ACQUIRING FOREIGN LANGUAGE LEXICAL STRESS BY HEARING

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SUMMARY

Lexical stress refers to the contrast of stressed and unstressed syllables in a word and is implicated in lexical access and speech segmentation (Cutler & Norris, 1988). However, there are no studies that have experimentally tested how foreign language (FL) lexical stress is codified and used for speech segmentation during the first stages of FL acquisition through hearing.

In relation to FL word recognition and lexical stress, research conducted on bilinguals has revealed contradictory results: Some studies (e.g., Dupoux, Sebastián-Gallés, Navarrete, & Peperkamp, 2008) have found lexical stress interference between the first language (L1) and FL, while others (e.g., Guion, Harada, & Clark, 2004) have not. One possible reason for such discrepancies is the difficulty of controlling previous exposure that each bilingual has experienced with their FL.

One way of controlling such previous experience is by employing participants who have never learnt that FL. In this thesis, participants were English speakers from Singapore with no previous learning experience of any Romance language.

The first question was whether FL lexical stress was codified. Participants studied Spanish cognates (e.g., MANgo, capital letters indicate lexical stress) and noncognates (e.g., viaJAR) presented auditorally;

afterwards, during a recognition task, the studied words were presented with the same lexical stress (e.g., viaJAR) or different lexical stress (i.e., *VIAjar). Lexical stress codification was expected if participants recognised studied words pronounced with same lexical stress and did not recognise studied words pronounced with different lexical stress. Results showed that lexical stress is codified and used for word recognition. Moreover, the probability of recognition was higher for cognates than for noncognates, suggesting access to L1 lexicon and deeper encoding. Furthermore, an analysis of reaction times showed that cognates with identical lexical stress in both languages (e.g., MANgo) activated L1 lexical representations faster than cognates with different lexical stress patterns (e.g., loCAL [in Spanish] and LOcal [in English]), indicating that lexical stress is a critical feature of lexical representation in the lexicon.

The second question was whether foreign lexical stress patterns could be learnt implicitly, under different levels of attention. Participants studied words that followed a lexical stress rule (words ending with vowels had trochaic stress [e.g., CASco], and words ending with consonants had iambic stress [e.g., viaJAR]); afterwards, they performed a lexical decision task, in which new words followed the lexical stress rule and nonwords violated it. The results showed that the participants could not explain the rule, but their correct lexical decisions were above chance levels, indicating that implicit learning of lexical stress patterns occurred, regardless of the level of attention paid to the spoken words.

The third question was whether listening to Spanish words would facilitate segmentation of words presented in sentences made of never-

previously-heard words. It was found that participants could not do so. It was suggested that segmentation requires greater previous exposure to the words to be segmented. The results are discussed regarding their implications in spoken word recognition modelling, FL acquisition theory, and FL education.

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CHAPTER 1

GENERAL INTRODUCTION

The belief that listening to a foreign language (FL)[1] facilitates its learning might not be far from the truth. For example, there are many cases of immigrants or travellers who in a short period of time achieve a good FL comprehension ability from emersion in the FL environment without formal instruction.

FL learners are frequently advised to listen to FL radio stations, conversations, music, and to hear and watch movies in order to improve their FL skills. Besides, many bookshops sell FL lessons in CDs to learn while driving or performing other tasks, giving the impression that a language can be learnt just by hearing or listening to it, with little effort. This idea is reflected in Ridgway's (2000) statement: "the more listening the better, and the subskills[2] will take care of themselves as they become automatised" (p.

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[1] This thesis uses the term FL, instead of second language (L2), because the language employed for the experiments (Spanish) is not the L2 of the participants. However, in other contexts, FL and L2 refer to the same language.

[2] For example, phoneme discrimination and word identification in continuous speech.

183). For Ridgway, graded listening tasks rather than formal instruction are the means to FL learning.

Field (1998, 2000) also acknowledges the importance of exposure to spoken FL for learners to become familiar with FL rhythms, phonological and lexical probabilities, as well as other cues that facilitate auditory perception and comprehension. In contrast to Ridgway (2000), Field (2000) and Rost (1990) argue that exposure to spoken language is not sufficient to develop language skills, but a language instructor is necessary for guiding listening and comprehension.

For Rost (1990), the subskills involved in listening are grouped in terms of perception[3] (recognising prominence within utterances), interpretation (formulating propositional sense, formulating a conceptual framework that links utterances together, interpreting the intention of the speaker), and enactment (utilising a representation of the discourse to make appropriate responses). However, these subskills could be employed in different manner by speakers of different languages. For example, although lexical stress is a feature present in many languages (e.g., Spanish and English), its function and interpretation in word recognition may vary. In Spanish, lexical stress is critical for word recognition because it helps to interpret the meanings of otherwise identical words (e.g., BEbe [he drinks] vs. beBE [baby]; lexical stress in capital letters). However, in other languages (e.g., English) this contrastive stress function is not so common. Therefore, it

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[3] The subskills involved in speech perception are: perception of phonemes, allophones, phoneme sequences, reduction of unstressed vowels, elisions, phonemic change at word boundaries, allophonic variation at word boundaries, lexical stress and pitch changes, as well as adaptation to speaker variation (Rost, 1990).

is likely that the functions of lexical stress in a first language (L1) affect the process of FL acquisition.

Although speech perception and spoken word recognition is performed effortlessly in the L1, learning a FL is widely considered to be not an easy task, especially when the FL language is learnt in the L1 context. This difficulty is experienced too by native speakers when listening to speakers employing other varieties of the same language (e.g., British English speakers listening to Singapore English for the first time). These problems in perception might be due to the fact that the segmental and suprasegmental cues employed in L1 parsing might not be useful in the FL. For example, in English, using lexical stress to spot possible word onsets in fluent speech could be a good strategy, since most of the words have the first syllable stressed (Cutler & Norris, 1988), but not in Spanish, in which most polysyllabic words are stressed on the penultimate syllable (Alcoba & Murillo, 1998). Nevertheless, the subskills necessary to perceive FL words seem to be adjusted automatically by repeated experience and exposure to that language.

To sum up, many variables must be rapidly computed during spoken word perception and recognition (e.g., perception of phonemes and allophones, lexical stress, etc.), and perception abilities seem to benefit from auditory exposure (Rost, 1990).

However, in relation to learning a FL lexical stress by hearing, aspects such as what improves (e.g., FL lexical stress codification of cognate or noncognate words), to what extent (e.g., whether there is interference between L1 and FL), how much attention to what is heard is needed, and the mechanisms implicated in learning by hearing have been scarcely studied experimentally.

Models of Word Recognition

The study of the processes underlying foreign word learning and recognition is important because the word is the basis for successful verbal communication (McQueen, 2007). Moreover, in order to be able to understand and speak, FL students have to dramatically increase their FL vocabulary. Therefore how we recognise foreign words, learn new ones, and segment foreign speech into words is a vital area in the study of FL word recognition and FL acquisition.

Research investigating spoken word recognition aims to identify the variables that affect or contribute to lexical access, regardless of whether the word is presented in isolation or inserted in continuous speech. Up to now, the structure or sequence of phonemes that form a word has been considered to be the most important feature driving recognition in the most cited models of word recognition. For example, in the Cohort model (Marslen-Wilson, 1987), a word is recognised when the sequence of phonemes predicts a word uniquely (e.g., the word *marital* will be successfully recognised after perceiving *marita*, since there are no other possible words starting with that onset). In connectionist models such as TRACE (McClelland & Elman, 1986), BIMOLA (based on TRACE but applied to bilingualism by Léwy and Grosjean, as cited in Schulpen, Dijkstra, Schriefers, & Hasper, 2003), and Shortlist (Norris, 1994), words are represented at three levels: the level of features, phonemes, and the word (BIMOLA also includes level of language). For TRACE and BIMOLA, perception captures acoustic features (e.g., voicing, consonant and vocalic features), which adjust according to experience in order to activate correct phoneme perception; phonemes activate words which also influence phoneme perception. According to this model, the recognised word is the byproduct of excitatory processes across levels, inhibitory processes within levels, and decay. In contrast, in the Shortlist model perception is totally bottom-up and any top-down influence is due to postlexical processes. Moreover, while in TRACE and BIMOLA speech segmentation is the result of word recognition, for Shortlist this is performed following a possible word constraint, by which the system segments the speech only into possible words (e.g., the spoken sequence *theblackdog*, could not be segmented in *th eblack do g*, because *th* and *g* are not possible words). For the NAM model (Luce & Pisoni, 1998), word recognition is the result of combined computations of word frequency[4], neighbourhood density[5], and neighbourhood frequency[6]. The optimal condition for a word to be recognised fast and accurately is for it to be a high-frequency word and to have few and low-frequency neighbours; the model assumes both bottom-up and top-down processes.

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[4] Word frequency is the number of times a word occurs in a language.

[5] Neighbourhood density refers to the number of words phonologically similar to a particular word.

[6] Neighbourhood frequency is average frequency of a word’s neighbours.

