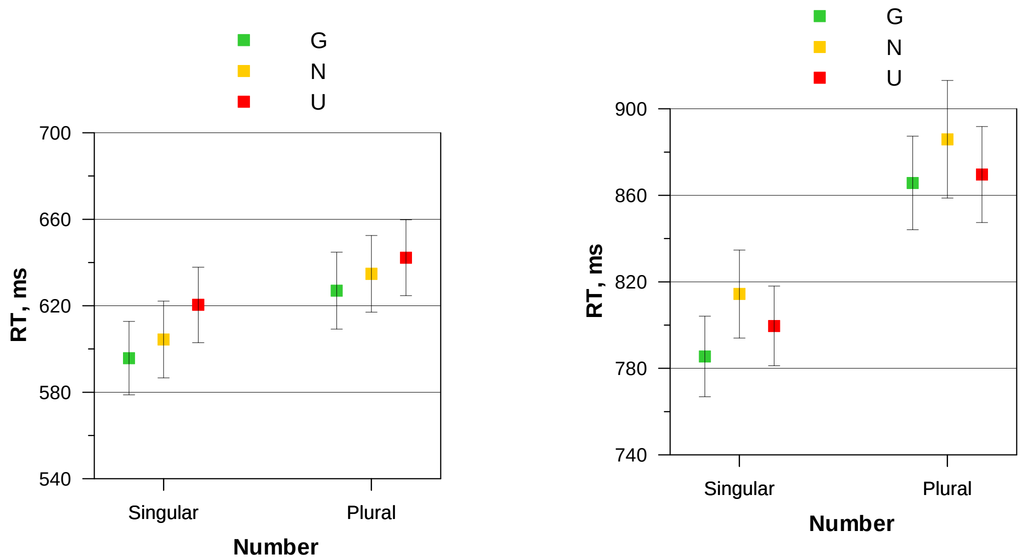
$\eta\rho^2$=.089], but showed that both components of priming, facilitation and inhibition, were significant in NV dependencies: $F(1,35)=10.14$, $p=.003$, $\eta\rho^2=.225$, and $F(1.35)=4.09$, $p=.05$, $\eta\rho^2=.105$, respectively.

L2 speakers

L2 speakers, like native speakers, showed processing advantage for gender agreement in NV dependencies, which, on average, was processed faster than agreement NA dependencies, M_{NA}= 839 ms (SE=20.64) and M_{NV}=835 ms (SE=20.38), but although the overall difference was only 4 ms, it made the effect for syntactic dependency for gender significant, $F(1,35)=11.74$, $p=.002$, $\eta\rho^2=.252$ (Figure 33b). A significant effect was also found for prime condition, $F(1.62, 56.6)=7.39$, $p=.003$, $\eta\rho^2=.175$, and for prime condition by dependency interaction, $F(1,35)=4.0$, $p=.023$, $\eta\rho^2=.103$. Using tests of within-subjects contrasts, priming effects for each dependency were examined separately, but, since nouns in the neutral condition in both types of dependencies were processed significantly longer than targets in the grammatical and ungrammatical conditions, distorting measures of facilitation and inhibition, an examination of the direction of priming effects was not possible, and further tests of within-subjects contrasts only focused on comparing the magnitude of priming in the two dependencies, excluding the neutral condition. In NA agreement overall response latencies to nouns in the ungrammatical condition were insignificantly longer than RTs to nouns in the grammatical condition (5 ms), M_U=810 ms (SE=18.93) and M_G=805.16 (SE=19.27), respectively. In NV agreement, the difference of 16 ms was significant, $F(1,35)=7.2$, $p=.011$, $\eta\rho^2=.171$, M_U = 802 ms (SE=19.5), M_G =786 ms (SE=19).

5.3.4 Processing of singular and plural nouns in number agreement

Figure 34a presents mean RTs for singular and plural number for native speakers. To examine the direction of priming effects in native processing, further analyses analyzed mean RTs for singular and plural nouns in a 2 (singular, plural) x 3 (grammatical, ungrammatical, neutral prime) within-subjects ANOVA. In native speakers, analysis yielded a significant main effects for number, $F(1, 35)=37.77$, $p< .001$, $\eta\rho^2=.519$, reflected in a significantly faster processing of singulars than plurals, $M_{SG}=607$ ms ($SE=17.2$) and $M_{PL}=35$ ms (SE=17.3), and a significant effect for prime condition, $F(1.76, 61.7)=14.03$, $p< .001$, $\eta\rho^2=.286$, reflected in significant overall priming effects that were obtained for number in an earlier analysis (20 ms of priming that included 12 ms of inhibition and 8 ms of facilitation). However, no significant number by prime condition interaction was found: $F(1,35)=3.03$, $p=.09$, showing that the difference in the magnitude of priming between singulars and plurals was not significant. Within-subjects contrasts, conducted separately for singular and plural nouns, showed significant priming for both singular nouns, $F(1,35)=50.73$, $p<.001$, and plural nouns, $F(1,35)=9.96$, $p<.001$, $\eta\rho^2=.592$. The magnitude of priming was greater for singulars (25 ms) than for plurals (15 ms), but, as shown above, the difference was marginally significant. In singulars the effect was largely due to significant inhibition of 16 ms, $F(1,35)=11.05$, $p=.002$, $\eta\rho^2=.307$, with insignificant facilitation (9 ms), whereas in plurals the effect was almost equally represented by insignificant facilitation (8 ms) and inhibition (7 ms).



(a)

Figure 34. Native (a) and L2 (b) participants' mean RTs for singular and plural nouns. *Note: The base line is shifted to 540 ms for native and 740 ms for L2 participants.*

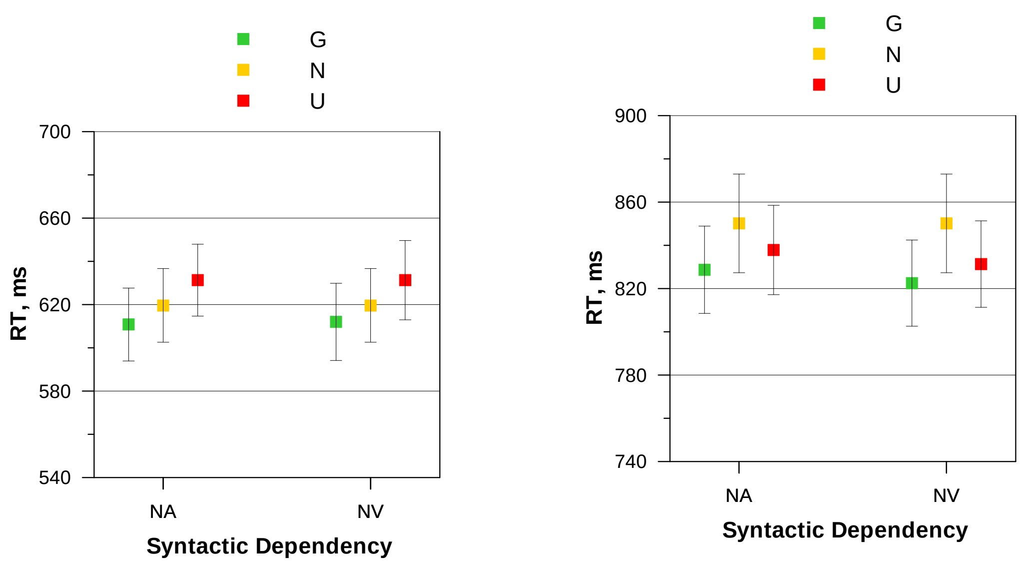
L2 speakers

In L2 speakers, similarly to native speakers, the analysis found significant main effects of noun number, $F(1, 35)=103.35$, $p< .001$, $\eta\rho^2=.764$, reflected in that plurals were processed overall significantly longer than singulars, M_{PL} = 874 ms (SE =22.7) and M_{SG}=800 ms (SE=18.6), and a marginally significant effect of prime condition, $F(1.63,57.1)=5.93$, $p=.068$, $\eta\rho^2=.145$, reflected in significant overall priming effects that were obtained for gender in the earlier analysis (9 ms of priming that consisted of 25 ms of facilitation inflated by delayed processing of nouns in the neutral condition and 16 ms of reverse inhibition due to the same reason). The number by prime condition interaction was not significant, suggesting insignificant differences in priming effects between singulars and plurals. Since measures of both facilitation and inhibition were distorted, further tests of within-subjects contrasts excluded the neutral condition and only focused on the magnitude of priming in the G and U conditions. L2 speakers did not exhibit priming effects for plural, and the tests statistically confirmed lack of significance inhibition for the 4 ms difference found between the grammatical and ungrammatical conditions. Priming of 14 ms in singular nouns was, however, significant: $F(1,35)=5.17$, $p<.029$, $\eta\rho^2=.129$. L2 RTs for number agreement as a function of number and prime condition are shown in Figure 34b.

5.3.5 The role of syntactic distance in number agreement

Native speakers

For number, within-subjects 2 x 3 ANOVA, with dependency (NA, NV) and prime condition (grammatical, ungrammatical, neutral) as factors, did not find a main effect of dependency, showing that there were no differences between the two dependencies in native speakers, with the same M=621 ms for each type of dependency (SE=16.56 for NA, and 17.57 for NV). There was a significant effect of prime condition, indicating differences in overall RTs as a function of prime condition, $F(1.77, 61.76)=14.03$, $p<.001$, $\eta\rho^2=.287$. No significant prime condition by dependency interaction, however, was found, indicating no differences in priming effects between the two dependencies (21 ms in the NA condition and 19 ms in the NV condition). According to Figure 35a, priming in both dependencies seemed equally robust and equally represented by facilitation and inhibition. Tests of within-subjects contrasts run for each dependency confirmed the observation for priming: $F_{NA}(1,35)=33.67$, $p<.001$, $\eta\rho^2=.490$ and $F_{NV}(1,35)=22.45$, $p<.001$, $\eta\rho^2=.391$, but showed that, although the differences between the facilitatory and inhibitory components of priming were minimal, inhibition was stronger than facilitation in both dependencies [12 ms, $F_{NA}(1,35) = 6.49$, $p<.015$, and 12 ms, $F_{NV}(1,35)=9.97$, $p<.003$, $\eta\rho^2=.222$, versus marginally significant facilitation of 9 ms in NA dependencies, $F(1,35)=3.4$, $p=.07$, $\eta\rho^2=.089$, and insignificant facilitation of 8 ms in NV dependencies].



(a) *(b)*

Figure 35. Native (a) and L2 (b) participants' mean RTs for number as a function of syntactic dependency.

Note: The base line is shifted to 540 ms for native and 740 ms for L2 participants.

L2 speakers

Within-subjects 2 x 3 ANOVA, with dependency (NA, NV) and prime condition (grammatical, ungrammatical, neutral) as factors, did not find the main effect of dependency in L2 speakers, M=839 ms (SE=20.86) for NA agreement, and M=835 ms (SE=20.3) for NV agreement. There was a significant effect for prime condition, $F(1.63,57.13)=5.93$, $p=004$, $\eta\rho^2=.145$, indicating differences in overall RTs as a function of congruency (Figure 35b). No significant prime condition x dependency interaction was found, indicating no differences in priming effects between the two dependencies (9 ms ms in both NA and NV conditions).

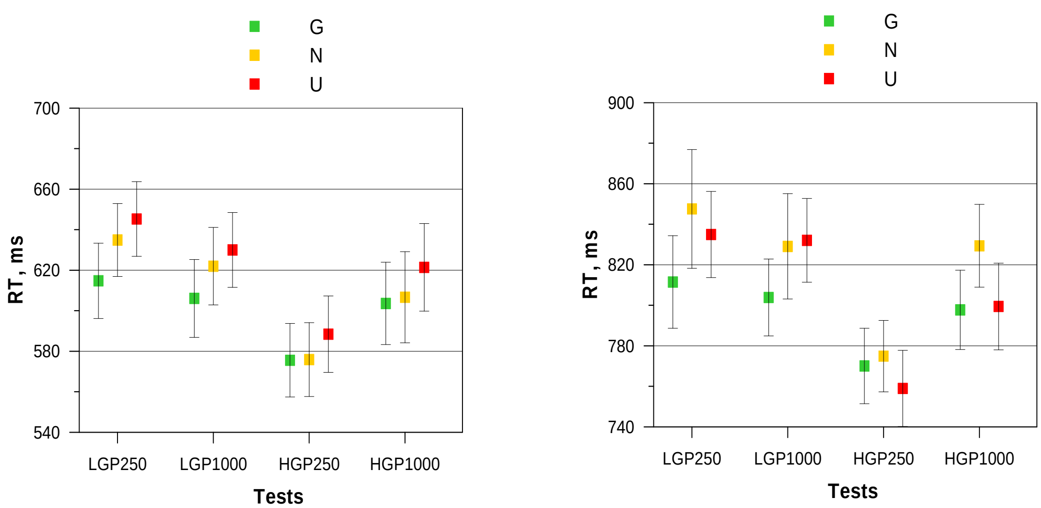
5.3.6 Summary

The study showed evidence of robust gender and number priming in both native and L2 participants, with gender agreement processed, on average, faster than number agreement. Both groups recognized masculine nouns faster than feminine nouns, but while native speakers showed an insignificantly larger priming effect for masculine nouns than for feminine nouns, L2 speakers showed a larger priming effect for feminines than for masculine. Similarly, singulars were recognized faster than plurals by both groups, with a larger magnitude of the priming effect. This longer recognition of plural nouns reflects the process of decomposition, with processing costs more pronounced in L2 speakers. While these effects observed in native speakers included both facilitation of nouns in the grammatical condition and inhibition of nouns in the ungrammatical condition relative to the neutral baseline (and were dominated by inhibition in masculine nouns), the components of priming in L2 speakers were obscured by their longer response latencies to the neutral prime, and, while nouns in the grammatical condition were recognized faster than nouns in the ungrammatical condition, the presence or absence of either facilitation or inhibition relative to the baseline was not clear. Interestingly, both groups recorded longer RTs in NA than in NV dependencies. Table 22 provides a summary of the main findings that suggest differences between the two categories which could have obscured the identification of the undelying processing mechanisms in the previous analysis. Therefore, in the following section I return to the examination of the mechanisms underlying the processing of gender and number separately.

5.4 Attentional mechanisms underlying gender and number priming

5.4.1 Gender priming

The mean RTs for gender for each group of participants are presented in Figures 36a and b. To investigate the mechanisms underlying the priming patterns in gender agreement based on the assumptions of the study that automatic processes can be captured at short SOAs in response to low GP and prelexical strategic processes can be captured at long SOA in response to high GP, I analyzed participants' responses to gender agreement in these two conditions.



(a) *(b)*

Figure 36. Native (a) and L2 (b) participants' mean RTs for gender as a function of test. *Note: The base line is shifted to 540 ms for native and 740 ms for L2 participants.*

Two-way within-subjects analyses of variance were conducted on these RTs, with test (LGP250, HGP1000) and prime condition (grammatical, neutral, ungrammatical) as factors for each group separately.

Analysis of priming patterns in native speakers revealed a significant effect of the prime condition, $F(2,70) = 33.01$, $p<.001$, $\eta\rho^2=.641$, but no effects for test or for prime condition by test interaction. Using planned within-subject contrasts within the ANOVA procedure, the two test conditions were analyzed independently to determine the pattern of priming effects in the native group. It was found that their priming patterns at SOA250 in response to low GP were clearly consistent with automatic processes: significant priming of 31 ms, $F(1,35)=22.96$, $p<.001$, $\eta\rho^2=.396$, consisted of significant facilitation of 20 ms, $F(1,35)=6.35$, $p=.016$, $\eta\rho^2=.154$, in the absence of significant inhibition (10 ms). Furthermore, priming patterns at SOA1000 in response to high GP were consistent with strategic processes: significant priming of 18 ms, $F(1,35)=9.78$, $p=.004$, $\eta\rho^2=.218$, consisted of marginally significant inhibition of 15 ms, $F(1,35)=3.52$, $p=.069$, $\eta\rho^2=.091$, in the absence of facilitation.

Table 22. Priming results for gender agreement and number agreement

	Native Participants	**L2 Participants**
Gender		
Marked versus unmarked forms	RTs: Masc < Fem (sig.) Priming: Fem ≤ Masc (ns.) Fem (sig.)→facilitation (sig.) Masc (sig.)→inhibition (sig.)	RTs: Masc < Fem (sig.) Priming: Fem < Masc (sig.) Fem (ns.) Masc (sig.)
Role of syntactic distance	RTs: NV < NA (marginally sig.) Priming: NA = NV NA (sig.) → inhibition (sig.) + facilitation (marginally sig.) NV(sig.) → facilitation (sig.) + inhibition (sig.)	RTs: NV < NA (sig.) Priming: NA < NV (sig.) NA (ns.) NV (sig.)
Number		
Marked versus unmarked forms	RTs: Sing. < Plural (sig.) Priming: Plural ≤ Sing. (marginally sig.) Sing. (sig.)→ inhibition (sig.) Plural (sig.)→inhibition (ns) + facilitation (ns)	RTs: Sing. < Plural (sig.) Priming: Plural ≤ Sing. (ns) Sing. (sig.) Plural (ns.)
Role of syntactic distance	RTs: NA = NV Priming: NA = NV NA (sig.) → inhibition (sig.) + facilitation (marginally sig) NV (sig.) → inhibition (sig.)	RTs: NA = NV Priming: NA = NV NA (ns.) NV (ns.)

Figure 37 shows the magnitude of priming and its two components observed in native participants in the two tests that represented the most favorable conditions for evoking either automatic or strategic processing.

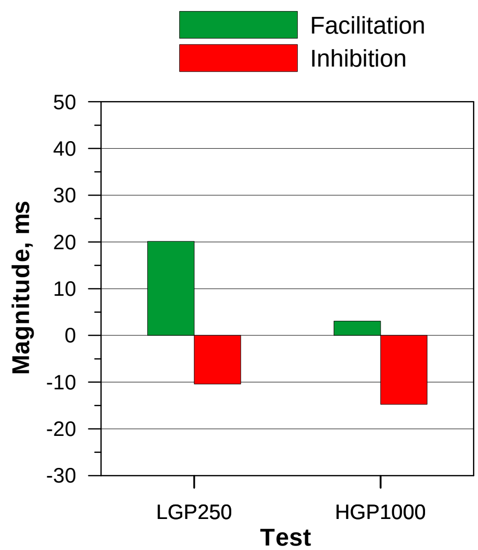


Figure 37. Facilitation versus inhibition over gender in native participants as a function of test.

Analysis of priming patterns in L2 speakers also found a significant effect of the prime condition, $F(2,70)=6.75$, $p=.002$, but no effects for test or for prime condition x test interaction. Within-subjects contrasts for each test showed that L2 participants' RTs for grammatical targets were significantly different relative to ungrammatical targets (priming of 24 ms) in the LGP250 condition, $F(1,35)=4.4$, $p=.043$, $\eta\rho^2=.112$, but it was not possible to determine the components of priming because of delayed RTs to the baseline. Interestingly, L2 speakers did not show any priming effects for gender at SOA1000 in response to high GP (Figure 36b).

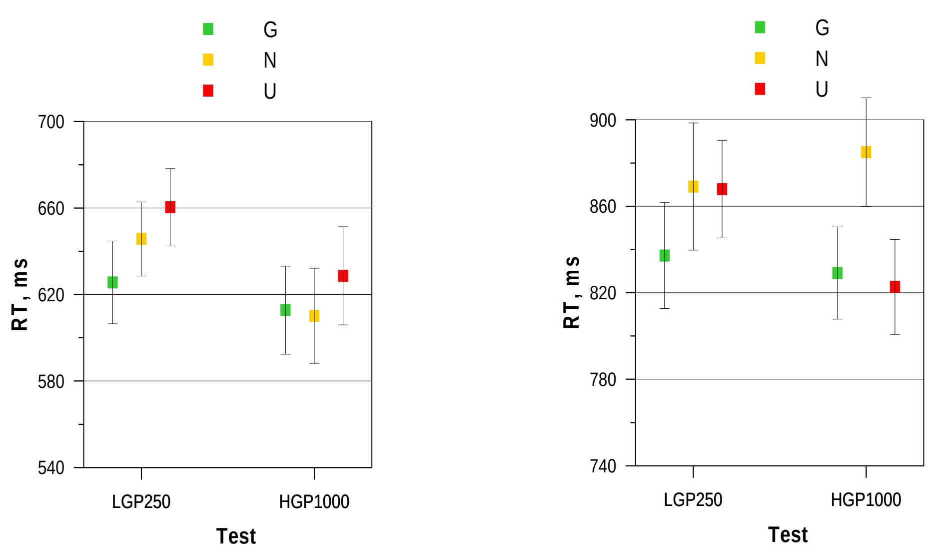
An examination of attentional mechanisms underlying the observed priming effects in gender agreement in the native and L2 groups according to the study's assumptions and operational definitions of these mechanisms would not be complete without examining the findings against the priming effects recorded in other conditions. As seen in Figure 36, the robust activation of gender information in response to low GP at the short SOA (represented by significant facilitation in the absence of inhibition) remained robust at the long SOA in the native group, $F(1,35)=15.67$, $p<.0001$, $\eta\rho^2=.309$, suggesting no significant changes in priming effects over time, which would be characteristic of postlexical processing. However, the absence of inhibition at SOA1000 in response to low GP is not consistent with the engagement of postlexical strategies and merits further analysis that will be provided in the general discussion. The priming patterns in response to high GP reflected two different mechanisms: the presence of insignificant but dominant inhibition at the short SOA in response to high GP was interpreted as evidence of postlexical strategic mechanisms, whereas the increase in the magnitude of priming and the presence of robust inhibition at SOA1000 was taken as evidence of expectancy-based processes evoked by high GP.

The L2 group demonstrated robust priming in response to low GP, which remained significant at SOA1000, $F(1,35)=7.32$, $p=.010$, $\eta\rho^2=.173$. Based on the assumption that postlexical mechanisms are not modulated by SOA, the finding that these effects did not change over time points to their strategic nature and postlexical locus. In response to high GP, L2 participants demonstrated insignificant reverse priming at SOA250 indicating the involvement of postlexical strategic processes, and the finding of no priming effects at

SOA1000 suggests that prime-target pairs were not perceived as related at the syntactic level at long SOAs.

5.4.2 Number priming

The mean RTs for number for each group of participants are presented in Figures 38a and b. To investigate the mechanisms underlying the priming patterns in number agreement and according to the same assumptions that automatic processes can be captured at short SOAs in response to low GP, and prelexical strategic processes can be captured at long SOA in response to high GP, we analyzed the participants' responses to number agreement, focusing on the two conditions designed to evoke either automatic or strategic processing.



(a) *(b)*

Figure 38. Native (a) and L2 (b) participants' mean RTs for number as a function of test.
Note: The base line is shifted to 540 ms for native and 740 ms for L2 participants.

Two-way within-subjects analyses of variance were conducted on these RTs, with test (LGP250, HGP1000) and prime condition (grammatical, neutral, ungrammatical) as factors for each group separately. In native speakers, a significant effect of the prime condition was found, $F(1.5, 52.8)=13.25$, $p<.001$, but, similar to gender agreement, no effects for test or for prime condition by test interaction. Using planned within-subject contrasts within the ANOVA procedure, the two test conditions were analyzed independently to determine the pattern of priming effects in each one. Figure 39 shows the size of priming and its components in the two tests.

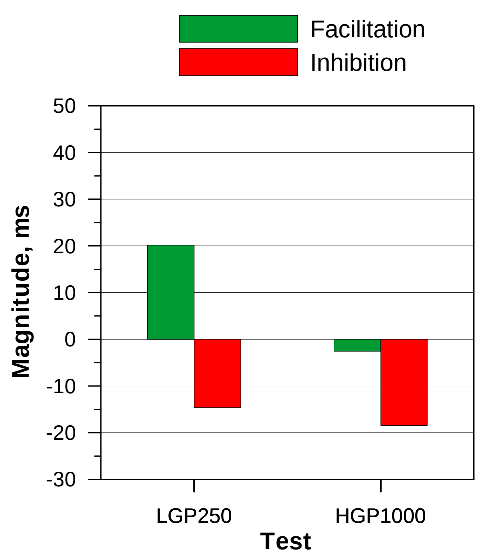


Figure 39. Facilitation versus inhibition over number in native speakers as a function of test.

The priming patterns at SOA250 in response to low GP could be categorized as consistent with postlexical processes: significant priming of 35 ms, $F(1,35)=26.0$, p<001, $\eta\rho^2=.426$, almost equally represented by insignificant facilitation of 20 ms, $F(1,35)=2.9$, $p=.098$, $\eta\rho^2=.077$, and insignificant inhibition (15 ms), $F(1,35)=2.6$, $p=.12$, $\eta\rho^2=.069$. The priming patterns at SOA1000 in response to high GP, similarly to gender, only involved strategic processes: significant priming of 16 ms, $F(1,35)= 9.07$, $p=.005$, $\eta\rho^2=.206$, consisted of significant inhibition of 19 ms, $F(1,35)=6.57$, $p=.015$, $\eta\rho^2=.158$, in the absence of facilitation.

For L2 speakers, the analysis found a significant effect of the prime condition, $F(2,70)= 7.1$, $p=.002$, $\eta\rho^2=.167$, but no effects for test or for prime condition x test interaction. Within-subjects contrasts for each test showed that L2 participants' RTs for grammatical targets were significantly different relative to ungrammatical targets (priming of 31 ms) in the LGP250 condition, $F(1,35)=6.21$, $p=.018$, $\eta\rho^2=.151$, but it their delayed responses to the baseline inflated facilitation and obscured inhibition, obscuring the direction of priming. As with gender, L2 speakers did not show significant priming effects for number at SOA1000 in response to high GP, but priming was reverse in direction as noun targets in the ungrammatical condition were recognized faster than targets in the grammatical condition (but the difference was not significant). The measures of facilitation and inhibition were not analyzed as they could not be taken as true representation of priming effects due to their significant distortion as a result of long processing of the neutral condition in comparison with grammatical and ungrammatical conditions (Figure 38b).

An examination of priming effects for number over time demonstrated that significant activation recorded at the early SOA in native participants remained robust at SOA1000, $F(1,35)=10.74$, $p=.002$, $\eta\rho^2=.235$. Interestingly, while at SOA250 priming was equally represented by marginally significant facilitation and inhibition, a hallmark of postlexical mechanisms, priming only had a significant facilitation component at SOA1000, $F(1,35)=8.67$, $p=.006$, $\eta\rho^2=.199$ Additional tests of within-subjects contrasts showed that priming decreased between SOA250 and 1000, and the decrease was significant: $F(1,35)=11.42$, $p=.002$, $\eta\rho^2=.246$, which argues against the involvement of postlexical processing at SOA1000. I return to this finding in the general discussion.

In response to high GP, the short SOA did not evoke significant priming or facilitation, but marginally significant inhibition, $F(1,35)= 4.07$, $p=.056$, $\eta\rho^2=.104$, which strengthened significantly at SOA1000, suggesting the presence of strategic mechanisms. At the short SOA these mechanisms operated postlexically, whereas at the long SOA they reflected activation due to expectancy. These findings, in combination with the finding of postlexical routines at SOA250 in response to low GP, are indicative of predominately strategic mechanisms engaged in number agreement processing.

The L2 group, which demonstrated robust priming in response to low GP, showed the same level of priming at the long SOA, $F(1,35)=10.55$, $p=.003$, $\eta\rho^2=.232$, indicating that priming was subserved by postlexical controlled mechanisms. In response to high GP, no priming effects were found at SOA1000 (priming was reverse in direction but insignificant), but at SOA250 the reverse priming effect was robust, $F(1,35)=4.27$, $p=.046$, $\eta\rho^2=.109$. These effects were interpreted as evidence of deviant strategic processes operating postlexically.

5.4.3 Summary

Thus, the priming patterns in the two critical tests showed that native speakers engaged automatic and expectancy-based prelexical processes for gender agreement and strategic postlexical processes for number agreement, whereas L2 participants processed both gender and number postlexically.

CHAPTER SIX: GENERAL DISCUSSION

The present study used a variant of Blumstein et al.'s (1991) and Arnott et al.'s (2005) grammatical priming paradigm to examine the manner, in which native and second language speakers access and integrate morphosyntactic information in gender and number agreement operating between nouns and adjectives within the same noun phrase (e.g., *prostoj kozjol* "simple-MASC-SG goat-MASC-SG") and between nouns and verbs across phrasal boundaries (e.g., *byl kozjol* "was-MASC-SG goat-MASC-SG"). Since the study explored the possibility that differences in the patterns of morphosyntactic priming between native and L2 speakers may reflect deficits in automatic and controlled lexical access processes in L2, it was critical to create online experimental procedures capable of dissociating underlying processing mechanisms. Two variables, grammaticality proportion and length of SOA, that have been tied to the operational definition of automatic and controlled processes (e.g., Neely, 1976, 1991), were manipulated in order to examine their impact on participants' lexical decision performance. The study isolated the mechanisms underlying priming and permitted the identification of key processing differences not previously reported in L2. Furthermore, the study provided evidence of native and nonnative gender and number priming patterns in a language, characterized by a morphologically complex system of agreement, in this case Russian, and offered a comprehensive analysis of the magnitude and direction of priming, the role of syntactic context, and underlying mechanisms. The present chapter discusses how native and L2 speakers access and integrate grammatical information when processing gender and number agreement, and considers the implications of the present research.

6.1 Native and nonnative attentional mechanisms

It was hypothesized that L1 and L2 speakers would exhibit differences in underlying mechanisms engaged in processing morphosyntactic structure, and that these would be reflected in the differences in the nature of these mechanisms and their locus, or the time frame of when these mechanisms operate during grammatical access. In particular, it was predicted that native participants would " invoke multiple, complicated processes that conjointly operate in the normal reading situation" (Neely, 1991, p.323), which include spreading activation, expectancy, and/or postlexical coherence-checking strategies, whereas L2 participants would display subtle differences in the dynamics of ASA and/or in expectancy-based processing that would influence processing at the integration stage postlexically, and would be evidenced in differences in priming patterns (Millberg et al., 1999). The pattern of results was complex, but, overall, the hypothesis was confirmed.

6.1.1 Native processing of local syntactic dependencies

6.1.1.1 Main finding

Morphosyntactic priming patterns for the native speakers who participated in the study indicated that local dependencies within and across phrasal boundaries invoked both pre- and postlexical processing mechanisms that were differentially engaged in NA and NV dependencies. The complex patterns of priming effects were not consistent with the notion of a single underlying process, and demonstrated that native participants employ a repertoire of attentional mechanisms depending on processing circumstances, syntactic contexts, and grammatical features.

6.1.1.2 Role of syntactic distance

A comparison of priming effects in the two dependencies showed that, although there were no significant differences in the size of priming effects between the two dependencies (nor was there the main effect of dependency found), these priming effects had a different time course depending on syntactic distance, which suggested the involvement of different mechanisms: with increase in SOA, the size of priming increased significantly in NA dependencies, whereas priming in NV dependencies showed no evidence of significant change. This change in priming over time in NA dependencies suggested the involvement of time-dependent prelexical mechanisms, but stable priming effects over time in NV dependencies provided evidence of time-independent postlexical strategic mechanisms.

In order to explain different priming patterns recorded for dependencies within and across phrasal boundaries, I considered the study by Blumstein and colleagues (1991), in which they identified processing differences for local dependencies within and across phrasal boundaries for normal controls in comparison with aphasic patients and offered several possible explanations of the differences. One possibility was related to the nature of the syntactic structure resulting from the juxtaposition of the dependency constituents, verb phrase versus noun phrase, in their case. Since constituents forming a VP (namely, the aux-verb: *is-going*) reflect a closer syntactic relationship than the relationship formed by the NP constituents (namely, the pronoun-verb: *he gives*), the authors related automatic processing routines recorded for the aux-verb constructions to a closer relationship and attentional processing routines recorded for the NP to the less local dependency.