Spoken word recognition modelling has advanced by incorporating segmental features other than the phonemes that affect recognition and segmentation (e.g., the Shortlist B model [Norris & McQueen, 2008]; PARSYN [Luce, Goldinger, Auer, & Vitevitch, 2000]; Word Recognition and Phonetic Structure Acquisition [WRAPSA], and Syllable Acquisition, Representation, and Access Hypothesis [SARAH], as cited in Jusczyk & Luce, 2002). For example, syllables rather than phonemes have been considered the basic units for lexical access, mainly in languages in which syllabic structure and boundaries are well defined as in Spanish, but not in English (Cutler, Demuth, & McQueen, 2002; Cutler, Mehler, Norris, & Seguí, 1986; Johnson, Jusczyk, Cutler, & Norris, 2003; Mehler, Dommergues, Fraunfelder, & Seguí, 1981; Norris, McQueen, Cutler, & Butterfield, 1997; Sebastián-Gallés, Dupoux, Seguí, & Mehler, 1992; Tabossi, Collina, Mazzetti, & Zoppello, 2000). Probabilistic phonotactics[7] have also been identified as a critical aspect for word recognition and segmentation; phonotactic probabilities are computed to decide whether a string of continuous phonemes and syllables are part of the same word (Toro, Sinnet, & Soto-Faraco, 2005; Saffran, Newport, Aslin, Tunick, & Barrueco, 1997; Saffran & Thiessen, 2003). Also, the specific location of phonemes and allophones (Johnson et al., 2003; McQueen, 2007), and the spoken durations of particular segments of speech (Vinke, Dilley, Banzina, & Henry, 2009), are cues employed in word recognition and speech segmentation. These cues may have different values for different languages.

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[7] Probabilistic phonotactics refers to frequency of occurrence of particular segments in syllables and words.

This section has shown that lexical stress has not been considered as a critical feature in models of word recognition. However, the next section will highlight its importance.

The Role of Lexical Stress and Implicit Learning

Although the rhythm of a word (i.e., the pattern of stressed and unstressed syllables, or lexical stress) has also been considered critical in word recognition and speech segmentation (e.g., McClelland & Elman, 1986), it has not been fully incorporated in all word recognition models yet. It is crucial that FL word recognition models incorporate lexical stress as an additional, important speech feature.

This thesis aims to investigate the importance of lexical stress in the process of FL word recognition. Previous reseach has investigated lexical stress codification in bilingual adults (as will be discussed in the next chapter). However, results are inconclusive as some studies show lexical stress interference in perception and codification from L1 (e.g., Dupoux, Sebastián-Gallés, Navarrete, & Peperkamp, 2008), while others have not (e.g, Guion, Harada, & Clark, 2004).

The reasons for such discrepancies are not clear. It is likely that discrepancies among the studies regarding FL lexical stress codification are due to the lack of control of the previous exposure of the bilingual to their FL.

This thesis controls previous exposure to the FL by studying how lexical stress is codified and used in speech segmentation during the first stages of FL acquisition, by adult participants who have had no previous learning experience with the FL. Also, current exposure to the FL may be critical; thus, it could be that FL lexical stress patterns are not codified immediately because they are unfamiliar to the listener (e.g., English multisyllabic words tend to be stressed on the first syllable, but Spanish words tend to be stressed on the middle syllable), but require large exposure to the FL for the perceptual system to tune to the new FL lexical stress patterns, so the new FL lexical stress patterns get codified. Considering such possibilities, the amount of exposure to the FL (less than ten minutes) is controlled throughout all the experiments of this thesis, and conclusions are drawn in relation to such brief exposure. It is also possible that FL lexical stress is codified only after the learner is aware of the differences between L1 and FL lexical stress, and the importance of lexical stress for FL word recognition. In experiments 3 and 4 of this thesis, awareness of FL lexical stress patterns is measured by requesting the participants to explain the lexical stress rules that the FL words they hear are subjected to. Another possibility is that perception of FL lexical stress is tied to a critical period (e.g., infancy) after which the perceptual capacity for lexical stress is fixed. In that case, the participants of this thesis will not be able to codify FL lexical stress. Hence, meticulous control of possible confounds have been considered throughout the experiments of this thesis.

The objective of this thesis is to explore the role of lexical stress in the recognition, acquisition, and segmentation of FL words (Spanish) presented auditorally[8] to English speakers. This type of research is new because it delves into the role that lexical stress has in acquiring FL vocabulary through hearing, when the learner has no previous experience with the FL.

This thesis will also focus on how these lexical stress patterns are implicitly and explicitly learnt. To the best of my knowledge, no published research has experimentally studied lexical stress in FL word acquisition. The empirical data obtained from the experiments on lexical stress and FL codification can be utilised in models of word recognition.

Moreover, the present experiments can provide important empirical data for FL acquisition theory. Many theories of FL acquisition predict some sort of L1 interference effects when learning FL, but such theories are not specific regarding which segmental, suprasegmental, grammatical and other features are affected, when this interference occurs (e.g., during the first stages of FL acquisition or at any time), the locus of interference (perception, encoding, or retrieval), and how this will occur for particular pairs of languages. For example, The Unified Competition Model (MacWhinney, 2005) predicts that transfer among languages will occur at different levels (phonological, lexical, morphosyntactic, etc.), in particular, the weaker FL will rely on L1. Other theories that postulate transfer and dependence on L1 procedures are the Autonomous Induction Theory (Carroll, 2007), and the Input Processing in Adult L2 Acquisition (Van Patten & Williams, 2007a).

With regard to learning, different theories give different emphasis to the role that implicit and explicit learning have in the acquisition of a new

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[8] Certainly, many other factors affect FL learning such as phonological short-term memory, for example. For a review of cognitive and external variables affecting FL learning see Bowden, Sanz, and Stafford (2005).

language. For example, the Skill Acquisition Theory (DeKeyser, 2007) postulates that language rules have to be taught explicitly through concrete examples. Rules must be given a priori so learners can generalise and apply them to the new input. Exposure per se leads to exemplar-based learning, poor generalisation and poor learning. Emphasis on the importance of attention and awareness for learning is also present in the Input, Interaction, and Output perspective (Gass & Mackey, 2007), McLaughlin's Information Processing Model, and Anderson's Adaptive Control of Thought-Rational (ACT-R) model (as cited in Mitchell, 2004). In contrast, the Monitor Theory created by Krashen (as cited in VanPatten & Williams, 2007b) postulates that FL acquisition emerges without awareness and only through meaningful and comprehensible input (i.e., when solving a problem). Other models such as the the Construction-based, Rational, Exemplar-driven, Emergent, and Dialectic Model (CREED; Ellis, 2007) consider learning to be the result of both implicit and explicit learning processes. Thus, exposure to spoken languages results in the perceptual system tuning in to the salient features of the language and its regularities, consequently the listener implicitly creates expectations based on cues. Predictive validity is very important in order to extract regularities to facilitate word recognition. Explicit learning is also important, especially when the cues in a new language are not salient enough to be captured by simple exposure and the learner keeps using inappropriate L1 cues.

In relation to implicit and explicit learning, single language studies (e.g., Radwan, 2005; Takahashi, 2005), meta-analyses (e.g., Norris & Ortega, 2006) and broad analyses on how languages are learnt (e.g., Lightbown & Spada, 2001) support the view that explicit learning is more effective than implicit learning. However, the studies comparing implicit and explicit learning benefits refer to the learning of grammatical and syntactic rules, which may be acquired more easily when the rules are overtly explained. Even though a lexical stress rule can be explained and understood (e.g., disyllabic words ending with consonant are stressed on the second syllable), the use of it is not assured. For example, in on-line language comprehension words must be segmented and accessed for meaning very quickly. Consciously applying the rule would be practically impossible; therefore, some form of automatic processing may be necessary. In addition, the rhythm of a language is not usually taught explicitly, but exposure is necessary to acquire it. If listening to FL speech, even when the student cannot understand all the words, facilitates lexical stress learning, and if this can be done without focused attention, then we can advise learners to listen as much as possible to FL, even if not paying full attention to it. In fact, there is some evidence that listening to L2 music aids L2 learning by providing the learner with the rhythm and diction of the new language (Téllez & Waxman, 2006).

The results of this thesis may also have pedagogical value. For example, Field (2005) investigated the importance of FL lexical stress pronunciation on intelligibility of English words by native English speakers and nonnative speakers. He found that intelligibility was deeply compromised when lexical stress was pronounced incorrectly. He concluded that teaching lexical stress is very important. The results of the experiments carried out in this thesis will examine the extent to which it is necessary to focus on lexical stress when teaching FL, so that participants perceive and learn the appropriate lexical stress of the foreign words.

Overview of the Main Research Questions and Organisation of the Thesis

The present thesis is centered on the lexical stress codification of foreign words and the implicit learning of foreign lexical stress rules.