A second possibility was related to the instantiation of syntactic agreement and its directionality. The authors reasoned that since verb constituents they used in their study are marked for agreement in the lexicon, when these constituents were juxtaposed, agreement proceeds in a forward direction from the auxiliary to the verb. In contrast, pronouns are not marked for agreement with the verb in the lexicon, and as a result, when the noun and verb are juxtaposed, the directionality of selection for agreement goes back from the verb to the subject pronoun. This greater complexity could invoke inhibitory processes rather than facilitatory processes since pronoun-verb/backward agreement would require a "check-back" procedure, whereas this check was unnecessary in case of aux-verb constructions. Therefore, pronoun-verb agreement would represent a more difficult task for the parser than auxiliary-verb agreement.

A third possibility stemmed from the phonological forms that mark various types of morphological endings. Since English endings for tense and aspect are phonologically more salient than the morphological endings for person agreement, what may appear as processing difficulty as a function of dependence may be processing difficulty as a function of salience, suggesting that the more phonologically salient endings are processed more quickly, as reflected in facilitatory effects.

A final possibility is that there is a difference in the relative information value of agreement construction. For example, verb tense and aspect provide critical information for sentence interpretation, whereas subject-verb agreement is largely redundant.

Arnott et al. (2005) extended Blumstein et al.'s methodology to consider the temporal location of the attentional processing mechanisms that could have contributed to the observed priming effects and examined morphosyntactic priming effects in patients with Parkinson's disease by employing a range of four SOAs to differentiate pre- and postlexical attentional mechanisms. The researchers proposed that the different priming patterns recorded for dependencies within and across phrasal boundaries do not represent the effects of task complexity on prelexical processing, but rather reflect the effects of agreement direction on the locus of the contributing processes. Hence, in their study, morphosyntactic priming effects consistent with prelexical (auxiliary-verb constructions) and postlexical (pronoun-verb constructions) processing routines represented the influence of forward agreement and backward prime-target agreement, respectively.

Continuing this line of reasoning to understand the processing dichotomy between the two types of dependencies in the current study, we examined the native participants' priming patterns in light of these five possibilities discussed above. The patterns of performance obtained for the native participants cannot be explained by directionality of agreement or by its effect on the locus of processing, since both NA and NV dependencies in the current study represented forward agreement, or by relative information value, since morphological markers of agreement carry similar gender and number information for the parser. However, the other two factors—syntactic distance and salience of morphological form—can account for observed differences in the Russian data. In addition, salience can also be represented by frequency of occurrence and perceptual salience (Goldschneider & DeKeyser, 2001). While the verb-subject (VS) agreement order used in NV dependencies is frequent in Russian, it is less frequent than a canonical noun-verb agreement in Russian and in other languages (Tomlin, 1986)[19] and, thus, more cognitively challenging than the canonical noun-adjective agreement. Besides, morphological endings required for noun-verb agreement ('*-i*' for plural and '*-a*' for feminine on the verb) *vis-à-vis* morphological endings required for noun-adjective agreement ('*-yj*' for masculine singular, '*-aja*' for feminine singular, and '*-yje*' for plural on the adjective) add to complexity of NV dependencies due to their insufficient perceptual salience.

Thus, NV dependencies in the current study evoked postlexical strategic processing mechanisms in native speakers. In contrast, NA dependencies, representing a canonical (frequently used) type of agreement order, a more local dependency and having more salient agreement markers, were more conducive to the engagement of prelexical (automatic or expectancy-based) mechanisms.

6.1.1.3 Attentional mechanisms underlying priming

Based on the three-process model of priming (Neely & Keefy, 1989; Neely, 1991), priming patterns observed in NA dependencies were interpreted as consistent with prelexical mechanisms: the findings of significant facilitation in the absence of significant inhibition in response to low GP was taken as evidence of automaticity, and

[19] According to a survey of 402 languages the majority of languages are either SOV (44.78%) or SVO (41.79%). VSO (9.20%) is much less frequent but still significant, and very few languages make use of VOS (2.99%), OVS (1.24%) or OSV (0.00%) as their basic word order. This pattern of word order frequencies, (SOV, SVO) > VSO > (VOS, OVS) > OSV, may be a consequence of more fundamental or general linguistic principles: the "theme-first principle", "verb-object bonding" and the "animate-first principle". The frequency of each word order is proportional to the number of the principles which that word order permits to be realized (all three principles are realized in SOV and SVO, two are realized in VSO, one in VOS and OVS, and none in OSV) (Tomlin, 1986).

the finding of significant inhibition in response to high GP pointed to the involvement of expectancy-based routines (Neely, 1991). However, the finding of marginally significant inhibition without facilitation observed at SOA250 argues for the involvement of postlexical processing. Further, the absence of facilitation in response to high GP is not fully consistent with the study's assumptions and may be interpreted as evidence of postlexical processing.

To account for these conflicting findings, we examined these priming patterns in light of the Gain/Decay Hypothesis (Milberg et al., 1999) described in chapter 2. A close inspection of the curves of three activation functions described by Milberg and colleagues suggested that automatic activation in native participants in NA dependencies could have risen and decayed faster than the rate described by the normal activation function proposed by the hypothesis, because the activation described by the authors had been based on associative semantic priming, while the present results are based on morphosyntactic priming, which could be viewed as a variant of category priming. Category priming activates a large number of connections, and taken in the context of Milberg et al.'s model for normal semantic activation ($\tau = 0.6$), the increased number of connections predicts that the summation of input would be larger for category than for associative priming, which would decrease the time constant that defines the activation function. As seen in Figure 1, a decrease in the time constant ($\tau = 0.2$) predicts activation that is both fast-acting and fast-decaying.

Thus, the peak of automatic activation in native participants might have occurred earlier, and at SOA250 we could have measured the effects of decaying ASA (by 400-500 ms) and increasing strategic mechanisms, consisting of both significant facilitation and inhibition. Besides, increased priming observed with increase of SOA also points to the emergence of strategic processes. A similar pattern of activation for local within-phrase dependency was described by Arnott et al. (2005) for older normal participants, who demonstrated decay of ASA at SOA of 500 ms and peak of activation at 1000 ms. This interpretation, also consistent with results previously reported by Neely (1977) for young native speakers of English, can account for the presence of inhibition at the short SOA and increase in the size of priming obtained for the native participants for NA dependencies in the current study.

Regarding the unexpected absence of facilitation of grammatical targets relative to the baseline in the test designed to evoke prelexical expectancy-based routines in response to an increase in the proportion of grammatical prime-target pairs can be accounted for by examining predictions for category priming. According to Becker (1980), category priming predicts larger expectancy sets compared to small expectancy sets generated by associatively related material that contain only a few words with strong associative relation with the prime. Neely (1991) clarifies: "Assuming that this small set includes the target, the target will be found very quickly in it and the result will be a large facilitation effect in the related priming condition. On the other hand, in the unrelated priming condition the inhibition effect will be small. That is so, because the person will have wasted very little time in exhaustively searching the very small expectancy set before he or she begins the search of the visually defined set, in which the unrelated target resides. For category materials, subjects use the category-name prime to generate a large expectancy set that contains all of that category's exemplars. Because the subject must, on average, search through a large number of category exemplars to find a target related to the prime in the expectancy set, the facilitation effect in the related priming condition will be small. However, inhibition in the unrelated priming condition will be relatively large, because a lot of time will have been wasted exhaustively searching this large expectancy set before the search of the visually defined set is initiated" (Neely, 1991, p. 302). Blumstein et al. add to this explanation, clarifying the pattern of inhibition without facilitation in their normal subjects: "Although the likelihood of predicting the correct morphological form of the verb is extremely high, the likelihood of predicting a specific verb target is extremely low, thus making strategic-based facilitation extremely unlikely" (1991, p. 410).

Morphosyntactic priming procedures in the study, in accordance with Becker's (1980) semantic contexts effect for category priming, resulted in inhibition dominance for native participants in response to high GP. Thus, in view of interpretations of the finding given above, the presence of inhibition without facilitation in response to high GP in NA dependencies observed in the current study indicates the engagement of expectancy-based processing.

As for NV dependencies, due to their larger complexity discussed above, activation of morphosyntactic information was slowed, and priming, recorded at the short SOA and represented equally by both facilitation and inhibition, was consistent with the operation of postlexical coherence-checking mechanisms. Further, priming recorded at the long SOA reflected a decay of activation, as the longer prime-target interval "destroyed" the association between the prime and the target in the less local syntactic dependency (Gor, November 24, 2012, personal communication).

6.1.1.4 Interim conclusion

The complex patterns of priming effects recorded in the native participants in the current study were not consistent with the notion of a single underlying process and demonstrated that they employed a repertoire of attentional routines—automaticity, expectancy, and backward-checking—depending on processing circumstances, syntactic contexts, and grammatical features.

6.1.2 L2 processing of local syntactic dependencies

6.1.2.1 Main findings

Although L2 speakers exhibited native-like processing of agreement in local syntactic dependencies in an offline grammaticality judgment task and had native-like error rates in word recognition in the lexical decision task, they exhibited subtle differences in the dynamics of activating morphosyntactic information during lexical access. In contrast with the multiple mechanisms engaged by the native participants pre- and postlexically, morphosyntactic priming patterns in agreement processing for the L2 speakers who took part in the study exhibited predominantly strategic routines operating at the postlexical level, which was reflected in the lack of interaction of prime and SOA, reverse priming in response to high GP, and delay in the neutral condition that reflected L2 participants' sensitivity to a different, and probably less familiar, syntactic structure. This "misbehavior" of the neutral condition precluded an examination of priming components for L2 participants. At the same time, this unexpected delayed processing of the neutral condition in this group of speakers was taken as additional evidence of the engagement of slower strategic routines that required the processor to go back to the target to check for coherence postlexically.

6.1.2.2 Role of syntactic distance

A comparison of priming effects in the two dependencies showed that, in contrast with the study's native speakers, who demonstrated that NA and NV dependencies evoke different attentional mechanisms, the L2 participants did not exhibit changes in priming patterns as a function of SOA, which indicated that they relied on the same strategic mechanisms operating postlexically. However, they exhibited differences in the processing of NA and NV dependencies, most notably, the peculiar GP effect they demonstrated in response to an increase in GP: priming in NA dependencies was reversed at both SOAs, reflecting facilitation of grammatically incongruent targets relative to grammatically congruent ones, whereas in NV dependencies this effect was only observed at the short SOA. This priming asymmetry, along with longer RTs for NA dependencies than for NV dependencies (confirmed earlier by the main effect of dependency), may be viewed as an indication of larger difficulties in processing NA dependencies than NV dependencies.

This finding is not in line with the hypothesis that taxing computations, such as the establishment agreement across syntactic boundaries, may present particular challenges to adult L2 learners as they may have limited access to cognitive resources during online processing (McDonald, 2006; Gillon-Dowens et al., 2010). It was found that NA dependencies seemed to evoke more effort on the part of L2 speakers in the current study.

One of the explanations for this finding of NA dependency being more difficult for L2 speakers in the current study may be related to the insufficient salience of agreement markers in NA dependencies for L2 speakers. When discussing salience of the two dependencies for native speakers, we identified syntactic distance, frequency, and perceptual salience, without evaluating the contribution of each factor. However, in nonnative processing, these factors may have a different weight, thus influencing acquisition and processing of different categories differently. For example, the morphological endings required for noun-adjective agreement may not be as salient as the morphological endings required for noun-verb agreement, despite their seeming perceptual salience due to more syllables and stronger sonority. That is, noun-verb agreement is marked only by the addition to the verb stem of a single vowel, namely '*-i'* for plural and '-*a*' for feminine, whereas adjective-noun agreement requires the addition of one- or two-syllable ending that contains a vowel and a sonorous consonant (*-yj'* for masculine singular, '-*aja*' for feminine singular, and *'-yje'* for plural). However, "the traditional adjectival paradigm [in Russian] has many more cells than there are distinct phonological forms, owing to pervasive syncretism" (Corbett, 2004, p.202), which may introduce a processing uncertainly for nonnative speakers, since syncretism of inflections and their greater variability reduces morphological regularity and makes them less salient (Goldschneder & DeKeyser, 2001). Further, in oral speech, these endings, when unstressed, are reduced, which makes their discrimination harder. Hence, while it may seem that the perceptual salience of a longer and more sonorous ending is an important aspect of salience, another aspect, i.e., morphological complexity, may take precedence for L2 speakers, offsetting perceptual salience and overriding the contribution of syntactic distance and frequency.

Further, recognition of inflected words has been shown to be less efficient in late L2 than in native processing as, with whole-word representations of inflected words being unavailable in L2, it relies on decomposition and depends on morphological complexity (Gor & Cook, 2010). So, NA dependencies, that boast more complex adjectival endings, could have evoked extra attention on the part of L2 speakers in the current study, making them check back from target to prime for coherence, and to be extra vigilant for errors.

In contrast, in NV dependencies L2 speakers could have relied on a simple strategy of establishing associations, or matching endings on the verb prime with similar endings on the noun target (e.g., *–a* with *–a*, as in *byl**a** gor**a***, "was FEM mountain FEM" and *-i* with *–i/-y*, as in *byl**i** zhuk**i,*** "were PL bugs PL) processing agreement in the absence of a sentential context at the lexical level (Barber & Carreiras, 2003, 2005). However, it is too early to make any far-reaching conclusions before this finding is replicated with a different group of L2 participants.

6.1.2.3 Processing mechanisms

The pattern of priming exhibited by the L2 participants indicates evidence of delayed automatic processing of morphosyntactic information resulting in the engagement of postlexical routines. As discussed in chapter 2, increased neural noise in the semantic networks of L2 speakers (Indefrey, 2006) may lead to reduced signal-to-noise ratios that can interfere with implicit processing. Prime information is processed more slowly and less efficiently, resulting in the slowing of converging input from related nodes, thus increasing the time constant, τ, that determines the rate of activation. Its increase from 0.6 to 0.8 would result in activation that rises and falls more slowly than normal and is less robust (Milberg, 1999) (Figure 1b). According to the three-process model of priming (Neely & Keefy, 1989), when morphosyntactic information is not activated automatically at a short SOA, it is not available to detect grammatical relatedness and to activate expectancy-based attentional processing routines. When context-based expectancies fail to get activated and are unavailable for the processor to check the target against, the processor activates postlexical strategies that evaluate morphosyntactic congruence by going back to the prime after accessing the target. The expected consequences of an increase in τ would normally be evidenced in the absence of normal facilitation at the short SOA, followed by a facilitation effect at the long SOA when normally the prime advantage would have degraded. Although the delayed processing of the neutral prime in the current study precluded an identification of reliable patterns of facilitation and inhibition in the L2 group, thus making it impossible to dissociate automatic and expectancy-based mechanisms, changes in L2 participants' direction and magnitude of priming over time were examined instead to verify the recruitment of postlexical routines. Since no changes in priming over time were found, which is inconsistent with the involvement of either automatic or expectancy-based time-dependent prelexical mechanisms, it was concluded that L2 priming patterns represented time-independent postlexical processing routines. Clearly, additional research is needed to substantiate these hypotheses.

6.1.2.4 Priming in morphosyntactically incorrect contexts

For native speakers, morphosyntactic priming effects were due to the facilitation of targets in grammatical constructions and the inhibition of morphosyntactically incorrect targets. Interestingly, while the L2 participants recognized grammatical constructions faster than ungrammatical constructions in response to low GP, they accessed the targets in prime-target pairs faster when these targets appeared in the ungrammatical condition in response to high GP. The advantage offered by ungrammaticality is contrary to simple models of grammatical priming that are based on grammaticality advantage (facilitation in congruent contexts only), and it is currently not clear whether the finding is an isolated anomaly, or represents a replicable phenomenon.

One possible explanation could be related to theories of knowledge/skill acquisition and automaticity. While different characteristics of automaticity have been emphasized by different researchers (see DeKeyser, 2001, for overview), it has been agreed that a large amount of practice leads to gradual automatization of knowledge, that the more automatized knowledge is, the less attention it requires and the less error-prone it is, and that a certain degree of automatization (in the broad sense of the term) is an important part of second language learning (DeKeyser, 2007a). However, it is important to distinguish between automaticity and expertise, which connotes some extra unusual training or experience not shared by most people (Hélie, Waldschmidt, & Ashby, 2010). For example, according to Palmeri, Wong, and Gauthier (2004) "experts know more than novices. They can verbalize more properties, describe more relationships, make more inferences..." (p. 378). According to this definition, very proficient language learners, who have developed their language knowledge through thousands of hours of specialized training and practice, can be characterized as experts. This gives rise to the question of whether the specialized training these language experts receive means that their language abilities are not only different from novices (i.e., low-proficiency language speakers) but also from native speakers. It has become common to refer to the native-nonnative differences as deficiencies (as does most of the literature discussed in the Introduction), often without recognizing the unique language 'sufficiencies' of these speakers. The L2 learners' speed-up in response to ungrammatical trials (reverse priming) in tasks promoting accuracy (i.e., tasks with high grammaticality proportion) could reflect their heightened sensitivity to grammatical violations (rather than 'insensitivity," Jiang, 2004) as a result of overtraining—years of explicit instruction, error correction, and extensive practice in identifying grammatical incongruency, characteristic of many language teachers and translators (heavily represented in the L2 group).

Further, drawing from the accuracy motivation account proposed by Glaser & Banaji (1999) and refined by Wentura (2000) within the affective priming paradigm in social psychology, we can suggest that when the participants had an accuracy goal, i.e., were motivated, or conditioned, to be accurate by lists with high grammaticality proportion, the target's grammatical features became more salient, in contrast with conditions with low grammaticality proportion, when participants were not motivated, or conditioned to be accurate. Therefore, when prime-target sequence was ungrammatical, a change in grammaticality triggered automatic correction processes in the 'experts' rather than in the native speakers. As is common in the case of correction processes, people may overcorrect (Wilson & Brekke, 1994), which results in reverse priming, so the participants responded faster to ungrammatical than grammatical prime–target sequences. Nevertheless, the specific mechanism underlying this finding remains an open issue.

6.1.2.5 Interim conclusion

The L2 participants in the current study showed native-like performance in terms of accuracy and sensitivity to grammaticality of gender and number agreement in online processing. On the other hand, they exhibited differences in the dynamics of activation of morphosyntactic information, which was delayed even in highly proficient speakers, presumably due to slowed input summation from connected nodes in the semantic network. This slower rise of activation reduced the availability of grammatical information and required these participants to evoke controlled processing at the integration stage (Millberg et al., 1999), which, due to the nature of late L2 language learning, may differ from native processing. Further, the finding of reverse priming discussed in the previous section, merits further investigation. If replicated under conditions motivating accuracy in highly proficient L2 speakers, this finding may provide a useful heuristics for explaining often-reported null effects in studies investigating L2 learners' sensitivity to errors.

6.2 Native and nonnative processing of gender and number

The study's findings indicate that gender and number priming is a robust phenomenon in Russian, similar to the effects that have been observed in other languages, as discussed in chapter 2. The study's hypotheses regarding similarities and differences between number and gender agreement are discussed below in light of the findings reported in chapter 5.

6.2.1 Gender versus number

It was hypothesized that gender agreement violations would be more disruptive than number agreement violations for both L1 and L2 speakers, and that L2 speakers would exhibit reduced sensitivity to gender agreement (not instantiated in their L1) than to number agreement (instantiated in their L1). These hypotheses were not confirmed by the study's findings. In contrast to previous research that suggested that gender-agreement violations may be cognitively more demanding than number-agreement violations (e.g., Antón-Méndez, 1996; Antón-Méndez, Nicol, & Garrett, 2002; Barber & Carreiras, 2003, 2005), the study showed that (1) gender agreement was processed faster than number agreement by both groups of participants and (2) priming effects were equally robust for both categories and for both groups of speakers. These findings are not in line with studies suggesting that first language transfer (e.g., Hawkins & Casillas, 2008; Hopp, 2007, 2010; Sabourin, 2003) or L1-L2 morphological congruency (Jiang et al., 2011) may influence the accessibility or acquirability of these features, and predict more effortful processing of gender agreement (gender-agreement violations, in particular). The findings agree with studies that found no evidence for a differential treatment of number and gender (e.g., Alemán Bañón, 2012; Dowens et al., 2011; Lukatela et al., 1987; Osterhout & Mobley, 1995; Sagarra & Herschensohn, 2011) and may be best accommodated by models that assign a similar status to number and gender features. For example, Picallo (1991) (as cited in Alemán Bañón, 2012) placed both features at the syntactic level proposing that gender (similar to number) projects its own syntactic phrase. The longer processing of number may reflect the longer RTs evoked by plurals as a result of the additional process of decomposition. However, this process did not affect the overall magnitude of number priming in the study, which was equally robust for both categories.

Importantly, the seeming similarity of gender and number agreement processing as shown in RTs and the magnitude of priming is evidence of the effective operation of the underlying processing mechanisms rather than similarity of the mechanisms (see section 6.2.4 below).

6.2.2 Marked versus unmarked features

The hypothesis that L1 participants and L2 participants would exhibit similar asymmetries between the two genders and the two numbers due to the Markedness Effect (Akhutina et al, 1999) was largely confirmed. According to the first prediction of this hypothesis, nouns in larger/frequent/morphologically unmarked default classes (masculines and singulars) would be processed faster and would produce larger priming than nouns in smaller/less frequent/morphologically marked classes (feminines and plurals). This prediction was confirmed for gender and partially for number (only for singular nouns that were all masculines). Both groups recognized masculine singular nouns as the default gender (and number) faster than they recognized feminine and plural nouns (as a non-default and morphologically marked gender and number).

The longer recognition time for plural nouns can be interpreted as the morphological decomposition effect, i.e., early obligatory segmentation of morphologically complex nouns into morpheme-sized units during online processing (e.g., Taft, 2004; Kazanina et al., 2008). While small differences between nouns in the grammatical and ungrammatical conditions observed in native speakers indicated some processing costs for the additional process, processing costs for plurals were more pronounced in L2 speakers, overriding the advantage of the grammatical condition. The two effects—markedness and decomposition—could have converged reducing or canceling the RT differences between nouns in the grammatical and the ungrammatical conditions and resulting in no priming effects.

The Markedness Effect further predicts that since nouns in default classes are more likely to occur, their non-occurrence would lead to inhibition, whereas nouns in smaller/less frequent/morphologically marked classes are less likely to occur, so their occurrence leads to facilitation (with or without inhibition). As discussed in chapter 2, the masculine singular is the unmarked gender and number in Russian (from the standpoint of its zero ending in the nominative and its larger class size than feminines or neuters), and, therefore, speakers expect the default masculine gender or singular number by default when processing language (Akhutina et al., 1999). According to this logic, concordant masculine/singular adjectives or verbs do not facilitate the upcoming noun more than the baseline "*prosto*" condition, as they provide no gender- or number-relevant information beyond what is expected. However, when a masculine/singular noun follows an incongruent gender- or number- marked adjective or verb, the masculine/singular gender/number bias is demonstrated by inhibitory effects. By contrast, the feminine nouns (as a non-default marked forms) are facilitated, because the time, required in order to recognize a feminine noun, can be reduced by gender-congruent information. This prediction was confirmed, but only for gender and only for native participants.

Masculine nouns in the current study showed stronger priming effects than feminine nouns reflected in both facilitation and inhibition, whereas feminines exhibited only significant facilitation. Plural nouns, on the other hand, demonstrated minimal priming in the native participants and no priming in the L2 participants, as a result of converging effects of markedness and decomposition, reflected in insignificant facilitatory and inhibitory components in native speakers and no priming in nonnative speakers.

These findings are in line with recent studies that also provided evidence that morphological markedness modulates processing in both native and L2 speakers: for example, native speakers of Hebrew showed greater sensitivity (reflected by a larger P600) to subject-verb agreement violations for marked plural verbs compared to unmarked singulars (Deutsch & Bentin, 2001), and adult English-speaking learners of

Spanish showed more sensitivity to agreement violations that involved an unmarked masculine singular noun and a marked adjective than to violations which involved a marked noun and an unmarked adjective (McCarthy, 2008).

6.2.3 The role of syntactic distance

It was predicted that both L1 and L2 participants would demonstrate similar sensitivity to the syntactic distance in both gender and number agreement processing, and that this would be evident in slower RTs for both gender and number agreement and smaller size of priming for NV dependencies (across syntactic boundaries) than for NA dependencies (within syntactic boundaries). This hypothesis was partially confirmed in that both groups recorded similar sensitivities and similar patterns of processing agreement. However, contrary to the predictions that syntactic distance would reduce sensitivity to the establishment of agreement, no differences between within-phrase (NA) and across-phrase (NV) agreement were recorded for number agreement for both groups of participants, whereas gender agreement within syntactic boundaries (NA) was processed longer and produced smaller priming in comparison to across-phrase (NV) agreement.

These results were consistent with asymmetrical patterns of processing syntactic dependencies observed in the current study's participants when RTs were collapsed over gender and number: NA dependencies engaged prelexical processing routines, whereas NV dependencies engaged postlexical mechanisms in native speakers; NA dependencies were processed longer and invoked reverse priming in the L2 participants. These findings suggest that other factors, besides syntactic distance, contribute to the complex interaction between the nature of grammatical categories and syntactic dependencies during online processing.

6.2.4 Attentional mechanisms underlying gender and number agreement

It was predicted that in native participants gender agreement would evoke prelexical automatic and expectancy-based processing routines, whereas number agreement (plurals, in particular) would evoke postlexical controlled routines. L2 participants, by contrast, were expected to rely mostly on postlexical controlled mechanisms in processing both categories. These hypotheses were partially confirmed, but with some modifications. Native speakers engaged both automatic and expectancy-based processes for gender agreement, but number agreement seemed to have evoked both automatic and postlexical routines. L2 participants, in contrast, processed both gender and number postlexically.

The robust facilitation at the long SOA, not accompanied by inhibition, observed in native speakers for gender agreement was inconsistent with postlexical processing. However, the absence of inhibition was inconsistent with the engagement of postlexical strategies, either, and merits further analysis. A logical explanation of this finding could be related to the study design: since the prime remained available during the length of the SOA, the participants could have reactivated the information contained in the prime, reengaging the ASA when the first wave of activation had subsided.

Interestingly, the same explanation can help interpret the finding of significant facilitation in the absence of inhibition at the long SOA observed in the native participants' processing of number agreement. When the prime was continuously present, participants could reactivate its information during the long SOA, which was reflected in a strong facilitation component. However, since number is a syntactic feature that has to be computed, the rule application may seem inconsistent with the engagement of ASA. Yet, in light of existing evidence for early obligatory and *automatic* activation of decomposition (Kazanina et al., 2008; Taft, 2004) this explanation seems plausible. The finding of both facilitation and inhibition at the short SOA, however, indicates that the 250 ms time frame may have been insufficient for automatic plural rule activation (prelexically), requiring the processor to activate postlexical strategy of checking for grammatical congruency, whereas 1000 ms may have been enough for reactivating an appropriate rule automatically. Therefore, contrary to the study's prediction, number evoked automatic activation in response to low GP at SOA1000. It must be noted, however, that this interpretation must be considered with caution in the absence of supportive empirical evidence. Obtaining such evidence appears to be warranted.

L2 speakers, who demonstrated uniform postlexical processing of gender and number agreement did not record any unusual effects that need to be analyzed further. Interestingly, when RTs were collapsed over dependencies and examined separately for gender and number, the reverse priming effect observed in L2 speakers in response to high GP in the analysis of NA and NV dependencies was only observed in number agreement. We currently do not have an explanation of this finding, which underscores the need for a future study to carefully delineate the contribution of individual variables to this peculiar effect.

6.2.5 Interim conclusion

The study showed that, while both groups of speakers demonstrated equally robust priming for gender and number agreement and similar patterns of processing syntactic dependencies, they relied on different attentional mechanisms, and only native speakers demonstrated the ability to evoke different routines. Although the current study's findings are preliminary, they suggest that different mechanisms may be required for processing different grammatical categories.

The study also demonstrated that while both groups of speakers recorded asymmetries between the two genders and the two numbers, they exhibited differences in how the Markedness Effect (Akhutina et al., 1999) is realized: the L2 speakers showed differential processing of feminines and masculines and singulars and plurals in the magnitude of priming, whereas the native speakers showed differential contribution of facilitatory and inhibitory components in response to the two genders and numbers.

These findings underscore the role of multiple factors in native and nonnative processing of gender and number agreement and suggest that the distinction between aspects of language that may require automatic processing routines and those that require controlled processing routines needs to be clearly delineated and operationalized, and the complex interactions between the processing mechanisms, grammatical categories, and syntactic dependencies need to be investigated further.

6.3 Limitations

The dissertation explored the processing of gender and number agreement in native and nonnative speakers of Russian in local syntactic dependencies, while at the same time investigating the contribution of underlying attentional mechanisms and the dynamics of accessing morphosyntactic information in memory. Interpretation of the present research should be made with several caveats in mind.

First, in order to avoid problems associated with fatigue and subject attrition, the study did not attempt to include a wider range of SOAs that would have required a much larger experiment. Hence, the present research is limited by its ability to adequately examine the time course of priming from emergence to decay.

Second, the results also indicated that, although the adverb “prosto” used as a neutral prime offered the greatest degree of neutrality in morphosyntactic priming for native participants, it did not provide a reliable measure of facilitation and inhibition in L2 participants, possibly due to it being a different syntactic structure, or due to the smaller proportion of the words that appeared in the neutral condition in comparison with the overall number of words in the other conditions. So, while overall morphosyntactic priming patterns in L2 were consistent with postlexical processing mechanisms, the failure of the neutral prime to dissociate the contribution of facilitation and inhibition to the priming effects in L2 did not allow a reliable evaluation of its locus, leaving the results for the L2 participants somewhat speculative.

Third, although the study was designed in such a way as to actively encourage automatic spreading activation and expectancy-based routines, it did not actively discourage the use of the postlexical coherence-checking mechanism, which may have been triggered by the high nonword ratio, especially in stimuli lists with low GP. This nonword ratio is a measure of informativeness of the prime-target relationship that is plausibly related to postlexical coherence-checking mechanisms (MacNamara, 2005; Neely, 1991). More specifically, in order for prime–target coherence to occur, the target must be a word and, therefore, the correct lexical decision will always be "*yes*" (word). In the case of incoherence, however, the target can be either an unrelated or incongruent word, or a nonword. If the stimulus list has a high nonword ratio (above .5), the absence of a relationship between the target and the prime becomes informative, signaling a "*no*" (nonword) response. Such a situation provides incentive for participants to develop "*yes*" (coherence) and *no* (incoherence) lexical decision biases. These predictions will hold true for 'grammatical' words (*yes*) and nonword targets (*no*), thereby reducing response times for these targets. In ungrammatical conditions, however, study participants will take extra time to overcome a false nonword prediction. This will lengthen responses to ungrammatical word targets, and a priming effect will be recorded. The nonword ratio (NR) is calculated according to the following formula (Neely, 1991):

$$NR = \frac{\textbf{Nonword targets}}{\textbf{Nonword targets + Word targets in the ungrammatical condition}}$$

Thus, NR is naturally correlated with GP. With increase in GP, the number of ungrammatical prime-target pairs necessarily decreases, increasing the NR. The only way to uncouple the GP and the NR is to change the ratio of word target to nonword target trials.