Lexical stress codification of foreign words will be discussed in the next two chapters. Chapter 2 focuses on the description of lexical stress in English and Spanish, followed by a more detailed discussion of the role that lexical stress has in these and other languages regarding word recognition, for both monolingual and bilingual populations. Chapter 3 reports two experiments carried out to study lexical stress codification of Spanish words by English speakers. The main research question in this section is whether FL lexical stress is encoded. As will be shown in the next chapter, studies with bilinguals are not conclusive regarding whether learners encode suprasegmental features through L1 filters. This may be due to the difficulty in controlling FL proficiency as well as for quantity and quality of exposure of bilingual participants to the FL. However in this thesis, by ensuring that participants share no previous FL knowledge, it will be more readily ascertained if codification of lexical stress and interference from L1 lexical stress patterns occurs during the first stages of FL learning.

Implicit learning of foreign lexical stress rules is discussed in Chapters 4 and 5. Chapter 4 explains what implicit learning is, and the relationship between attention, awareness, and implicit learning. Chapter 5 describes how implicit learning of lexical stress rules can be measured, and presents two experiments investigating whether Spanish lexical stress rules can be learnt implicitly and how this learning affects lexical decisions of never-previously-heard Spanish words. The main research question in this section addresses the issue of whether FL lexical stress rules can be learnt by mere exposure to spoken language and how this learning can affect lexical decisions. Whilst it is believed that exposure to the rhythm of the FL is helpful for language acquisition, no study to my knowledge has experimentally tested this assumption.

Chapter 6 investigates whether the exposure to spoken FL words facilitates speech segmentation. The main research question is whether the knowledge acquired implicitly regarding FL lexical rules can be applied to an on-line task such as speech segmentation.

Finally, the last chapter presents a summary and a detailed discussion of the main findings, the implications of the findings, limitations, future research directions, and the conclusion. This thesis is a small step towards understanding language perception and encoding processes. Futhermore, it will allow us to gauge the importance of lexical stress in FL learning.

CHAPTER 2

LEXICAL STRESS

Lexical stress refers to the contrast of stressed and unstressed syllables within single words. Stressed syllables are better articulated, processed for a longer duration, and receive more attention. Furthermore, mispronunciations are spotted faster, and receive longer eye fixations and refixations during silent reading than unstressed syllables (Akker & Cutler, 2003; Ashby & Clifton, 2005; Kiriakos & O'Shaughnessy, 1989). In addition, stressed syllables are pronounced with higher pitch[9], are longer[10] and louder[11], and contain full vowels in English (Low & Brown, 2003). Moreover, words pronounced with correct lexical stress are recognised faster and more accurately than words pronounced with incorrect lexical stress (Baum, 2002). This indicates that lexical stress is implicated in the process of word recognition.

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[9] Pitch is frequency of vibration of the vocal cords, it is measured in hertz (Hz); its main aim is to emphasise a syllable (or word).

[10] Length is the physical duration of a sound measured in milliseconds (ms); length is the second most important component after pitch to emphasise a syllable.

[11] Loudness is intensity at physical level and it is measured with decibels (dB), it refers to energy in production and also contributes to syllable prominence.

Lexical Stress in Standard English

Arciuli and Cupples (2006) analysed 7,349 disyllabic English words from the CELEX database (Baayen, Piepenbrock, & van Rijn, 1993). They found that 61.4% followed a trochaic pattern (lexical stress on the first syllable, as in ZEbra), 33.22% had an iambic pattern (lexical stress on the second syllable, as in exPLODE), and both syllables were stressed in 5.38% of all the words. The analyses also revealed that some endings (or rhymes), such as -age, -er, -ip, -ock, and -us, occur more frequently in nouns and in words with trochaic stress patterns. Endings such as -act, -ed, -ibe, -oin, and -use were found more frequently in verbs and in words with iambic stress patterns. Moreover, iambic stress was typical for endings containing double letters with silent *e*, as in imPASSE and biZARRE. So, it can be said that in general, disyllabic nouns tend to have the trochaic stress pattern but disyllabic verbs tend to have the iambic stress pattern. The lexical stress for adjectives was not related to a particular pattern. However, Archibald (1993) noticed that adjectives ending with consonant clusters followed iambic stress patterns (e.g., abSURD) compared to adjectives ending with a single consonant (e.g., SOlid).

Even though lexical stress can denote contrastive stress, used to differentiate otherwise identical words (e.g., PERmit [noun] vs. perMIT [verb]), those pairs are not very common in English. In fact, it serves to differentiate approximately only 300 noun-verb pairs (Field, 2005). Therefore, lexical stress mispronunciations may not disrupt communication drastically.

Lexical Stress in Singapore English

Along the stress-timed and syllable-timed language continuum, standard British English is clearly stress-timed, that is, the duration between stressed syllables is regular. However, Singapore English is relatively syllable-timed (i.e., syllables have similar durations, or there is little variability in successive vowel duration [Low, Grabe, & Nolan, 2000]). Poor contrast between long and short vowels, pronunciation of middle neutral vowels, and abrupt transition between consecutive words may affect prosody in Singapore English (Deterding, 2001). Moreover, Low and Grabe (1999) found pitch differences for the last syllable in phrase-final position, giving the erroneous impression that Singapore English stresses the last syllable—and not the penultime syllable—of polysyllabic words. In addition, Low and Brown (2003) reported that both varieties of English stress words ending with -ic differently (e.g., acaDEmic vs. aCAdemic, in standard British English and Singapore English, respectively), -ism (e.g., COMmunism vs. comMUnism). Also, there is the tendency in Singapore English to stress a syllable later (e.g., CAlendar, INculcate vs. caLENdar, inCULcate).

Finally, Chang and Lim (2000) noticed that standard British English speakers stressed the first syllable of compound nouns (e.g., ARMchair), but the last syllable for noun phrases (e.g., old CHAIR). In contrast, Singapore English speakers tend to stress the last syllable (i.e., the word *chair*) for compound nouns and noun phrases.

Lexical Stress in Spanish

Spanish contains only five full vowels and no vowel reduction occurs in unstressed syllables. The structure of a syllable is very simple and can only be V, CV, VC, CCV, CVC, or CVVC[12], that is, a syllable cannot end with two or more consonants. Moreover, there are no words with ambisyllabic letters (in comparison with English wherein the *l* in *palace*, for example, can pertain to either of the two syllables).

In general, disyllabic Spanish nouns and adjectives ending with a vowel are trochaic (e.g., CAsa [house]) and words that end with consonants are iambic (e.g., paPEL [paper]). According to Guion et al. (2004), 85% to 95% of the words follow that pattern.

For native Spanish speakers, the study of syllabification and lexical stress are emphasised from a young age since it determines writing rules (e.g., all trochaic three-syllable words are written with a stress mark (´): *PÉtalo* [petal]). Moreover, lexical stress in Spanish is used to differentiate nouns and verbs (e.g., beBÉ (baby) vs. BEbe [he drinks]), as in English, but in Spanish the differentiation implies not only different grammatical categories (noun vs. verb), but also meaning.

Furthermore, lexical stress cues the subject of the verb (i.e., the person who does the action of the verb such as I, you, or he). In Spanish, the subject of the verb is not compulsory either in written or spoken form. In order to

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[12] In CVVC syllables, the vowels must be either two closed vowels (i and u) or a combination of one closed and one open vowel (a, e, o). Two consecutive open vowels form part of different syllables, as in ca-er (to fall).

understand who is the subject of the verb, it is necessary to pay attention to lexical stress and the suffix attached to the verb. An example is: CANt**o** [I sing], CANt**as** [you sing], CANt**a** [he/she sings], canT**Amos** [we sing], canT**ÁIS** [you sing, plural], CANt**an** [they sing]). Thus, if the stress lies on the second syllable, the listener can rapidly foresee that only canTAmos (we sing) and canTÁIS (you sing, plural) are possible subjects of the sentence, facilitating appropriate lexical access and comprehension.

Finally, lexical stress cues verb tense. Note that Spanish has many verb tenses, consequently the listener needs to rapidly spot segmental differences (e.g., just one vowel: CANt**o** [I sing], CANt**a** [he sings]) and lexical stress to figure out the subject and verbal tense. For example, canTAra (that I had sung) versus cantaRÁ (he will sing); CANto (I sing) versus canTÓ (he sang); CANte (that he sings) versus canTÉ (I sang), and so on.

Lexical Stress Comparison between standard British English, Singapore English, and Spanish

Standard British English has mainly trochaic stress words, but Spanish has more iambic stress words than English. Singapore English also follows trochaic stress but it does not reduce vowels on unstressed syllables as much as standard British English does. Spanish vowels have the same duration in stressed and unstressed syllables. The regular trochaic stress pattern of English provides a reliable cue for marking the beginning of words in continuous speech, facilitating segmentation. In contrast, the more variable lexical stress pattern in Spanish does not make it a reliable cue for word segmentation. However, lexical stress provides more constrastive information (i.e., it is used to differentiate verb tenses, subjects of the verb, and between otherwise identical words) in Spanish than in English, implying that lexical stress may be more important for lexical access in Spanish than in English.

Lexical Stress in Word Recognition

According to Cutler (1997), lexical stress constrains lexical access by reducing the cohort of possible candidates at lexical activation. For example, the word *zee* (sea) in Dutch is recognised slower in the nonword *muzee* than in *luzee* because the first syllable (mu, in the word muzee) activates words such as *museum*, but the first syllable of *luzee* does not activate any word in Dutch. The effect disappears when the first syllable of *muzee* is stressed (MUzee), as no word in Dutch starts with the stressed MU, competition vanishes and *zee* is identified rapidly.

Evidence of the role of lexical stress in lexical access is provided by Mattys and Samuel (1997). They employed the migrant paradigm, in which participants hear a target word (or nonword) followed by two stimuli played dichotically (nonwords that played simultaneously produce the illusion of hearing a real word; e.g., the simultaneous presentation of the nonwords *kontrovarsy* and *bisglorefe* results in hearing *controversy*). Participants had to identify whether the target word (or nonword) was one of the stimuli played dichotically. They found that the auditory illusion happened whenever the mispronunciation of the stimuli presented dichotically occurred in an unstressed syllable (e.g., *KONtrov***a***rsy;* error in bold letter), but the illusion did not happen when the mispronunciation laid on the strongest syllable (e.g., K**I**Ntroversy). This indicates that lexical access may start on the strongest syllable, and misperceptions on weak syllables tend to be "repaired" by top-down processes (lexical to phonemic pathways).

Support for lexical stress as a means to lexical access in Spanish has been provided by Gutiérrez-Palma and Palma-Reyes (2008) using visual masked priming. In Spanish, all polysyllabic words have lexical stress. However, some written words also have a stress mark (´), which indicates lexical stress and is used according to orthographic rules. The stimuli were words with no stress mark (e.g., ANcla [anchor]). The primes were the same word with stress mark indicating the correct syllabic stress pattern *áncla, or the incorrect syllabic stress pattern *anclá, or the same target word (ancla) used as a control. Note that *áncla and *anclá are orthographically incorrect, but the first is prosodically correct, while the second it is not. The results showed that primes as ancla (control) and *áncla facilitated word recognition equally, but *anclá resulted in longer RTs, indicating that lexical stress influences lexical access. Using different SOAs, they found that lexical stress processing requires approximately 100 to 143 ms.

However, lexical stress seems to be even more important for lexical access in Spanish than in English. Soto-Faraco, Sebastián-Gallés, and Cutler (2001) showed that incorrect syllabic stress disrupts lexical access in Spanish. They presented auditorally the sentence (in Spanish): *Nobody knew how to read the word…*followed by a truncated word as a prime (e.g., prinCI); afterwards, the participants had to perform a lexical decision (i.e., they had to discriminate between words and nonwords) of stimuli presented visually, in which critical trials had real Spanish words such as prinCIpio (beginning), or PRINcipe (prince), in which the first two syllables differ on lexical stress. Target words (e.g., prinCIpio) matching the lexical stress of the truncated prime (prinCI) were recognised faster, while words which mismatched the prime (PRINcipe) were recognised slower than control words, indicating inhibition. Cooper, Cutler, and Wales (2002) studied lexical access in English using Soto-Faraco et al.'s paradigm, with words such as ADmiral, and admiRAtion. In the first stimulus (ADmiral), the word has primary stress on the first syllable followed by a weak syllable. The stimulus admiRAtion has secondary stress on the first syllable and primary stress on the third syllable. They found facilitation (faster reaction time [RT]) when the truncated word matched the lexical stress of the target word (i.e., ADmi facilitated ADmiral); but ADmi did *not* inhibit admiRAtion. In contrast, Van Donselaar, Koster, and Cutler (2005) found in Dutch the same results as Soto-Faraco et al.: Inhibition for mismatching primes.

Overall, these results can be interpreted as English providing less weight to lexical stress for lexical access, in comparison to Spanish or Dutch. So, it could be argued that the lexical stress of Spanish words may not be completely codified and used for word recognition by English speakers. Due to the importance of lexical stress in Spanish for lexical access and contrast among otherwise identical words (e.g., TÉRmino [clause] vs. terMIno [I end] vs. termiNÓ [he finished]), knowing whether learners perceive and automatically encode lexical stress is important for models of word recognition and language acquisition. This will be investigated in the experiments conducted in the next chapter.

Lexical Stress and Bilingualism

The studies carried out with bilinguals can provide cues regarding whether lexical stress of the FL can be ultimately learnt and used to a similar extent as monolinguals do, particularly when both languages have different lexical stress patterns.

Sanders, Neville, and Woldorff (2002) studied how lexical stress is used by bilinguals in a phoneme spotting task (e.g., /b/). They used semantically correct sentences (e.g., In order to recycle the *b*ottles you have to separate them), syntactically correct (e.g., In order to lefatal *b*okkers you have to thagamate them), or acoustic sentences (e.g., Ah ilgen di lefatal *b*okkerth ha maz di thagamate fon). The target /b/ could be in a strong-syllable initial position (e.g., *b*ottle), strong-syllable medial position (e.g., to*b*acco), weak-syllable initial position (*b*alloon), weak-syllable medial position (e.g., tim*b*er), or be absent. Participants were English, Spanish, and Japanese monolinguals, and late Spanish-English and Japanese-English bilinguals. The results showed that bilinguals applied English lexical stress to spot the phoneme, showing that late bilinguals can learn and use L2 lexical stress in perception, even when meaning is not available.

Guion et al. (2004) compared lexical stress perception in native English, early Spanish-English bilinguals, and late Spanish-English bilinguals. They presented sentences such as *I'd like a…* and *I'd like to…*followed by a pair of nonwords which differed in lexical stress (e.g., BEIbekt and beiBEKT). Participants had to choose which sentence was more like a real English sentence to them. The variables under study were syllabic structure, lexical class (noun or verb), and phonological similarity of the nonwords with real words. They found that native English and early Spanish-English bilinguals used all three variables (syllabic structure, lexical class, and phonological similarity) to assign stress. However, the cues provided by the structure of the syllable was not used as effectively by early bilinguals in comparison to the native speakers; particularly, the early bilinguals overlooked the presence of two vowels in the last syllable as an indicator of stress. Late bilinguals relied basically on lexical class and phonological similarity with real words. The results indicate that late bilinguals seem to apply lexical stress by analogy to similar examples retained in long-term memory. Lexical stress attribution due to syllabic structure knowledge seems to be applied implicitly after long exposure with the language.

These previous experiments show that bilinguals process new sounds by relying on the FL words's lexical stress patterns stored in long-term memory. This is in consonance with Masoura and Gathercole's (1999) findings showing that stored knowledge of the phonological structure of the language (and probably lexical structure of language) facilitates the learning of new vocabulary. However, it is unclear whether FL lexical stress is codified appropriately when learners do not have enough vocabulary assisting the acquisition of new words. Hence, more research is needed to ascertain lexical stress codification of FL words at the first stages of FL acquisition.

Archibald (1993) explored the lexical stress abilities in perception and production of seven Spanish speakers studying English. Based on the results, he speculated that L2 beginners (three participants) tend to employ L1 filters at perception (an average of 17% of error at perception). However, Guion et al. (2004) found that late Spanish-English bilinguals were highly accurate (96%) in stress placement of English words. This suggests that L1 perceptual filters are not permanent.

González's (2002) doctoral dissertation focused on transference effects of lexical stress from L1 (English) to L2 (Spanish). He found that negative transfer (i.e., interference) from English to Spanish metrical rules was very low for L2 beginners and intermediate students, concluding that Spanish metrical rules were applied very soon. He also did not find differences between lexical stress perception and production. However, for cognate words[13] with different lexical stress in L1 and L2, negative transfer was found, particularly in beginners. The perception task consisted of the presentation of words pronounced with different lexical stress patterns, and

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[13] Cognate words are words which have forms that are perceptually, both in sound and spelling, similar in different languages (De Groot & Nas, 1991).

the participants had to choose the correct pronunciation. Previous hearing experience with the words was not controlled, therefore it is possible that beginners could have chosen a more familiar English-stress pattern when a cognate Spanish word was unknown. Thus, the results are not conclusive regarding cognate lexical stress codification and further study is necessary.

Goetry, Wade-Woolley, Kolinsky, and Mousty (2006) compared first graders with different language backgrounds: French and Dutch monolinguals, French-Dutch bilinguals, and Dutch-French bilinguals. French-Dutch bilinguals refer to native French speakers attending Dutch schools, and Dutch-French bilinguals refer to native Dutch speakers attending French schools. They found that lexical stress perception was very difficult for French monolinguals but not for Dutch monolinguals, because lexical stress in French has no grammatical or semantic value. Importantly, French-Dutch bilinguals did not significantly differ from Dutch monolinguals, indicating that the ability to perceive lexical stress depends on the language the child is in contact with, and the functions this has for lexical access and word recognition.