In the current study, however, the numbers of words and nonword targets in the experimental stimuli lists were kept fixed, as they typically are in standard experimental procedures, with 50 % words and 50 % nonword targets. This led to an NR higher than .5 and created a strategic response bias to respond *yes* (word) when the target was congruent with the prime and *no* (nonword) when the target was not congruent with the prime, requiring participants to overcome the nonword bias.to dissociate automatic from prelexical processes in L1 and L2 speakers, the fixed nonword ratio may have encouraged the participants to engage postlexical mechanisms in lieu of automatic or expectancy-based mechanisms.

And finally, the present research did not attempt to investigate differences between mostly formal L2 learners and those who had had extensive immersion experience and 'real-life' practice through study-abroad or work-abroad opportunities. The relationship between language learning experience and mechanisms underlying lexical access warrants evaluation.

6.4 Directions for Future Research

Bearing in mind the limitations mentioned above, an obvious direction for future research is to provide further empirical validation for the present findings. First, since the present within-subjects investigations were limited by the employment of only two SOAs of 250 and 1000 ms, further research that examines the time course of morphosyntactic priming from emergence to degradation in both L1 and L2 needs to employ a wider range of SOAs. This is particularly important for a comprehensive examination of the time course of activation in L2. If activation of morphosyntactic information in L2, indeed, rises more slowly than in native speakers, it will produce facilitation (without inhibition) at SOA that is longer than 250 but shorter than 400 ms, when strategic mechanisms are activated (Chertkow et al., 1994). Hence, an inclusion of a range of medium SOAs (e.g., 350, 500, and 750) in a future study would help determine whether robust ASA in L2 speakers emerges at a different time course from that of native speakers, or not at all.

Second, since the adverb "*prosto*" did not provide reliable measaures of facilitation and inhibition in nonnative participants, other options should be explored and piloted on this population before a major investigation is undertaken.

Third, to discourage postlexical processing mechanisms, future research should employ a low ratio of nonwords in the stimulus lists, as well as a single-choice or go/no-go button-activated response format. The go/no-go response is believed to discourage the engagement of postlexical processes in a lexical decision task (Pererea, Rosa, & Gómez, 2002).

Fifth, the finding of reverse priming in L2, identified in response to high GP and only for plural nouns, needs be investigated. While it may help explain why some studies did not demonstrate L2 speakers' morphosyntactic sensitivity to grammatical violations, the hypothesis provided in the current study remains speculative until replicated under similar experimental conditions.

Finally, investigating a relationship between language learning experience (formal versus informal) and mechanisms underlying lexical access also deserves research interest. In particular, it would be useful to know whether immersion-type 'real-life' language learning in a target-language country may enrich the repertoire of attentional mechanisms in L2 speakers by developing their ability to engage automatic mechanisms in response to aspects of language that evoke automatic processing in native speakers.

CHAPTER SEVEN: CONCLUSION AND IMPLICATIONS

This dissertation represents a comprehensive evaluation of events at the lexical access level of language processing in native and advanced nonnantive speakers of Russian and demonstrates similarities and differences in L1 and L2 online processing of number and gender agreement within and across phrasal boundaries in Russian. No study to date has explored differences in L1 and L2 online processing of agreement from the point of view of markedness, role of grammatical category, and syntactic distance, while at the same time investigating the contribution of underlying attentional mechanisms and the dynamics of accessing morphosyntactic information in memory. By dissociating processes that have previously been confounded, the present research represents a novel approach to language processing in L2 that has important theoretical and practical implications.

The results show that multiple underlying mechanisms (both automatic and controlled), rather than a single mechanism, contribute to morphosyntactic priming effects in native speakers of Russian, who in the current study were able to employ these processes differentially depending on the type of feature/category, the syntactic structure, and the processing task they encountered. In contrast, expert nonnative speakers, who were able to perform at the native-like level in offline tasks, exhibited native-like accuracy in the lexical decision task, and demonstrated native-like priming patterns overall, exhibited subtle differences in processing morphosyntactic information when their priming patterns were analyzed more closely. However, these subtle differences cannot be classified as deficits, but rather they reflect delayed activation of morphosyntactic information and reliance on postlexical strategic mechanisms during processing. Although automatized through study, practice, and professional work, these strategic mechanisms are likely to reflect differences in cognitive aptitude, level of automatization, and attentional biases (e.g., reflected in differential attentional allocation towards incongruent stimuli relative to congruent stimuli).

Thus, L2 differences that appear to be related to different components of grammar and are usually regarded as deficits, may reflect differences in the dynamics of lexical activation. Because lexical access processes are crucially involved in all aspects of language processing, a delay in the spread of activation from one representation to another may have a cascading effect on language processing (Blumstein & Milberg, 1999; Milberg et al., 1999), including processing of grammar. Future studies, therefore, need to be informed by consideration of the dynamics of the neural system underlying language processing.

It is conceivable that L1/L2 differences in the dynamics of lexical access may have repercussions for language testing: testing those aspects of language which may require automatic or expectancy-based processing routines at an earlier time than morphosyntactic information has been activated in L2, may yield different results for this group of speakers, biasing interpretations of these results towards representational or processing deficits. With current advances in technology, behavioral findings can and should be related to ERP investigations of regional brain activity in real-time language processing in order to capture the exact time course of the processing events.

The results also suggest that lexical access may not only be dependent on the cognitive demands of online tasks, which impose time constraints on morphosyntactic information activation, but, importantly, on the nature of grammatical categories and syntactic contexts that may require the engagement of different processing routines.

The present research has adopted a psycholinguistic approach to the investigation of L2 morphosyntactic processing. As a consequence of this novel approach, insight has been gained into the behavioral bases of L2 performance. Understanding patterns of native and nonnative processing of gender and number agreement in a language with rich morphology, as well as understanding the role of syntactic distance in agreement realization has important implications for theories of both native language processing and language processing in L2. It is the hope of the author that distinguishing among the mechanisms involved in lexical access will provide a useful heuristic that will serve as a point of departure for better understanding the processing of morphosyntactic information in L2, thereby contributing to the current debates about the nature of L1/L2 differences in grammar processing and providing the impetus for further research in this area.

APPENDICES

Appendix A

Background questionnaire

Thank you for taking the time to fill out the Background Questionnaire! By answering the following questions you will provide the researcher with general information about yourself and your language learning experience. Your personal information will be kept confidential (please refer to the Consent Form for details regarding confidentiality).
* Required

Personal ID code *To keep your confidentiality, please create (and remember!) your personal ID code that you will use throughout the experiment in lieu of your name. The code should contain two letters (e.g., your initials) and four digits (e.g., your birthday).

Age? *

Gender? *

- Female
- Male

What is your first/native language? *

What other language(s) do you know? *

How many semesters of formal Russian study at the university level have you taken? *

- one-two
- three-four
- five-six
- seven-eight
- more than eight

What kind of Russian practice did/do you have? *Please check all that applies.

- I studied in Russia.
- I lived in Russia.
- I attended an intensive Russian summer program.
- I have Russian-speaking friends/relatives.
- I only studied Russian in the classroom.
- Other:

If you had/have intensive Russian practice, please explain when, where, and for how long.

How good is your eyesight? *

○ I have normal vision

◉ I have corrected to normal vision

○ I have vision problems

What is your dominant hand? *

○ Right

○ Left

◉ I use both hands

Do you own/ have access to a PC/notebook with Windows? *DMDX is a Windows-based display system used in psychological laboratories around the world to measure reaction times to linguistic stimuli. The DMDX program will not run on a Mac!

◉ I own/ have access to a PC/notebook with Windows and will be able to install the DMDX software (less than 4 KB)

○ I own/have access to a PC/notebook with Windows but cannot/do not wish to install the DMDX software

○ I do not own/have no access to a PC with Windows

Will you have an opportunity to print and scan documents during your work on the experiment? *You will need to print instructions for easy reference and scan and email a signed remuneration form back to the researcher.

○ Yes

○ No

Please provide your name and address *This information is required to send you a check for $40 after you complete the experiment. It will be kept confidential and will not be used in data analysis.

Please provide your address. *This information is required for sending you a check for $40 after you complete the experiment. Only the researcher will have access to your contact information.

Appendix B

Language proficiency test

Please read the following text in which every 7th word is deleted. Fill out as many blanks as you can using each word in its correct grammatical form. Please do the test quickly (do not spend more than 7-10 minutes). This is not part of the experiment—the results will heLGP me determine your current level of proficiency.

Осенью 1841 года четырнадцатилетний Лев Толстой приехал в Казань, чтобы поступить в Казанский университет. Толстой мечтал стать дипломатом и поэтому _______________(1) факультет восточных языков. Чтобы подготовиться к _______________(2) в университет, Толстой стал серьёзно заниматься; _______________(3) стал изучать восточные языки: арабский, татарский ______________(4) турецкий. Он занимался самостоятельно и с __________________ (5), а через три года он поступил ______________(6) Казанский университет и стал студентом турецко-арабского _____________(7) восточного факультета.

У Толстого были прекрасные ______________(8) к изучению иностранных языков, но первый ______________(9) он учился плохо: его не устраивало, ______________(10) в университете преподают языки. В это _______________(11) он понял, что работа дипломата его ______________(12) не интересует. Он начал ходить на _____________(13) молодого профессора-юриста Мейера, и эти лекции ____________(14) очень понравились. Он решил стать юристом, _____________(15) в 1845 году перешел на юридический ______________(16).

Профессор Мейер заметил нового студента и ___________(17) ему самостоятельную работу, которая его очень _____________(18). В это время Толстой написал для ____________(19) правила специально для этой работы. Вот ____________(20) из них: "1)

Что должен сделать, делай, ________________ (21) ни на что. 2) Что делаешь, делай ___________(22). 3) Никогда не смотри в книгу, если _______________(23) забыл, а старайся сам вспомнить. 4) Не _______________(24) говорить людям, которые тебе мешают, что __________(25) мешают".

Позже, в 1904 году, он _____________ (26): "...Когда я был в Казанском университете, _________ (27) первый год ничего не делал. На ____________(28) год я стал заниматься. Мной заинтересовался __________(29) Мейер, который дал мне работу. Я __________(30), меня эта работа увлекла, я стал _____________(31) читать. Это чтение открыло мне бесконечные ______________(32)."

На юридическом факультете Лев Толстой проучился ______________(33) два года. Вскоре он понял, что _____________(34) хочет быть юристом. В апреле 1847 ______________(35) он ушел из университета, не окончив ____________(36) курс юридического факультета. Он даже не ____________(37) сдавать весенние экзамены. Так закончился студенческий ___________(38) в жизни Толстого. Но Толстой надеялся через _____________(39) время сдать экзамены за весь университетский __________(40). Он составил для себя программу на два года, из которой видно, что Толстой серьезно решил самостоятельно продолжать свое образование.

Translation of "Language proficiency test"

In the fall of 1841 fourteen-year-old Leo Tolstoy came to Kazan to apply to the University of Kazan. Tolstoy dreamed of becoming a diplomat and, therefore, _______________ (1) the School of Oriental Languages. To prepare for the _______________ (2) at the university, Tolstoy began to study hard; _______________ (3) began to study oriental languages: Arabic, Tatar ______________ (4) Turkish. He worked independently and with __________________ (5), and three years later he was accepted ______________ (6) the Kazan University and became a student of the Turkish-Arab _____________ (7) of the School of Oriental Studies.

Tolstoy had excellent ______________ (8) for the study of foreign languages, but during the first ______________ (9) he studied poorly: he didn't like ___________ (10) languages were taught at the university. At this _______________ (11), he realized that the work of a diplomat interests him no______________ (12). He began to attend _____________ (13) read by a young professor of law Meyer and ____________ (14) these lectures very much. He decided to become a lawyer _____________ (15) in 1845 went to Law ______________ (16).

Professor Meyer noticed the new student and ___________ (17) him work, which _____________ (18) him. At this time Tolstoy wrote for ____________ (19) rules specifically for this work. Here are ____________ (20) of them: "1) What you must do, do ________________ (21) no matter what. 2) What you do, do ___________ (22). 3) Never look up _______________ (23) forgot and try to remember yourself. 4) Do not _______________ (24) to tell people that they interfere with your __________ (25). "
Later, in 1904, he _____________ (26): "... When I was at the University of Kazan, I did nothing_________ (27) the first year. During the ____________ (28) year I started to study. __________ (29) Meyer became interested in me and gave me work to do. I __________ (30), and was fascinated by this work, and began to read_____________ (31). Reading opened endless ______________ (32). "
At the Department Leo Tolstoy studied ______________ (33) for two years. He soon realized that he _____________ (34) want to be a lawyer. In April of the ______________of 1847 (35), he left the university without completing the ____________ (36) of the Department of Law. He did not even ____________ (37) the spring exam. Thus ended the university ___________ (38) in the life of Tolstoy. But Tolstoy was hoping that in _____________ (39) time he would take exams for the entire university __________ (40). He developed a two-year program of studies, which shows that Tolstoy had decided to seriously pursue education on his own.

Appendix C

Target stimuli used in the experimental conditions in the grammaticality judgment task

NV-FF	g	Анна Ивановна чувствовала себя отлично.	Anna Ivanovna was feeling very well.
NV-FF	g	Вчера в Вашингтоне снова была гроза.	There was another storm in Washington yesterday.
NV-FF	g	Бабушка устала и хочет хорошо отдохнуть.	My grandmother was tired and wanted to relax.
NV-FM	u	Мы были счастливы, что война кончился.	We were happy that the war was over.
NV-FM	u	Его сестра недавно поступил в институт.	His sister recently went to college.
NV-FM	u	Учительница говорил громким голосом.	The teacher spoke in a loud voice.
NV-MM	g	Владимир умел так интересно рассказывать!	Vladimir was such a skilled narrator!
NV-MM	g	Кирилл пошел вперед быстро и уверенно.	Cyril went ahead quickly and confidently.
NV-MM	g	Аня сказала, что их сын сильно заболел.	Ann said that their son was seriously ill.
NV-MF	u	Летом квартет много путешествовала.	In the summer the quartet traveled a lot.
NV-MF	u	Максим Горький долго жила в Италии	Maxim Gorky lived in Italy for a long time.
NV-MF	u	Мы не знали, что выступала Медведев.	We did not know that Medvedev spoke.
NV-PP	g	Друзья решили встретиться через месяц.	Friends decided to meet in a month.

NV-PP	g	Интересно, что об этом думают спортсмены.	I wonder what athletes think about it.
NV-PP	g	Посмотри, как хорошо танцует Кристина!	Look how well Christina can dance!
NV-PS	u	В выходные ребята любит ходить в зоопарк.	On weekends, the guys like to go to the zoo.
NV-PS	u	Вика и Люба познакомилась очень давно.	Vick and Luba met a very long time ago.
NV-PS	u	Почему концерты начинается так поздно?	Why do concerts start so late?
NV-SS	g	Я не понимаю, почему дверь не закрывается.	I do not understand why the door can't lock.
NV-SS	g	Анжелика очень хорошо фотографирует.	Angelica takes very good pictures.
NV-SS	g	Директор, наверное, будет очень занят.	The director will probably be very busy.
NV-SP	u	Александр еще не знает, где он будут жить.	Alexander does not know yet where he will live.
NV-SP	u	Владислав никогда никуда не опаздывают.	Vladislav is never in on time.
NV-SP	u	Человек громко и весело засмеялись.	The man laughed loudly and cheerfully.
NA-SS	g	По-моему, это довольно сложный текст.	In my opinion, this test is fairly complex.
NA-SS	g	Скажи, в вашем городе есть детский театр?	Tell me, is there a children's theater in your town?
NA-SS	g	Ты знаешь, что сегодня дождь и сильный ветер?	Do you know that it will rain and there will be strong winds?
NA-SP	u	Рождество--любимые праздник в нашей семье.	Christmas is a favorite holiday in our family.
NA-SP	u	У его подруги есть русские самовар.	His girlfriend has a Russian samovar.