These results are in consonance with Dupoux et al.'s (2008) findings. They studied lexical stress word encoding by French participants learning Spanish. Dupoux et al. used a lexical decision task (LDT), similar to Experiments 1 and 2 in this thesis. Lexical stress in French is used to lengthen final syllables in prosodic groups, and lexical stress has no contrastive informational value as it does in Spanish. In Dupoux et al.'s study, the critical comparison was the performance for those trials wherein lexical stress was not manipulated (e.g., LOro [parrot]) and those in which it was changed (e.g., *loRO). Participants had to identify the latter trials as nonwords. Dupoux et al.

compared the percentage of errors and found that participants made more errors when the lexical stress was changed (false alarms, average error: 58%) than when the lexical stress was not manipulated (miss, average error: 24.3%). They concluded that French learners of Spanish do not codify lexical stress because this is not a critical cue for lexical access in French. However, despite the difference in errors, from the values reported above, it can be estimated that the percentage of correct recognition of non-manipulated words was very high (approximately 76% of hits)[14], indicating that lexical stress encoding could have been present. Moreover, some words employed were low-frequency words and the authors acknowledge that participants may have not known the meaning of some words (p. 698). Importantly, another limitation of this study is that cognate and noncognate words were used as stimuli without control (i.e., it is possible that some cognate words were identified as real words due to similarity with French, being never heard or hardly heard in Spanish before, and therefore lexical stress was completely unknown or overlooked). From the 112 words employed, more than the half of them were Spanish-French cognates (e.g., vegetal and végétal [vegetable], déficit and déficit [deficit], cáncer and cancer [cancer], in Spanish and French, respectively) including false friends (i.e., words with same spelling in both languages, but with different meaning; e.g., débil [weak] and débile [stupid], in Spanish and French, respectively)[15]. In order to overcome these problems, the studies carried out in this thesis controlled and studied codification for cognate and noncognate words in order to obtain more valid results.

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[14] Hits = 100% - miss = 100% - 24.3% = 75.7%.

[15] Note that the stress mark in French has phonetic, semantic, and etymological significance but does not necessary indicate lexical stress, as in Spanish.

In general, appropriate lexical stress in FL is acquired. However, the use of it depends on the age of acquisition (the earlier, the better), use and contact (the more, the better), and probably the role that lexical stress has in the L1 and FL (if lexical stress has the same function in both languages, that function is likely to be used in FL). Moreover, exposure to FL seems to facilitate the use of implicit knowledge, such as syllabic structure and lexical stress placement. Finally, it is not clear whether lexical stress of cognate words is perceived, learnt, and to what extent it relies on long-term memory and results in interference. Experiments 1 and 2 are designed to investigate FL lexical stress codification after a brief exposure to FL words presented auditorally to English-speakers adults with no previous experience with the FL.

CHAPTER 3

LEXICAL STRESS CODIFICATION EXPERIMENTS

Will English-speaking Singaporeans[16] encode lexical stress while hearing Spanish words? This is the general question dealt in the experiments in this chapter.

Lexical stress in Spanish is critical for word recognition and lexical access. Yet, it is still unknown whether adult English speakers encode lexical stress while learning FL words for first time. English words tend to have a trochaic stress pattern, while the presence of trochaic and iambic stress patterns in Spanish is more balanced. So, lexical stress in Spanish cannot be predicted just by simple probabilistic calculations. It is not clear whether English speakers will codify iambic stress patterns automatically. In addition, Spanish does not reduce vowels to indicate unstressed syllables.

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[16] Singaporeans are proficient in at least two languages, one of them is English. English is the language of formal instruction, high proficiency in English is a requirement in education, and it is commonly used in formal and informal situations. Most of the participants also spoke Mandarin, which does not use lexical stress but tone. Therefore, any lexical stress transfer effect can only be attributed to English and not Mandarin. The data of those non-Mandarin speakers were analysed independently and compared with the Mandarin speakers and no differences were found. Therefore, those data were kept in the databases.

It is expected that the encoding of Spanish lexical stress patterns depends on the functions (e.g., to denote lexical category [REcord vs. reCORD]) and the characteristics (e.g., vowel reduction, pitch change, regular trochaic stress patterns, etc.) that lexical stress have in English. English words have lexical stress, and lexical stress has in some cases contrastive informational value (e.g., REcord vs. reCORD), so participants's perception should be attuned to capture this feature. Thus, it is predicted that participants can encode lexical stress while learning foreign words. However, since lexical stress is not as critical for lexical access in English as it is in Spanish, it is also expected that lexical stress codification for Spanish will not be perfect. Moreover, since Singapore English is relatively syllable-timed, I also expect that Singaporeans will be attuned to perceive lexical stress due to changes in pitch and duration rather than basing lexical stress differences on perception of reduced vowels (which are not found in Spanish).

Furthermore, there are words that share very similar phonological structure in English and Spanish (near homophones; e.g., exit /eksɪt/ and éxito /eksito/ [meaning *success,* in Spanish], in English and Spanish, respectively), and in some cases both languages share very similar phonological features and meanings (cognates; e.g., mango /mæŋgəʊ/ and mango /maŋgo/). For both homophones and cognates, processing differences have been found in comparison to nonhomophones and noncognates (Costa, Sanesteban, & Caño, 2005; Schulpen et al., 2003), suggesting that the two languages of bilinguals interact in terms of perception and production. By using cognates, Experiment 1 will also delve into how lexical activation of L1 can affect memory and FL lexical codification. It is expected that phonologically similar words in both languages will activate English words stored in the lexicon, although they are pronounced according to Spanish pronunciation. According to Costa et al. (2005), even though the same phonemes can have different realisations in different languages, bilinguals may have one representation for that phoneme (as foreign accent suggests). In any case, words with more phonological overlap probably map the word representations in both languages and are considered cognates in comparison to words with no phonological overlap (e.g., table [in English] vs. mesa [table, in Spanish]). Consequently, different effects at the level of recognition between cognate and noncognate words are expected. Particularly, it is expected that accuracy differences between the recognition of Spanish cognate and noncognate words will emerge. Specifically, it is expected more recognition of cognate words because accessing meaning (based on English word similarity) will result in a deeper memory trace. However, cognates can differ in their lexical stress patterns (e.g., SOlar [English] and soLAR [Spanish]). Due to the fact that there is more overlap (segmental plus suprasegmental features) between cognate words with identical lexical stress in English and Spanish (e.g., MANgo) than between cognate words with different lexical stress (e.g., DRAgon [English] and draGÓN [Spanish]), it is expected that the process of recognition (measured by word recognition latencies) for these type of cognates will be different.

Experiment 1

In Experiment 1, participants studied cognate Spanish words (e.g.,CObra, KIwi, acTOR, draGÓN) and noncognate Spanish words (e.g., DUcha, NUNca, loGRAR, coJÍN) pronounced with correct lexical stress, one by one. Afterwards, participants heard half of the studied words pronounced with the same lexical stress as it was studied (i.e., same-stress condition: CObra, acTOR, DUcha, loGRAR) or with different lexical stress (i.e., different-stress condition: *kiWI, *DRAgon, *nunCA, *COjin) and had to indicate whether they recognised each word as one of the words studied previously. They had to respond *yes* if the word was studied before and sounded exactly as it was studied, and to respond *no* otherwise. No information about lexical stress changes was given to the participants during either the study phase or the test phase (recognition task). If lexical stress is codified, then *yes* responses should be biased towards words pronounced with the same lexical stress as were studied. In addition, in the recognition phase, new words that were not studied were also presented for recognition. Table 3.1 shows the design of the experiment with some examples.

Table 3.1. Design of Experiment 1.

Study phase	Test phase		
	Same-stress	Different-stress	Nonstudied-word
		Cognates	
BINgo, draGÓN	draGÓN	*binGO	laTÍN
		Noncognates	
SAStre, volVER	SAStre	*VOLver	*MUjer

Hypotheses

The first hypothesis was that if participants encode lexical stress, then they will more successfully recognise Spanish words (e.g., viaJAR [to travel]) pronounced with the same lexical stress pattern between study and test, in contrast to those pronounced with different lexical stress at test (e.g., *VIAjar). This outcome is presented graphically in the left panel of Figure 3.1. This will occur for both cognate and noncognate words. In contrast, if lexical stress of Spanish words has not been encoded, recognition will be similar for words pronounced with the same or different lexical stress at test, as depicted in the right panel of Figure 3.1.

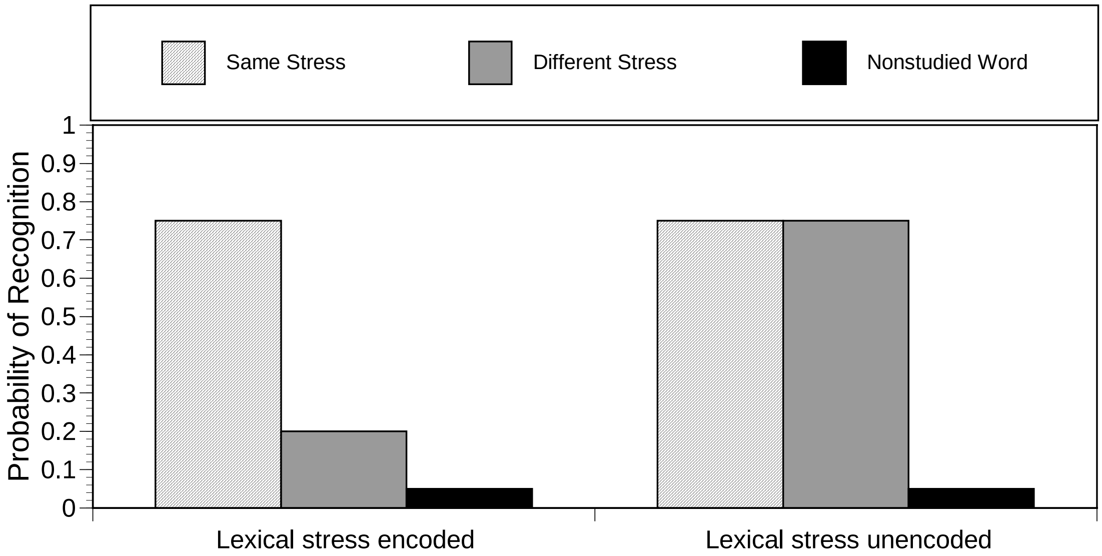

Figure 3.1. Possible outcomes of hypothesis 1 in Experiment 1.

The second hypothesis was that if cognate words map L1 representations, the proportion of recognised cognate words (e.g., mango) will be higher than noncognate words (e.g., viajar), regardless of lexical stress (same or different) used at test, due to deeper encoding and access to meaning. In contrast, if FL cognate words do not tap onto L1 representations, the probability of recognition will be similar for cognates and noncognates. Assuming lexical stress is in fact encoded, the possible outcomes are depicted in Figures 3.2 and 3.3.

It is worth noting that cognate words are assumed to have a single representation in the bilingual lexicon (De Groot & Nas, 1991). Therefore, it is expected that Spanish cognate words map the English representation. However, this is the only study to my knowledge that presents cognates auditorally to participants who have never been formally exposed to Spanish. It is interesting to find out whether cognates are processed differently than noncognates even though pronunciation between Spanish and English is dissimilar and the participants are not informed about the existence of cognate words in Spanish.

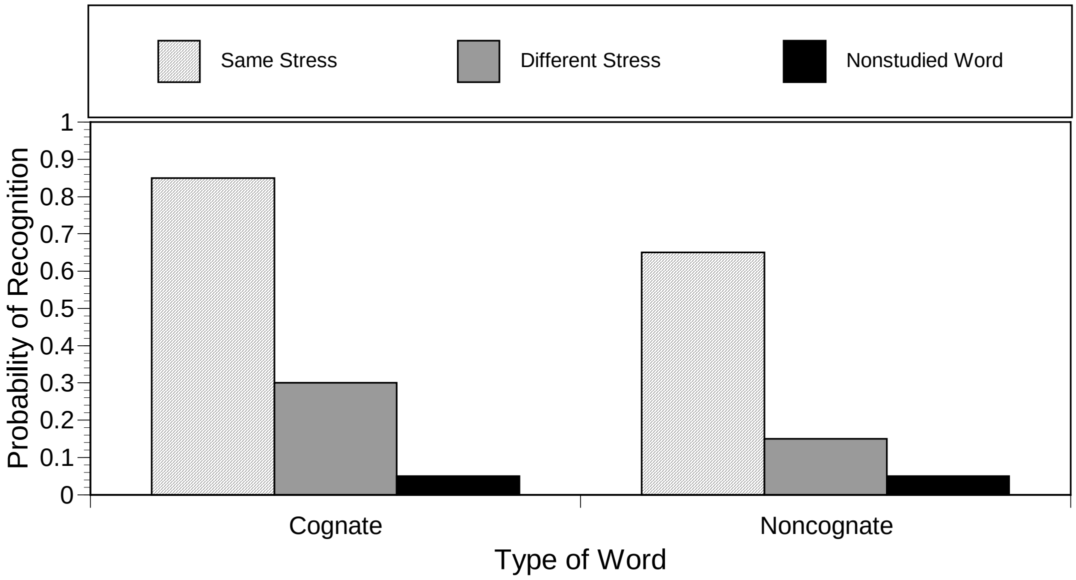

Figure 3.2. Possible proportion of recognition of cognates and noncognates assuming lexical access to L1 and lexical stress codification.

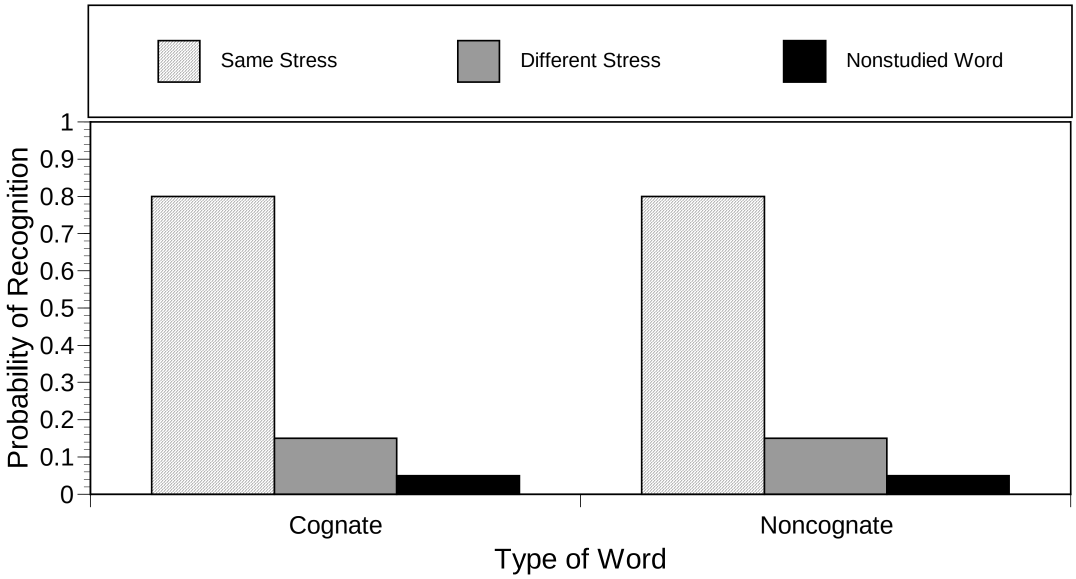

Figure 3.3. Possible proportion of recognition of cognates and noncognates assuming no lexical access to L1, but lexical stress codification.

Method

Participants

Thirty-six students[17] from the National University of Singapore, with no known hearing impairment, participated for course credit. All of them had never studied Spanish or another Romance language before.

Materials

The stimuli were 72 words, half cognate words and half noncognate words. In selecting the final list of cognates and noncognates, 21 Spanish-naïve participants who did not participate in the main experiment listened to 355 Spanish words (made of cognates and noncognates), one by one, and were requested to guess their meaning according to their similarity with English words. Whenever a Spanish word reminded them of an existing English word, they were asked to type the English word; however, if the word did not remind them of any English word, they had to type an "x" to indicate lack of similarity with any known English word. For the 72 words eventually selected, mean correct identification of cognates (i.e., correct match of the Spanish word with its corresponding English cognate, as with the word *mango*) and noncognates (i.e., no match between the Spanish word and any English word [i.e., "x" responses]) were both 90% (*SDs* = .06), showing that the two types of words were appropriately chosen.

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[17] Among the students, four were foreign students (Vietnamese, Korean, Malaysian [Chinese], and American [Chinese]). The pattern of responses was identical to the Singaporeans. So, the data of these four participants were considered in the analyses.

Half of the cognates (18) had lexical stress on the first syllable (trochaic stress; e.g., MANgo) and the other half were stressed on the second syllable (iambic stress; e.g., loCAL). Notice that the cognate English counterparts (e.g., MANgo, LOcal) were trochaic stress[18], so if there was interference between L1 lexical stress patterns and FL lexical stress patterns this could be evidenced. In that way, it could be studied whether the lexical stress of cognate words, such as loCAL (LOcal in English), had been codified or not. If the participants recognise *LOcal pronounced with the same lexical stress pattern as English during the test phase as a studied word, it means that they have disregarded the Spanish lexical stress pattern and L1 interference may be operating.

The rest of the words were noncognates, with 17 of them trochaic (e.g., SAStre [tailor]), and 19 with iambic stress patterns (e.g., volVER [return])[19]. Lexical stress followed the general rule by which disyllabic Spanish words ending with a vowel are trochaic (e.g., TAxi [taxi]) and words ending with a consonant are iambic (e.g., loCAL [local]). The words are listed in Table A1 in Appendix A.