NA-SP	u	Среди наших друзей есть опытные адвокат.	Some of our friends are experienced lawyers.
NA-PP	g	Мужские голоса уже совсем рядом.	Male voices are already very close.
NA-PP	g	Хорошо, когда рядом хорошие друзья!	It is nice when good friends are nearby!
NA-PP	g	На шее у Марии были красивые бусы.	Mary was wearing beautiful beads on her neck.
NA-PS	u	В библиотеке есть русский журналы.	In the library there are Russian magazines.
NA-PS	u	У этого режиссера всегда интересный фильмы.	This director always makes interesting films.
NA-PS	u	На завтрак у нас сегодня свежий фрукты.	For breakfast we have fresh fruit today.
NA-FF	g	Сегодня особенно скучная программа.	Today's program is particularly boring.
NA-FF	g	Это любимая героиня Льва Толстого.	This is Leo Tolstoy's favorite character.
NA-FF	g	У твоей подруги очень добрая улыбка.	Your friend has a really kind smile.
NA-FM	u	Я знаю, что это очень серьёзный работа.	I know this is a very serious job.
NA-FM	u	Сообщают, что в Египте опасный ситуация.	It is reported the situation in Egypt is dangerous.
NA-FM	u	Я рада, что у тебя дружный семья.	I am glad that you have a united family.
NA-MM	g	У нас в группе есть очень умный студент.	In our group there is a very smart student.
NA-MM	g	Почему на твоем диване грязный чемодан?	Why is there a dirty bag on your couch?
NA-MM	g	Скажите, у вас есть индийский чай?	Do you have Indian tea?
NA-MF	u	Популярная певец давно не дает интервью.	The popular singer does not give interviews.
NA-MF	u	Мы думаем что деревянная дом	We think that a wooden house is better.

		лучше.	
NA-MF	u	Попробуй--это необыкновенно вкусная сыр.	Try it - the cheese is incredibly delicious.

Abbreviations:

g—grammatical
u—ungrammatical
NA—Noun Adjective agreement
NV—Noun Verb agreement
F—feminine gender
M-—masculine gender
S—singular
P—plural

Complete list of sentences used in the grammaticality judgment task

List 1[20]

Please evaluate the following 108 sentences rating them as Grammatical or Ungrammatical. If a sentence is not grammatical, underline/highlight the error. Please respond quickly and do not check or correct your responses. The task should take you no more than 15-20 minutes.

1. Анжелика очень хорошо фотографирует.	Ungrammatical	Grammatical
2. Летом Анастасия хочет поехать в Турцию.	Ungrammatical	Grammatical
3. Посмотри, как хорошо танцует Кристина!	Ungrammatical	Grammatical
4. Давайте перенесем наш визит на завтра.	Ungrammatical	Grammatical
5. Россия предложила США отменить визы.	Ungrammatical	Grammatical
6. В Америке мало знают грузинское вино.	Ungrammatical	Grammatical
7. Среди наших друзей есть опытные адвокат.	Ungrammatical	Grammatical
8. Марина никогда не ест суп со сметана.	Ungrammatical	Grammatical
9. Андрей рассердился и позвал менеджера.	Ungrammatical	Grammatical
10. Девушка улыбнулась и помахала им рука.	Ungrammatical	Grammatical
11. В Москва много памятников истории.	Ungrammatical	Grammatical
12. Его сестра недавно поступил в институт.	Ungrammatical	Grammatical
13. Сегодня особенно скучная программа.	Ungrammatical	Grammatical
14. По радио звучала любимая песня мама.	Ungrammatical	Grammatical

[20] List 2 featured the same sentences presented in a different order with grammatical and ungrammatical conditions reversed.

15. Интересно, о чем ты все время думаете?	Ungrammatical	Grammatical
16. Попробуй--это необыкновенно вкусная сыр.	Ungrammatical	Grammatical
17. Я знаю, что это очень серьёзный работа.	Ungrammatical	Grammatical
18. Не забудьте спросить телефон врач.	Ungrammatical	Grammatical
19. Человек громко и весело засмеялись.	Ungrammatical	Grammatical
20. Максим Горький жила в Италии долгое время.	Ungrammatical	Grammatical
21. У его подруги есть русские самовар.	Ungrammatical	Grammatical
22. Даша давно все рассказала Ирине.	Ungrammatical	Grammatical
23. Бабушка устала и хочет хорошо отдохнуть.	Ungrammatical	Grammatical
24. Оля так и не вспомнила автора картины.	Ungrammatical	Grammatical
25. Интересно, что об этом думают спортсмены.	Ungrammatical	Grammatical
26. Мы надеемся, что вы к нам скоро приедете.	Ungrammatical	Grammatical
27. Петин отец уже час работает в гараж.	Ungrammatical	Grammatical
28. У твоей подруги очень добрая улыбка.	Ungrammatical	Grammatical
29. У нас в группе есть очень умный студент.	Ungrammatical	Grammatical
30. Дедушка покупает внукам много	Ungrammatical	Grammatical

подарки.		
31. Владимир умел так интересно рассказывать!	Ungrammatical	Grammatical
32. Скажи, в вашем городе есть детский театр?	Ungrammatical	Grammatical
33. Александр еще не знает, где он будут жить.	Ungrammatical	Grammatical
34. Студенты не знали, сколько лет фильму.	Ungrammatical	Grammatical
35. Эта передача идет каждый понедельник.	Ungrammatical	Grammatical
36. В библиотеке есть русский журналы.	Ungrammatical	Grammatical
37. Давай поставим сюда холодильника.	Ungrammatical	Grammatical
38. Наверное, это кошка разбила лампа.	Ungrammatical	Grammatical
39. Академик Петров очень помог институт.	Ungrammatical	Grammatical
40. Почему концерт начинается так поздно?	Ungrammatical	Grammatical
41. Популярная певец давно не дает интервью.	Ungrammatical	Grammatical
42. В этом семестре Виктор ничего не успевает.	Ungrammatical	Grammatical
43. Анна Ивановна чувствовала себя отлично.	Ungrammatical	Grammatical
44. Это любимая героиня Льва Толстого.	Ungrammatical	Grammatical
45. К урокам русского нужно много	Ungrammatical	Grammatical

готовился.		
46. Улыбайся чаще--улыбка продлевать жизнь .	Ungrammatical	Grammatical
47. На шее у Марии были красивые бусы.	Ungrammatical	Grammatical
48. Почему ты всегда пишешь карандаш?	Ungrammatical	Grammatical
49. Молодые люди были на выставке.	Ungrammatical	Grammatical
50. В воскресенье вечером я будет свободна.	Ungrammatical	Grammatical
51. О художник почти ничего не известно.	Ungrammatical	Grammatical
52. Мой сын сейчас читает роман Акунина.	Ungrammatical	Grammatical
53. Мальчик с детства гордился брат.	Ungrammatical	Grammatical
54. Говорят, что завтра было опять холодно.	Ungrammatical	Grammatical
55. На праздник пришли все жители город.	Ungrammatical	Grammatical
56. Водитель машина быстро закрыл окно.	Ungrammatical	Grammatical
57. Кирилл пошел вперед быстро и уверенно.	Ungrammatical	Grammatical
58. Мы не знали, что выступала Медведев.	Ungrammatical	Grammatical
59. Чай с лимоном помогает при простуде.	Ungrammatical	Grammatical
60. Ребята очень устали и хотели обедать.	Ungrammatical	Grammatical
61. Владислав никогда никуда не опаздывают.	Ungrammatical	Grammatical
62. После экзамена студенты пошли гуляют.	Ungrammatical	Grammatical
63. Старый ученый передал книги	Ungrammatical	Grammatical

библиотека.		
64. Посмотри, как радуются птицы весне.	Ungrammatical	Grammatical
65. Скажите, у вас есть индийский чай?	Ungrammatical	Grammatical
66. Алёна не сразу заметила студент.	Ungrammatical	Grammatical
67. Вика и Люба познакомилась очень давно.	Ungrammatical	Grammatical
68. Хорошо, когда есть крыша над головой.	Ungrammatical	Grammatical
69. Я должна с вами серьезно поговорим.	Ungrammatical	Grammatical
70. У Ильи Петровича, по-моему, нет жены.	Ungrammatical	Grammatical
71. Хорошо, когда рядом хорошие друзья!	Ungrammatical	Grammatical
72. Я рада, что у тебя дружный семья.	Ungrammatical	Grammatical
73. Мужские голоса уже совсем рядом.	Ungrammatical	Grammatical
74. Аня сказала, что их сын сильно заболел.	Ungrammatical	Grammatical
75. Мы думаем что деревянная дом лучше.	Ungrammatical	Grammatical
76. Лектор интересно рассказывал о Клеопатра.	Ungrammatical	Grammatical
77. Рождество--любимые праздник в нашей семье.	Ungrammatical	Grammatical
78. На день рожденья он подарил сестра цветы.	Ungrammatical	Grammatical
79. Люди спорить о роли Горбачева в истории.	Ungrammatical	Grammatical

80. Я всегда хотел поговорить с космонавтом.	Ungrammatical	Grammatical
81. По-моему, это довольно сложный текст.	Ungrammatical	Grammatical
82. Я не понимаю, почему дверь не закрывается.	Ungrammatical	Grammatical
83. Учительница говорил громким голосом.	Ungrammatical	Grammatical
84. Николай часто вспоминал Елизавета.	Ungrammatical	Grammatical
85. Давай решим, что мы теперь будем сделать.	Ungrammatical	Grammatical
86. У этого режиссера всегда интересный фильмы.	Ungrammatical	Grammatical
87. Летом квартет много путешествовала.	Ungrammatical	Grammatical
88. Портман сыграла в фильме «Черный лебедь».	Ungrammatical	Grammatical
89. Почему на твоем диване грязный чемодан?	Ungrammatical	Grammatical
90. Этот музыкант теперь работает в театре.	Ungrammatical	Grammatical
91. На завтрак у нас сегодня свежий фрукты.	Ungrammatical	Grammatical
92. В выходные ребята любит ходить в зоопарк.	Ungrammatical	Grammatical
93. Наташа давно хочет купить компьютер.	Ungrammatical	Grammatical
94. Сообщают, что в Египте опасный	Ungrammatical	Grammatical

ситуация.		
95. Мы были счастливы, что война кончился.	Ungrammatical	Grammatical
96. Друзья решили встретиться через месяц.	Ungrammatical	Grammatical
97. Люди задавали музыкант много вопросов.	Ungrammatical	Grammatical
98. Иван Петрович часто звонил Борису.	Ungrammatical	Grammatical
99. Вчера журналисты говорили с певицей.	Ungrammatical	Grammatical
100. Мне очень нравится соната Шостаковича.	Ungrammatical	Grammatical
101. Зрители не отпускали балерину со сцены.	Ungrammatical	Grammatical
102. Ты знаешь, что сегодня дождь и сильный ветер?	Ungrammatical	Grammatical
103. Зоя Михайловна мне писала о муже.	Ungrammatical	Grammatical
104. Я плохо говорить и понимать по-испански.	Ungrammatical	Grammatical
105. Директор, наверное, будет очень занят.	Ungrammatical	Grammatical
106. Федор посылает деньги тете в Пнево.	Ungrammatical	Grammatical
107. Летом в нашем городе открыли гостиницу.	Ungrammatical	Grammatical
108. Вчера в Вашингтоне снова была гроза.	Ungrammatical	Grammatical

Appendix D

List of stimuli for Study 2

Target/Prime	Простая	Простой	Был	Была	Просто	xxx	Простые	Были
FEM REAL	ФОРМА	РОТА	СПИНА	КУХНЯ	ГУБА	СТЕНА	x	x
	ЗОНА	ТАЙНА	КАША	ФРАЗА	БОРЬБА	ДЫРА	x	x
	ЯМА	ПРОСЬБА	ЗМЕЯ	ДОСКА	ЛЕНТА	РОЖА	x	x
	ТУФЛЯ	НУЖДА	ВЕНА	ДРАКА	ПОЗА	ДАТА	x	x
	ПЛИТА	РЮМКА	ПОЧТА	ПРЕССА	ШУБА	ВАННА	x	x
FEM NONCE	РЕФА	ЗОРА	ЗЕЯ	ТЕМЬЯ	СЕРТА	ГЛАКА	x	x
	КАПНЯ	ВЬМА	КОЛПА	НАМПА	МЫБА	ЛОДВА	x	x
	ДРУЖТА	БЛЯПА	ДЕЧТА	ТПАЛА	ГОРМА	ВЕТМА	x	x
	МИДА	НОМБА	ТАШНЯ	ГОЗА	НЫЩЦА	СМЕГА	x	x
	ШКУВА	МОЛЯ	КОСНА	ЗМРЕЛА	ФИНА	РОЧВА	x	x
MASC REAL	ЯЗЫК	ОБРАЗ	ВОЗДУХ	ОТВЕТ	КАРМАН	ВЕТЕР	ДУРАК	МАЛЬЧИК
	ЗАПАС	ВАГОН	ПОЯС	ПОЕЗД	СПОСОБ	КОРАБЛЬ	БОЕЦ	БАНДИТ
	ПРИБОР	РУБЕЖ	КИРПИЧ	САРАЙ	ЛИДЕР	УСПЕХ	МИНИСТР	КОЛДУН
	КОНТАКТ	ГРОХОТ	КОРПУС	ЭТАП	СОСТАВ	ГАЛСТУК	СЕРЖАНТ	ЛЕТЧИК
	ТОПОР	ОБЪЕМ	ЧЕРЕП	ЗАВОД	РАЙОН	РАЗМЕР	ЖИТЕЛЬ	АНГЕЛ
MASC NONCE	ОРГАС	КЕАТР	БОЛЛАР	РЕСЯЦ	ЭТАХ	МОМЕРС	МОРОЛЬ	СОСЕП
	ПИДЖАЧ	ЖОЛОД	ТОСТЮМ	ГОВАР	ПОЖАЙ	МОСКВИП	КТУДЕНТ	ВЫВОК
	МУЗЕЛ	ЗОРОГ	ПОТДЕЛ	НАЗАР	ПРИЕК	НОСОЛ	МЫСТРЕЛ	ЭКРАП
	ЛАГЕЧ	РОЮЗ	НЕВЕР	ПОНВЕРТ	МЕШОТ	РУКАТ	КВОРЕЦ	АКТЕМ
	КОНЬЯР	ДУМАН	НОСТОК	ТАЛОГ	СКАНТАМ	ПОКОН	ДЕНИЙ	ФОНАНЬ
PLURAL REAL	x	СУТКИ	ДОЖДИ	x	ЗУБЫ	ПАРНИ	УМЫ	ШАГИ
	x	ВЗРЫВЫ	НОЖИ	x	ТРУСЫ	ЖИРЫ	СТИХИ	ГРИБЫ
	x	МИГИ	КРУГИ	x	СКЛОНЫ	ВНУКИ	СЛУХИ	ВОЛКИ
	x	КОСТРЫ	ЗАЙЦЫ	x	РУБЛИ	ГАДЫ	КРИКИ	ВОРЫ
	x	ХВОСТЫ	ДОЛГИ	x	УЗЛЫ	КУСТЫ	ДУБЫ	СТОЛБЫ
PLUR. NONCE	x	УГМЫ	СУТЫ	x	МОСЫ	МУДИ	ЧЕМЦЫ	КВОРЫ
	x	ЩИДЫ	ЗНАРИ	x	СНУСЫ	ПЛАГИ	ДИПЫ	ФЕДЫ
	x	ЗВЕЙИ	ШТАЛЫ	x	ШЛУПЫ	ШУЦЫ	КНУКИ	БЕРХИ
	x	ШКАРЫ	ГРОДЫ	x	ВОСТЫ	ОРМЫ	БАДРЫ	СЛУЗЫ
	x	КРЕМТИ	ГРЕНИ	x	СРОНЫ	ТЫРЫ	РКАТЫ	ТМОТЫ

Translation of "List of stimuli for Study 2"