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[18] In order to ensure that all the cognate words in English had trochaic stress, their lexical stress patterns were checked against the MRC (Wilson, 1988) and CELEX (Baayen et al., 1993) databases. In addition, to ensure knowledge of the cognate words selected, 20 different participants rated the English cognate words for familiarity. In a familiarity scale from 1 to 7 (7 is the maximum), the average familiarity rating was 6.89 (*SD* = .12), indicating that the participants knew the meaning of the cognate words. Familiarity with the cognate words was necessary to make inferences regarding cognate words accessing the L1 lexicon. In addition, nine participants who did not take part in the main experiment listened to all the Spanish words used in Experiment 1 and indicated the stressed syllable of each word. The average correct response was .78 (*SD* = .16). Correct attribution of lexical stress was equal for cognates (*M* = .76, *SD* = .18) and noncognates (*M* = .80, *SD* = .15), as shown by a between-subjects analysis of variance by items (ANOVA), $F(1,71) = 1.08$, $MSE = .03$, $p > .05$. So, possible differences at codification of cognates and noncognates cannot be attributed to L1 interference at the perception level.

[19] Out of the 36 noncognates, 17 were trochaic and 19 iambic. It should have been 18 for each group. This mistake was found out later and corrected in Experiment 2.

The 72 disyllabic Spanish words were spoken by a native female Spanish speaker[20], digitally recorded in 16-bit mono, 44.1 kHz, .wav format. The the overall root-mean-square amplitude levels for each token were digitally levelled to ensure equal presentation levels. These auditory tokens were used in the study phase of the experiment. The stimuli were then re-recorded with the same lexical stress (e.g., POny), and with different lexical stress[21] (i.e., the emphasis lying on the incorrect syllable; e.g., *poNY). The re-recorded tokens were used in the test phase. Re-recording of the stimuli with correct stress was necessary in order to create tokens that were not physically identical to the ones employed in the study phase and, consequently, to minimise recognition due to other features (such as pitch of a particular token, or a click sound, for example) rather than lexical stress.

Table 3.2 shows the characteristics of the stimuli. Cognates and noncognates did not differ in number of phonemes or spoken duration, *Fs* < 1. Also, spoken durations for the same-stress and different-stress conditions were equated, $F < 1$. These controls ensured that cognate and noncognate words only differed in the cognate/noncognate status (and not length, that could affect retention), as well as to ensure that word recognition between same-stress and different-stress conditions was not driven by differences in spoken duration cuing the correct pronunciation.

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[20] The Spanish dialect employed was standard Spanish, as spoken in north and central Spain.

[21] Note that all the different-stress tokens violate the Spanish pronunciation rule (lexical stress rule) by which words ending with a vowel are trochaic, and words ending with a consonant are iambic.

Table 3.2. Average number of phonemes and word duration of the stimuli used in Experiment 1.

		Word duration (ms)		
		Study phase tokens	Test phase tokens	
Words	No. of Phonemes		Same stress	Different stress
Cognates	5.28 (.85)	732 (124)	733 (108)	730 (143)
Noncognates	5.17 (.81)	713 (112)	707 (97)	705 (101)

Note. *SD*s in parentheses.

Design and Procedure

The stimuli (72 words) were randomly assigned to three lists made of 24 words each (12 cognates and 12 noncognates, and half of them had trochaic stress patterns and the other half iambic stress patterns). Two lists of words were presented at the study phase with correct lexical stress (i.e., 48 words). These two lists (but using the re-recorded tokens) were then presented in the test phase, one list with the same lexical stress (24) and the other one with different lexical stress (24). In addition, the third list of words (24) that was not studied was included in the test phase as nonstudied words (new words). Note that half of the words in the nonstudied list were pronounced with correct lexical stress, and the other half with incorrect lexical stress[22].

Table 3.3 shows the quantity of words presented during the study and test phases.

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[22] Correct and incorrect lexical stress according to Spanish lexical stress pronunciation rules.

Table 3.3. Number of words presented in Experiment 1.

	Number of words			
	Cognate		Noncognate	
	Trochaic	Iambic	Trochaic	Iambic
Phase				
Study	12	12	12	12
Test				
Same-stress	6	6	6	6
Different-stress	6	6	6	6
Nonstudied words	6	6	6	6

Using a balanced latin-square procedure, the three lists of words were rotated in the study and test phase (same-stress, different-stress, and nonstudied conditions) to create six versions of the experiment as depicted in Table 3.4. Participants were assigned randomly to one of the six versions programmed with E-prime 1.2.

In the study phase, participants were requested to memorise 48 words. Participants were not informed about the purpose of the experiment, they also did not receive any information about the importance of encoding lexical stress, and no details about the task to be performed during the test phase were provided. The words were presented binaurally through Beyerdynamic DT150 headphones at approximately 70 db SPL. Words were presented randomly and each word was repeated three times, with one second between repetitions, and three seconds between different words. Since participants were unfamiliar with the language, the words were repeated three times to improve the probability that all the words were correctly heard. The instructions asked the participants to memorise each word, and to not keep rehearsing previous trials in memory, but to focus on each presentation. This was to avoid subvocalisation and rehearsal of previous words that could interfere with the encoding of the word being heard.

In the test phase, participants heard 72 words presented in a random order. For each word, participants had to indicate whether they had studied that word previously or not. They used a PST Serial Response Box (Schneider, Eschman, & Zuccolotto, 2002) to respond, with the right-most button labelled YES, and the left-most button labelled NO. Specifically, they were requested to press YES if the word was presented during the study phase *and* it was pronounced exactly as it was previously presented. They were instructed to press NO if the word was studied *but* sounded different, *or* if the word was not studied before. No information about how different the word could sound or about lexical stress changes was provided.

The study phase test took nine minutes approximately. The full session lasted 20 minutes.

Table 3.4. Versions of Experiment 1.

Study phase	Test phase		
	Same-stress	Different-stress	Nonstudied-word
		Version I	
MANgo (cognate)			
loCAL (cognate)	MANgo	*LOcal	PANda
SAStre (noncognate)	viaJAR	*sasTRE	*COjín
viaJAR (noncognate)			
		Version II	
MANgo (cognate)			
loCAL (cognate)	loCAL	*manGO	*panDA
SAStre (noncognate)	SAStre	*VIAjar	coJIN
viaJAR (noncognate)			
		Version III	
PANda (cognate)			
loCAL (cognate)	PANda	*LOcal	MANgo
SAStre (noncognate)	coJIN	*sasTRE	*VIAjar
coJIN (noncognate)			
		Version IV	
PANda (cognate)			
loCAL (cognate)	loCAL	*panDA	*manGO
SAStre (noncognate)	SAStre	*COjin	viaJAR
coJIN (noncognate)			
		Version V	
PANda (cognate)			
MANgo (cognate)	PANda	*manGO	loCAL
coJIN (noncognate)	coJIN	*VIAjar	*sasTRE
viaJAR (noncognate)			
		Version VI	
PANda (cognate)			
MANgo (cognate)	MANgo	*panDA	*LOcal
coJIN (noncognate)	viaJAR	*COjin	SAStre
viaJAR (noncognate)			

Note. Asterisk (*) denotes incorrect lexical stress pronunciation according to Spanish rules. All the different-stress tokens violate the rule.

Results and Discussion

All participants obtained an average probability of *yes* responses (*yes* response: recognition of a word as it was previously studied) 2.5 *SD*s within the overall average ($M = .47$, $SD = .10$), indicating that there were no outliers. So, the results of all participants were considered in the analyses.

Table 3.5 summarises the probability of word recognition. Note that *yes* responses to words in the same-stress condition are hits, while *yes* responses in the different-stress and nonstudied-word conditions are false alarms. For example, a false alarm occurs if the participant responds *yes* to the question “have you studied this word before”? when the pronounced word boiCOT was presented in study phase, and the pronounced word *BOIcot was presented in the test phase.

Table 3.5. Average probability of word recognition of Experiment 1.

	Type of Word	
Test Condition	Cognate	Noncognate
Same-stress (hit)	.83 (.15)	.56 (.20)
Different-stress (false alarm)	.74 (.20)	.40 (.22)
Nonstudied-word (false alarm)	.15 (.14)	.14 (.11)

Note. *SD*s in parentheses.

A 2 (Type of Word: Cognate, Noncognate) x 3 (Test Condition: Same-stress, Different-stress, Nonstudied-word) within-subjects ANOVA revealed a significant main effect of type of word, $F(1,35) = 99.63$, $MSE = .02$, $p < .001$, and a main effect of test condition, *F*(2,70) = 217.79, *MSE* = .03, *p* < .001, qualified by a significant interaction, *F*(2,70) = 22.24, *MSE* = .02, *p* < .001. Figure 3.4. shows the results.