Target/ Prime	Prostaya (Fem)/ Simple	Prostoy (Masc Sing) / Simple	Byl (Masc Sing Past)/ Was	Byla (Fem Sing Past)/ Was	Prosto/ Simply	xxx	Prostye (Plural)/ Simple	Byli (Plural Past)/ Were
FEM REAL	FORMA/FORM	ROTA/DIVISION	SPINA/BACK	KOUHNYA /KITCHEN	GOUBA/LIP	STENA/ WALL	x	x
	ZONA/ZONE	TAYNA/SECRET	KASHA/PORRIDGE	FRAZA/ PHRASE	BOR'BA/ST RUGGLE	DYRA/HOLE	x	x
	YAMA/PIT	PROS'BA/ REQUEST	ZMEYA/SNAKE	DOSKA/BOA RD	LENTA/RIB BON	ROZHA/SNO UT	x	x
	TOUFLYA/ SHOE	NOUZHDA/ NEED	VENA/VENE	DRAKA/FIG HT	POZA/POSE	DATA/DATE	x	x
	PLITA/STOVE	RYUMKA/GLAS S	POCHTA/POST	PRESSA/PRE SS	SHOUBA/ FUR COAT	VANNA/ BATH	x	x
FEM NONCE	РЕФА	ЗОРА	ЗЕЯ	ТЕМЬЯ	СЕРТА	ГЛАКА	x	x
	КАПНЯ	ВЬМА	КОЛПА	НАМПА	МЫБА	ЛОДВА	x	x
	ДРУЖТА	БЛЯПА	ДЕЧТА	ТПАЛА	ГОРМА	ВЕТМА	x	x
	МИДА	НОМБА	ТАШНЯ	ГОЗА	НЫЩЦА	СМЕГА	x	x
	ШКУВА	МОЛЯ	КОСНА	ЗМРЕЛА	ФИНА	РОЧВА	x	x
MASC REAL	YAZYK/ TONGUE	OBRAZ/IMAGE	VOZDUH/AIR	OTVET/ ANSWER	KARMAN/P OCKET	VETER/ WIND	DOURAK/ FOOL	MAL'CHIK/ BOY
	ZAPAS/STORE	VAGON/CAR	POYAS/BELT	POYEZD/ TRAIN	SPOSOB/ WAY	KORABL/ BOAT	BOETS/ FIGHTER	BANDIT/ GANGSTER
	PRIBOR/INSTRU MENT	ROUBEZH/BORD ER	KIRPICH/BRICK	SARAY/ SHED	LIDER/LEA DER	OUSOEH/ SUCCESS	MINISTR/MIN OSTER	KOLDUN/ WIZARD
	KONTAKT/CON TACT	GROHOT/ROAR	KORPUS/BLOCK	YETAP/ STAGE	SOSTEV/MA KEUP	GALSTOUK/ TIE	SERZHANT/SE RGEANT	LETCHIK/ PILOT
	TOPOR/AXE	OBYOM/ VOLUME	CHEREP/SKULL	ZAVOD/ PLANT	RAYON/ DISTRICT	RAZMER/ SIZE	ZHITEL'/ INHABITANT	ANGEL/ ANGEL
MASC NONCE	ОРГАС	КЕАТР	БОЛЛАР	РЕСЯЦ	ЭТАХ	МОМЕРС	МОРОЛЬ	СОСЕП
	ПИДЖАЧ	ЖОЛОД	ТОСТЮМ	ГОВАР	ПОЖАЙ	МОСКВИП	КТУДЕНТ	ВЫВОК
	МУЗЕЛ	ЗОРОГ	ПОТДЕЛ	НАЗАР	ПРИЕК	НОСОЛ	МЫСТРЕЛ	ЭКРАП
	ЛАГЕЧ	РОЮЗ	НЕВЕР	ПОНВЕРТ	МЕШОТ	РУКАТ	КВОРЕЦ	АКТЕМ
	КОНЬЯР	ДУМАН	НОСТОК	ТАЛОГ	СКАНТАМ	ПОКОН	ДЕНИЙ	ФОНАНЬ

PLURAL REAL	x	SOUTKI/24HOURS	DOZHDI/RAINS	x	ZOUBY/TEETH	PARNI/GUYS	OUMY/BRAINS	SHAGI/STEPS	
	x	VZRYVY/BLASTS	NOZHI/KNIVES	x	TROUSY/COWARDS	ZHIRY/FATS	STIHI/VERSES	GRIBY/MUSHROOMS	
	x	MIGI/MOMENTS	KROUGI/CIRCLES	x	SKLONY/SLOPES	VNOUKI/GRANDSONS	SLOUHI/RUMOURS	VOLKI/WOLVES	
	x	KOSTRY/FIRES	ZAYCY/HARES	x	ROUBLI/RUBLES	GADY/SNAKES	KRIKI/CRIES	VORY/THIEVES	
	x	HVOSTY/TAILS	DOLGI/DEBTS	x	OUZLY/KNOTS	KOUSTY/BUSHES	DOUBY/OAKS	STOLBY/POSTS	
PLURAL NONCE	x	УГМЫ	СУТЫ	x	МОСЫ	ПУДИ	ЧЕМЦЫ	КВОРЫ	
	x	ЩИДЫ	ЗНАРИ	x	СНУСЫ	ПЛАГИ	ДИПЫ	ФЕДЫ	
	x	ЗВЕЙ	ШТАЛЫ	x	ШЛУПЫ	ШУЦЫ	КНУКИ	БЕРХИ	
	x	ШКАРЫ	ГРОДЫ	x	ВОСТЫ	ОРМЫ	БАДРЫ	СЛУЗЫ	
	x	КРЕМТИ	ГРЕНИ	x	СРОНЫ	ТЫРЫ	РКАТЫ	ТМОТЫ	

Appendix E

Instructions for the SOA250 group

Номер: 250

Уважаемый участник эксперимента!

Мы рады, что Вы согласились принять участие в нашем эксперименте! Вам понадобятся компьютер, интернет и около получаса свободного времени. Перед началом эксперимента убедитесь, что компьютер подключен к интернету, и закройте все не нужные в данный момент программы (включая электронную почту, программы с уведомлениями, типа IM (Instant Messenger), чтобы они не влияли на работу экспериментальной программы. Отключите телефоны и попросите вас не беспокоить в течение получаса, так как эксперимент требует максимальной концентрации внимания.

Вы найдете все экспериментальные файлы в архиве dmdx_native_250.zip на сайте ftp://lexicaldecision:dmdx@ftp.drivehq.com/experiment/native/250 Сохраните этот архив на рабочем столе компьютера. Если Вы не сумеете разархивировать его обычным образом, щелкните на него правой клавишей мышки и из списка предложенных программ (*Open with*) выберите Windows Explorer.

Организуйте на своем компьютере новую папку с любым именем и скопируйте туда ВСЕ файлы из скачанного архива. ВАЖНО: ни в коем случае не удаляйте никакие файлы из экспериментальной папки, не переименовывайте их и не переносите их в другие папки!

Войдите в эту папку и запустите установочную программу setup.exe. Программа DMDX была разработана около 10 лет назад учеными университета Аризоны для определения времени реакции на лингвистические стимулы и используется лингвистами всего мира для проведения подобных экспериментов. Программа совершенно безопасна, многократно проверена и абсолютно необходима для проведения эксперимента. Закончив установку DMDX, запустите задание, которое называется test_native_250.bat и следуйте инструкциям по его выполнению.

ВАЖНО: В начале эксперимента Вам понадобится ввести **номер, написанный перед приветствием (250), свое имя и фамилию на английском языке (латинскими буквами), а также дату рождения (число, месяц, год без точек и пробелов).** Например, если Вас зовут Петр Петров и вы родились 1 января 1995 года, то надо написать: 250Petr Petrov1195.

Когда эксперимент закончится, данные будут автоматически отправлены и программа закроется. На выполнение задания у Вас уйдет около 20 минут.

ВАЖНО: Если по какой-либо причине этого не произошло и программа все еще открыта, нажмите кнопку ESC на клавиатуре, на вопрос *Save data?* выберите опцию *Yes*, и данные будут сохранены в папке в новом файле с расширением .azk. **Пожалуйста, пошлите этот файл по адресу nromanova3@gmail.com** Если вопрос будет *Abort job?* выберите опцию *Yes,* и пошлите новый файл diagnostics.txt из экспериментальной папки по тому же адресу.

Для удобства, распечатайте, пожалуйста, эти инструкции перед началом эксперимента.

СПАСИБО ЗА УЧАСТИЕ!

Translation of "Instructions for the SOA250 group"

Code: 250

Dear Participant!

We are glad that you have agreed to participate in our experiment! You will need a computer, access to the internet, and about half an hour of free time. Before the experiment, please make sure that you have a connection to the internet and please close all the programs (skype, e-mail, IM, etc) that you are not currently using as they may slow down the experimental program. Please turn off your phone and ask people not to bother you during the time of the experiment as it requires maximum concentration.

You will find all the experimental materials in the archived folder dmdx_native_250.zip at ftp://lexicaldecision:dmdx@ftp.drivehq.com/experiment/native/250 Please save it on your desktop. If you can't do it automatically, you may need to open it with Windows Explorer.

Create a new folder and copy all the experimental files there. Please do not delete, rename or move any file.

Install the DMDX program starting setup.exe. The program, developed about 10 years ago by researchers from Arizona University is used throughout the world to conduct psycholinguistic experiments measuring reaction times to linguistic stimuli. It is safe and absolutely necessary for the experiment. After installing DMDX, launch the experiment called test_native_250.bat and follow the instructions.

Important: At the beginning of the experiment you will **need to enter the code found at the top of this letter (250), as well as your name, and date of birth without spaces).** For example, if your name is Petr Petrov, and you were born on January 1, 1995, please enter: 250Petr Petrov1195[21].

It will take you about 20 minutes to complete the experiment. When you finish it, the program will send the results to the researcher's address automatically.

If this did not happen and the program is still open, please press ESC, save the data with .azk extension and **send the new file to nromanova3@gmail.com** If the program asks you whether you would like to *Abort job?* select *Yes,* and your results will be saved in the experimental folder as diagnostics.txt Please sent it to the researcher's address above.

For your convenience, please print out theses instructions.

Thank you for participation!

[21] The request to provide the name was only used for the preliminary study with Russian participants. Each participant will be assigned an individual code in the main study.

Appendix F

Complete list of targets used in the Main Study

СТЕНА	СЕМЬЯ	ШЕЯ	КОЖА
ВОЛЯ	СРЕДА	СМЕНА	БЕДА
ОЛНА	ТРУБА	ЗОНА	НУЖДА
БИТВА	КАПЛЯ	ТЬМА	РОЗА
ТАЙНА	МОРДА	ВАННА	СКАМЬЯ
ЖЕРТВА	ШТУКА	КАНДА	ШТРУЯ
ДУМА	БАНЯ	НУКЛА	КОТНЯ
ТРЯПКА	СКАЛА	ЩЕПНА	НОКА
МАЙКА	БАШНЯ	ШТОНА	НАРЯ
ЛУЖА	МИНА	АРСА	ГИЛЬСА
ИСКРА	ЛЕНТА	РОТА	СПИНА
НИТКА	ЁЛКА	ВСТРЕЧА	ПТИЦА
ИКРА	ТОННА	ДРАКА	ГРАФА
ЛОЙКА	ЩИЛА	ЦИФРА	КРЫСА
ПАЙГА	НОЗЛЯ	БАЗА	ТУФЛЯ
ТРОНЯ	МОША	СОСНА	РОЖА
КОНА	ДАРТА	ШЛЯПА	РАМА
ДОВА	ОСТА	ЮБКА	СПАЛЬНЯ
ЩУХА	СТРАМА	ЗМЕЯ	ПУЛЯ
НАВКА	СКИДА	ВИНА	ДОЗА
ГАЗНА	СКУХА	ШАПА	ТАХМА
РИПКА	ГУДКА	ВОЙРА	ВОГА
ПРАВТА	ЛЫБА	СТОРА	ГРАЖА
РЕКА	СЛЕЗА	НОЧА	ПЧЕНА
МЕЧТА	ЗИМА	КАДА	ЛОША
ВЕДЬМА	ВЕНА	ЯЗРА	БРЫСА
ПРЕССА	ЛАМПА	ГАША	НАЛЬКА
ТРОЙКА	КАША	НИСТВА	ДОРА
СТРАМА	ЧЕНА	КУХНЯ	ЗВЕЗДА
ЧОРА	НОПКА	ПЕСНЯ	ПРОСЬБА
РОКА	НЕРСТА	КУРТКА	ТАЙГА

ТУНРА	ЯХНА	ДЫРА	ТРОПА
ПРИТВА	ДАНКА	ЖАЖДА	БОРЬБА
ЩЕКА	ШКОЛА	ЛАСНА	СМОНА
ГОРА	ТОЛПА	ШАБА	ЖАВА
РЫБА	ФРАЗА	НАЛКА	ГЕПКА
ТРАВМА	ДАТА	СВИРА	ЧОТА
СУМКА	ВИЗА	ВАЙКА	БАРЯ
КРЫСА	ЯМА	ГРУППА	ФОРМА
ЕДА	ДОСКА	КАРТА	КРЫША
ПЛИТА	СВЕЧА	ЛОДКА	ЦЕНА
БОМБА	РЮМКА	РАНА	БАНДА
ВЕСНА	ВЕТКА	ПОЧТА	ДАЧА
КИШКА	СВИНЬЯ	ПРОБКА	СМОЛА
МУКА	ПРОЗА	ПЕТЛЯ	ТУЧА
ШКУРА	ДЛИНА	ДОЛЯ	СТРУЯ
ПОЧРА	КОПА	ЛОЖКА	ЗЛОБА
ФОДА	СЕТЛА	МОДА	ГЛИНА
НИСКА	МЮСТРА	БАКА	СХУНА
КУГА	ЗВАКА	ТИГА	ВЫША
ПОНА	ДВОЙТА	ГИПА	РОПА
ГОЧКА	КРОПА	ГАЛДА	КРОСА
КРУДА	РАЗА	ПОДА	ТЫЛКА
РАВА	БУША	ТАБЛЯ	ТЕВА
ТЕМЛЯ	ОВРА	ЛАСА	КУПНЯ
ЛАША	МОВЛЯ	НОБКА	ЕЗКА
ЧЕРТА	ГУБА	СЦЕНА	ПЬЕСА
БУКВА	ИЗБА	МУХА	ТРАВА
НОРМА	СТАЯ	ШАПКА	ПОЧВА
ШУБА	НОЗДРЯ	ПОЗА	ПАЧКА
КАССА	СТРЕЛА	ТРАССА	СТАТЬЯ
ГРАПА	СЯДА	ТАЙКА	ТЫШКА

ВУКА	ЕМКА	ПУЧА	СТРУМА
МЫКА	СТУПЛЯ	БЕЗНА	МОПЛЯ
НАМА	ХОДРА	ПАЗА	ПУРКА
ШВАТКА	ТЯКА	СУЛА	СПАГА
МЫШЦА	ИГРА	ПАЛЬНА	САХТА
ГЛАВА	ТЕЩА	ШТАЯ	МИТКА
ЛУНА	СУММА	ГРОДА	КРУША
СХЕМА	ДРУЖБА	ЛЯГА	ТЯНЯ
РОСА	ПИЩА	СТОБА	НИЗА
НИДА	ДОЗНЯ	УДАР	СОЛДАТ
ЗУКА	ФАЛА	ЭТАЖ	ПРИКАЗ
ЗАРА	НИЛЛА	ПРИЕМ	АКТЕР
ЛЯТВА	ПУХТА	ДИВАН	КОСТЮМ
ЧАТА	КУСА	КОСТЕР	УЖИН
СЛЮМА	РАТА	СЕРЖАНТ	АНГЕЛ
МИВА	ЛЕТКА	ОБЪЕКТ	КРЮЧОК
СВОЛА	ГАЧКА	ГЕНИЙ	ХОХОТ
КРАМА	КОБА	БАЗАР	ГАРАЖ
РОЛЯ	ФАЙКА	БАШМАК	МАРШРУТ
ГЕРОЙ	ЗАКОН	ЦОРНИК	ПАТРУНЬ
ЗАВОД	УРОК	АКЦЕМ	БОГАК
КАТЕР	ПАСТУХ	ГЕЗЕРВ	УДАН
ТЕРМИН	ИСПУГ	БОЦМАР	ТЕАНС
ЛЕТЧИК	КОСМОС	ОТКОР	УКОН
ЗНАТОН	БОЛЮС	САТИП	ВОРОД
НАГАЖ	ПОГРЕД	ТРИТИК	КОНТРАМ
ПЛОВАРЬ	ЧУДАМ	РИЗЫВ	ТИРАГ
ВЕЙЦАР	ВИНЯК	ВОЗРАСТ	ДУРАК
МЕТОР	ГОЛУК	МИНИСТР	СТУДЕНТ
ПАРЕНЬ	МЕСЯЦ	ВОИН	СЕВЕР
СОЮЗ	КУСОК	РУКАВ	СЕНТЯБРЬ
КУЛАК	СТАКАН	ОБМАН	ЭТАП
МАЙОР	МОРОЗ	КОРМОЗ	ПЛЕНИХ
ОБЕД	ЖИТЕЛЬ	ОСМОТ	ПОДЛЕН
РЫНОК	ЭКРАН	САЛАН	ДЕРЕЦ

ВОКЗАЛ	ПОЯС	КЕЛЕТ	НАЧОК
БАНДИТ	ПРИБОР	ДАШЛЫК	ДУВШИН
ПЛАКАТ	КРОЛИК	РАССКАЗ	ВОЗДУХ
МАТРОС	ОЧАГ	КОРАБЛЬ	СПОСОБ
КВАРТАЛ	МУСОР	ЖИВОТ	АРТИСТ
ПОЛДЕНЬ	БУФЕТ	ПОКОЙ	ПОРОГ
КОНВЕРТ	ШПИОН	ВЫВОД	ШОФЕР
ЛАХВАТ	УПРЕС	РЕЖИМ	УХОД
ПОЛЯТ	ЗАПРОЙ	ТАЛАНТ	БАРАК
ГВАДРАТ	ВЕРТЕМ	КОЛХОЗ	ТАБАК
ГУТНИК	ТАКАЛ	КУПОЛ	КРИЗИС
БАЦАН	ПЛАКАН	ВСАДНИК	ЗАКАТ
ПУЧОН	МЕРТЕЖ	КУПЕН	ЛАТОН
КИРОГ	ХАОП	ПОРОФ	АРБУН
МУРОРТ	КАРЛИН	ТРАЧОК	ОБРЫК
ИГРОН	КИТЕНЬ	ТАНДАРТ	ТОВОД
СЕРБЛЮД	ГАБАН	МУДРЕК	КОДЕС
МУЖИК	ВОЛОС	ЗАНКИР	МЕЦЕПТ
ЗАПАС	БИЛЕТ	НОСОХ	ДРЕНЕР
АДРЕС	РАЗУМ	НАЙПЕР	ГАКЕЛ
КОЛДУН	КУЗОВ	СОЮЗ	СОВЕТ
КОНЦЕРТ	КАБЛУК	РАЗМЕР	ОРГАН
КИГАНТ	КОНТУП	АЛЬБОМ	ТОВАР
ПЛЕСАРЬ	ВАРКЕТ	МАЛЫШ	ФРАНЦУЗ
БРЕЗЕН	КРЕДИМ	СТРЕЛОК	ЗАВТРАК
ВОЖАР	ОРЕШ	ЛИМАТ	БАПРЕТ
ВЕНЕК	ДАЗДЕЛ	СОШМАР	ГАМИН
МОМЕНТ	ЯЗЫК	БАРУС	ЮРИС
ПОЕЗД	ДВОРЕЦ	ТАРАСЬ	КУРГОН
БОЕЦ	ТЕАТР	ТЕРДАК	РАПОР
МАСТЕР	ОТДЕЛ	РОМАН	ОБРАЗ
ЗАБОР	НОСОК	РАЙОН	ОСТРОВ
СОСТАВ	ПРЕДЕЛ	ВОРОТ	ЗВОНОК
КОНТРОЛЬ	СНАРЯД	ПРОЦЕНТ	ЧЕРЕП
ЗРИТЕЛЬ	ПИДЖАК	ХОЛОД	КОНТАКТ

САРАЙ	ФОНАРЬ	МЕДВЕДЬ	КОРПУС
РЕМОНТ	ТРАКТОР	СИГНАЛ	ПОДВИГ
КОМАР	РЕСУРС	ЛИДЕР	РУЧЕЙ
ВОСТОК	ФАШИСТ	КИРПИЧ	ЮМОР
САХАР	ГРАДУС	САЛОН	ФОКУС
УТЮМ	ФИНАК	ТОГОТЬ	ПАРОН
КВОРЕЦ	ОКРУР	ЛУБЕН	ОЖОН
ПАРАК	ЛУМИР	МОГОН	ЗИМВОЛ
ДВОЙНИР	СТАНОМ	ВАПОР	ЛИНДАЖ
СИЗИК	ДЕМОТ	СУГРОН	МЕБЕД
СТОРОХ	РОТЕСТ	ЗУМРАК	РОЯНЬ
НАКЕЙ	КРАНАТ	ЭКСПЕР	МАНЕВ
ОБЫС	ЛОТИВ	УЩЕР	МОЛОР
НИРАТ	РЫВОС	ЯЩИК	МАЛЬЧИК
ОВОТ	КРЕБЕТ	ЛАГЕРЬ	ПОВОД
ОТВЕТ	НОМЕР	ПРЕДМЕТ	ОТРЯД
МУЗЕЙ	ДОЛЛАР	УСПЕХ	ВЫСТРЕЛ
ПОЖАР	РУБЕЖ	ПОРТРЕТ	МОСКВИЧ
ОРКЕСТР	ПРОСПЕКТ	ОРДЕН	НОЯБРЬ
КОТЕЛ	МОРЯК	АВГУСТ	ОВРАГ
ТОМАР	УРОЛ	ГРОХОТ	ЗАКАЗ
ПОКРОГ	НИОСК	ГАЛСТУК	БУЛЬВАР
УСТАК	КЕЗИС	БОКАЛ	АРЕСТ
ГУЛТАН	БРАСЛЕН	КОФИЛЬ	ХИЛИН
МЕРТВЕК	КРЕБЕНЬ	ДАЗАН	ЛАРЬЕР
КАРМАН	СОСЕД	АСПЕК	ПАЛУН
ГОЛОД	КОРОЛЬ	СУХАН	ХОБОР
ПОДВАЛ	ТОПОР	БЕГЛЕК	РЫЧАН
КАЗАК	КОНЬЯК	МРАМОН	САЛИВ
ТРАМВАЙ	ПЕТУХ	НИНЖАЛ	РАКТИК
РИЗРАК	НАЯК	УЗОМ	ГОБОР
ПОЗОН	СИПЛОМ	ДОКТОР	САПОГ
АРАС	СВИТЕН	ПОЛЕТ	ХУТОР
РАДИС	УКАП	ПРИМЕР	ВАГОН
ГУСТЫРЬ	ТЕВЕЦ	НАЛОГ	КОЗЕЛ

ВЕТЕР	ЗАПАХ	ПОРТФЕЛЬ	КОРЕНЬ
ХАЛАТ	ТУМАН	ХАШИЗМ	СОНТАН
ОБЪЕМ	ПРИНЦИП	ФОРОХ	ФАДНИК
СЕКРЕТ	ПУСТЯК	МАЛАЧ	КИРУРГ
ВИЗИТ	РЮКЗАК	ТУПИН	ГИЛЕЦ
БОПОЛЬ	ЗЕМЛЯР	СЕКАН	БУНДИР
КРУЗИН	ТРАКОН	ЛЕРМЕР	МУСКУН
ПРИЧАК	ПАУН	КЕВРОЗ	КВОРЕЦ
ГУДОН	МЕКТОР	ПОЧЕР	ЭФИМ
СУНДУР	АЗАР	МОРЕЦ	БУГОС
СЮРПРИК	КОСТЫНЬ	ТАРЯД	ПОЛВАН
ГОКОЛ	ВИСОТ	УМЫ	РУБЛИ
ЩЕНОР	ЛОДЕЙ	ПЛАНЫ	ЗВУКИ
КОСТУП	БУКЕС	КРУГИ	ФАКТЫ
КРУСТ	ТИТУШ	СРОКИ	СЛУХИ
ГОСТИ	ЗУБЫ	ВОЛКИ	ГРИБЫ
КЛЮЧИ	СТВОЛЫ	ЛУЧИ	КРЕСТЫ
ВНУКИ	ВОРЫ	ВЗРЫВЫ	МИФЫ
ЖАНРЫ	БЕСЫ	ШАРЫ	КАДРЫ
БЛИНЫ	ТИГРЫ	ГАДЫ	СПОРЫ
ШАНГИ	СИЛЬТРЫ	РИТМЫ	ПРУДЫ
СМЫСЫ	РЕМЛИ	ШПУСКИ	КРАММЫ
ШНУРНИ	ПАРФЫ	КРЮЛИ	ЩЕЛЧИ
РАГИ	ВОСЫ	ПСИКИ	ЖАРТЫ
МИВИ	КЛАТЫ	БИЖИ	БРЮЛИ
ВОЖДИ	ДВОРЫ	ПОМЫ	ПРОСЫ
ПЛАТКИ	ПЛАЩИ	ШНУТЫ	ФОССЫ
ШАНСЫ	СЫРЫ	СТИМИ	БАЛПЫ
ТАНЦЫ	ШТАТЫ	КНУДЫ	ЧОДЫ
КЛАССЫ	ТЕМПЫ	СЛЕДЫ	ЧЛЕНЫ
СЛОКИ	ХРИБЫ	ТИПЫ	ХОДЫ
ТЕНДЫ	ТАРПЫ	ДЕДЫ	СКЛОНЫ
МАПЫ	ЗУРКИ	НОЖИ	ВКУСЫ
КИТРЫ	СТОБЫ	ПОСЛЫ	ЖЕСТЫ
ВУБЫ	ТИКЛЫ	ЛОКТИ	ЦИКЛЫ

ТРУДЫ	НОСЫ	ВЕРХИ	ШТРАФЫ
МОЗГИ	ГОРШКИ	ФЛАГИ	ХОЛМЫ
САДЫ	ДОЖДИ	ОРЛЫ	ГРУЗЫ
ЗНАКИ	КЛЕЩИ	ГРЕХИ	ВОПЛИ
ХВОСТЫ	КРИКИ	ЗАКТЫ	БОРДЫ
КОНИ	ЗВЕРИ	ОТЗЫ	ЛАНКИ
ДОЛГИ	БЫКИ	НАСЫ	НОРТЫ
БИНТЫ	МОСТЫ	РУНТЫ	РОЗДЫ
ГРОШИ	ЗАДЫ	СИНКИ	МАКТЫ
РАБЫ	ГВОЗДИ	КЛЮТЫ	ПЛЕГИ
ДУБЫ	ЖУКИ	ЗАКТЫ	НИТЫ
ГРЕКИ	КРАНЫ	БОЛЛЫ	КЕРСТНИ
ВИХРИ	МАТЧИ	ОГНИ	ВРАГИ
ГУБЦЫ	ЛЮНИ	СПИСКИ	ШКАФЫ
КЕСТИ	ЭЛЬМЫ	ФОНДЫ	ТАНКИ
ЛАХИ	ГАЛЬЦЫ	ЖИРЫ	БАКИ
ПЛАСЫ	ТЮГИ	МЯЧИ	ТОСТЫ
КЛАМЫ	ЖИНСЫ	ШВЕПЫ	КИВТИ
ХАЗЫ	ТРЕССЫ	ГНОДЫ	ЗВОМЫ
ТЭРЫ	ДАЗЫ	МОНЦЫ	ВУТКИ
РИВНИ	ЛЫНЫ	ТЕРВИ	СТИСИ
МУНГЛИ	ФЛОБЫ	ТЕНЬГИ	СВИЛЫ
ГОХЛЫ	ВОГИ	УГЛЫ	СТРАХИ
ШАГИ	МУЖИ	РЕЛЬСЫ	КОСТРЫ
СУДЫ	РОДЫ	УСЫ	РЕМНИ
НЕГРЫ	ЦВЕТЫ	ТЫЛЫ	ГРОБЫ
ЛИСТЫ	КУСТЫ	СТОПЫ	ШТЫКИ
ШТАБЫ	ПУНКТЫ	ШУЛЫ	СКВЕТЫ
СТИХИ	ГАЗЫ	МАРДЫ	ВУНТЫ
СТОНЫ	ТРУПЫ	ГУНТЫ	ПЕХЛЫ
ЗАЙЦЫ	ПИРЫ	НУЛЬСЫ	ТОКСЫ
ДАРЫ	ВЗОРЫ	ГАРЫ	ДОРЩИ
ЩИТЫ	СОКИ	НЕМЦЫ	ЗАЛЫ
ЧИНЫ	СЛОНЫ	МЕЧИ	КОТЫ
ДИСКИ	НРАВЫ	ХРАМЫ	СТОЛБЫ

БАЛЫ	ПРЫЖКИ	СВОДЫ	ЧЕХИ
ТРОВЫ	МУЛИ	СКОТЫ	ЧУЛКИ
ДЖИБЫ	ЗАЧКИ	ГРАТЫ	ГОТКИ
СТРАЩИ	ВИРЫ	РИМНЫ	ГАНИ
ТРЮНИ	КЛЫГИ	ШТЫГИ	ГРОВЫ
ГАТКИ	ТРЮЛЫ	ТРАНЫ	ЖГУМЫ
ШАНЫ	ШПРИТЫ	ЕЧИ	ЗАГИ
ЛИДИ	НОРЖИ	ВОРДЫ	ТРЕМЫ
КАЙЛЫ	СКРИБЫ	ВЕТЫ	ДЫЗЫ
ДИДЫ	КЕРБЫ	КИБЫ	ДУЛЬТЫ
ЮНТЫ	ТАРЦЫ	ГРАПЫ	КЛОФЫ
ВРАЧИ	КАМНИ	ЖЛАНГИ	ЧАЗЫ
ПЕСКИ	ЦАРИ	КЕНКИ	ПАЛЫ
АКТЫ	ПЛОТЫ	ТАКИ	КРИППЫ
ПЛОДЫ	УЗЛЫ	ГОМЖИ	ШРАДЫ
ФРУКТЫ	ГУСИ	ШЛЕНЫ	НУБКИ
ЧУЛЫ	ФЕКИ	РОЛСТЫ	ДИНТЫ
ТУРМЫ	ГУЧКИ	ТАМПЫ	ТУКИ
НЕСТЫ	МЕДРЫ	ПРИСЫ	МЕФЫ

Appendix G

Debriefing questionnaire

Thank you for completing the experiment! Please complete the following questionnaire that will help the researcher analyze the results.
* Required

Please provide your personal code. You don't have to provide your code if you choose to respond anonymously.

How much time in total did you spend on the experimental tasks? *Please do not include the time you spent on the background questionnaire and the screening task.

Did you have any technical difficulties? *If you did, please explain how you solved them.

Did you remain focused working on the experimental tasks? *If you were not focused, please explain why.

Did you experience any other difficulties/problems performing the experimental tasks? *If you did, please explain.

Please evaluate how many REAL words you did NOT know. *(How often did you hit NO thinking a letter string was not a real word and received WRONG as feedback?)

- [ ] I didn't know very few words (less than or about 10%)
- [ ] I didn't know quite a few words (about 20%)
- [x] I didn't know many words (about 30%).
- [ ] I didn't know half of the words (about 50%)
- [ ] Most of the words were unfamiliar (more than 60%)

What do you think was the goal of the experiment? *

What recommendations can you give to the researcher? *

Do you think the amount of remuneration is adequate for the time and effort? *

Would you like to participate in future studies? *

- [ ] Yes, I would. Please inform me of future studies conducted by you or your colleagues.
- [ ] I am not sure. You may inform me of your future studies but I do not wish my email address to be given to other researchers.
- [ ] No, thank you. I am not interested any more.

If you would like to receive research announcements in the future, please provide a reliable email address.

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