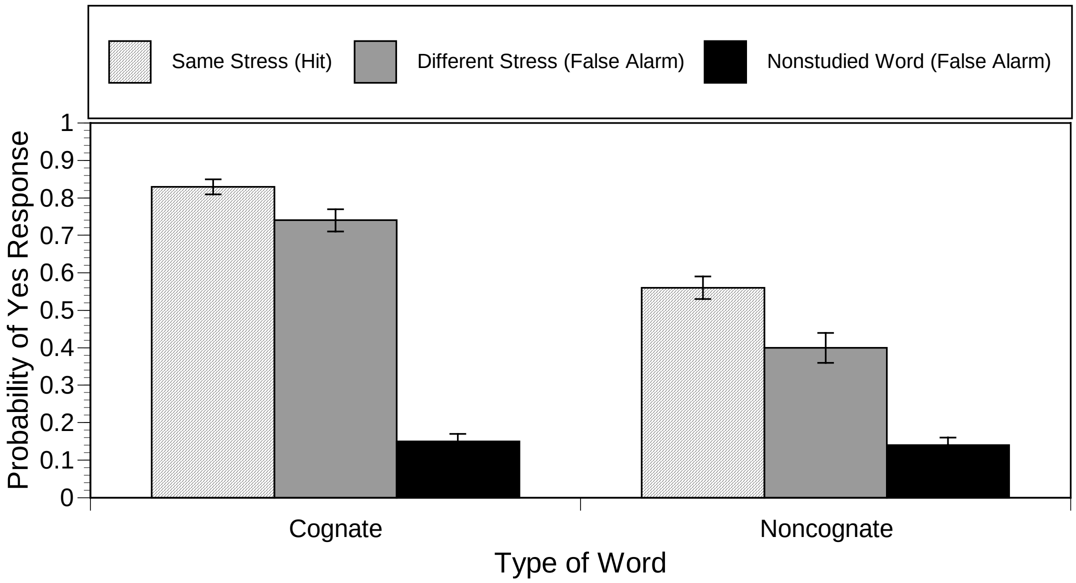

Figure 3.4. Average probability (+*SE*s) of *yes* responses to cognates and noncognates at the different test conditions of Experiment 1.

Simple main effects of test condition for cognate and noncognate words tested whether the phonological form and lexical stress of the foreign words were codified and used at recognition. The simple main effect of test condition at cognate words was significant, *F*(2,70) = 188.27, *MSE* = .03, *p* < .001. Likewise, the simple main effect of test condition of noncognate words was also significant *F*(2,70) = 65.63, *MSE* = .03, *p* < .001.

The nature of these significant single main effects were then subjected to orthogonal planned comparisons[23] in order to directly test the hypothesis that FL lexical stress is codified during the first stages of FL acquisition (i.e.,

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[23] Orthogonal planned comparisons (instead of multiple pairwise comparisons) were employed to directly test the hypotheses.

to compare the same-stress condition with the different-stress condition). For cognates, the probability of *yes* response for same-stress words (*M* = .83, *SD* = .15) was significantly higher than the probability for different-stress words (*M* = .74, *SD* = .20), *F*(1,35) = 4.99, *MSE* = .05, *p* < .05. Although the probability of false alarms was high, it was significantly lower than the probability of hits, so it can be said participants codified the lexical stress of cognate words. Similarly, the probability of *yes* response for noncognate same-stress words (*M* = .56, *SD* = .20) was higher than the probability for different-stress words (*M* = .40, *SD* = .22), *F*(1,35) = 15.09, *MSE* = .06, *p* < .001. Thus, it can be said that participants codified the lexical stress pattern of the words.

The second planned comparison compared recognition for studied (regardless of lexical stress [same or different]) and nonstudied words to ascertain that participants studied the words presented at the study phase. That is, if participants had obtained a similar probability of *yes* responses for nonstudied and studied words, then participants were learning nothing, and the study of lexical stress would have been meaningless. This planned comparison showed that the average probability of *yes* response for studied words was higher than for nonstudied words. For cognate words, the average probability of *yes* response for studied words (overall *M* = .79, *SD* = .14) was higher than for nonstudied words (*M* = .15, *SD* = .14), *F*(1,35) = 377.25, *MSE* = .04, *p* < .001. For noncognate words, the average probability of *yes* response for studied words (overall *M* = .48, *SD* = .17) was higher than for nonstudied words (*M* = .14, *SD* = .11), *F*(1,35) = 141.18, *MSE* = .03, *p* < .001.

The second hypothesis regarding L1 access was tested by analysing the simple main effect of type of word at each of the different test conditions. If participants were accessing their L1 lexicon, the probability of *yes* response for cognate words should be significantly higher than for noncognate words, due to deeper processing (i.e., access to the meaning of the word). The simple main effect of type of word at the same-stress condition was significant, the probability *yes* response for cognate words ($M = .83$, $SD = .15$) was higher than for noncognate words ($M = .56$, $SD = .20$), $F(1,35) = 55.03$, $MSE = .02$, $p < .001$. The simple main effect of type of word at the different-stress condition was also significant, *yes* response for cognate words ($M = .74$, $SD = .20$) was higher than for noncognate words ($M = .40$, $SD = .22$), $F(1,35) = 59.22$, $MSE = .04$, $p <. 001$. That is, a higher proportion of cognate than noncognate words were recognised. In contrast, in the nonstudied-word condition, *yes* response for cognates ($M = .15$, $SD = .14$) and noncognates ($M = .14$, $SD = .11$) did not differ, $F < 1$, showing that this was the source of the interaction, and indicating that the probability of *yes* response to nonstudied words did not differ across cognates and noncognates.

The overall pattern of results suggests that Spanish cognate's lexical stress was not completely filtered or disregarded even though half of the cognate words had a different lexical pattern than their English counterparts. That is, lexical stress was codified and not fully overridden by L1 filters. Moreover, it seems that cognate words were accessing L1 lexical representation.

Due to a higher probability of recognition (both hits and false alarms), I have assumed that cognate words tap onto L1 representations, and that meaning was activated. But, does this happen when the pattern of lexical stress of the Spanish word (e.g., loCAL) is different from its English counterpart (e.g., LOcal)? Is it tapping the same representation? Segmental differences (e.g., different pronunciation of vowels in Spanish and English) seem not to have impaired access to meaning, but it is unclear whether same and different lexical stress patterns are tapping the same representation in L1. An analysis of RTs would be appropriate to discover differences in processing between cognate words with same lexical stress as English (e.g., MANgo) and those with a different lexical stress (e.g., loCAL).

The indicated analyses were performed. The purpose of the analyses was to explore whether lexical stress is an important component for lexical access. Particularly, it was expected that cognates with identical lexical pattern in English and Spanish (as in MANgo, maximum matching with the L1 lexical representation) were responded faster than cognates with different lexical stress patterns (which only match at the segmental level, as in loCAL). Moreover, it was expected that the lexical stress of noncognates would not affect lexical access (measured through reponse latencies) because these words are not part of the participant's lexicon yet.

Before performing the analyses, all the audio files were screened a posteriori for possible silent gaps at the beginning of the auditory file. Some files had a period of silence at onset, which ranged from 2 ms to 421 ms. Onset silence times of the affected tokens were subtracted from the participants's RT to obtain accurate response latencies. Response latencies exceeding 2.5 *SD*s from each participant's respective means were removed and a 2 (Type of Word: Cognate, Noncognate) x 2 (Lexical Stress: Trochaic, Iambic) within subjects ANOVA[24] was performed on latencies and accuracies of hit responses. In relation to latencies, the main effect of type of word was significant, $F(1,33) = 31.12$, $MSE = 26019.39$, $p < .001$, cognate words (M = 1250.63, SD = 208.87) were responded faster than noncognate words (M = 1404.95, SD = 221.55). However, lexical stress and the interaction between type of word and lexical stress did not reach significance, $F(1,33) = 1.90$, $MSE = 34108.90$, $p > .05$, and $F < 1$, respectively. Since the effects to be tested were specified in advance, I followed Roberts and Russo's (1999, pp. 87, 226 -227) recommendation of running planned comparisons. As expected, cognate words were responded faster when the lexical stress of the Spanish cognate word was the same that the English counterpart (i.e., trochaic stress, M = 1217.55, SD = 259.08, as in MANgo) than when the cognates had different lexical stress in English and Spanish (M = 1283.72, SD = 202.18), although the difference was marginally significant, $F(1,33) = 3.59$, $MSE = 20747.91$, $p = .067$. In contrast, latencies between trochaic (M = 1394.41, SD = 257.63) and iambic noncognate words (M = 1415.49, SD = 272.70) did not differ, $F < 1$. The results suggest that lexical stress is an important feature for automatic lexical access.

Planned comparisons also showed that trochaic cognates were recognised faster than trochaic noncognates, $F(1,33) = 20.70$, MSE = 25694.70, $p < .001$, and iambic cognates were recognised faster than iambic noncognates, $F(1,33) = 10$, $MSE = 29531.62$, $p < .01$. The results are shown in Figure 3.5.

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[24] Thirty-three participants obtained data for all cells.

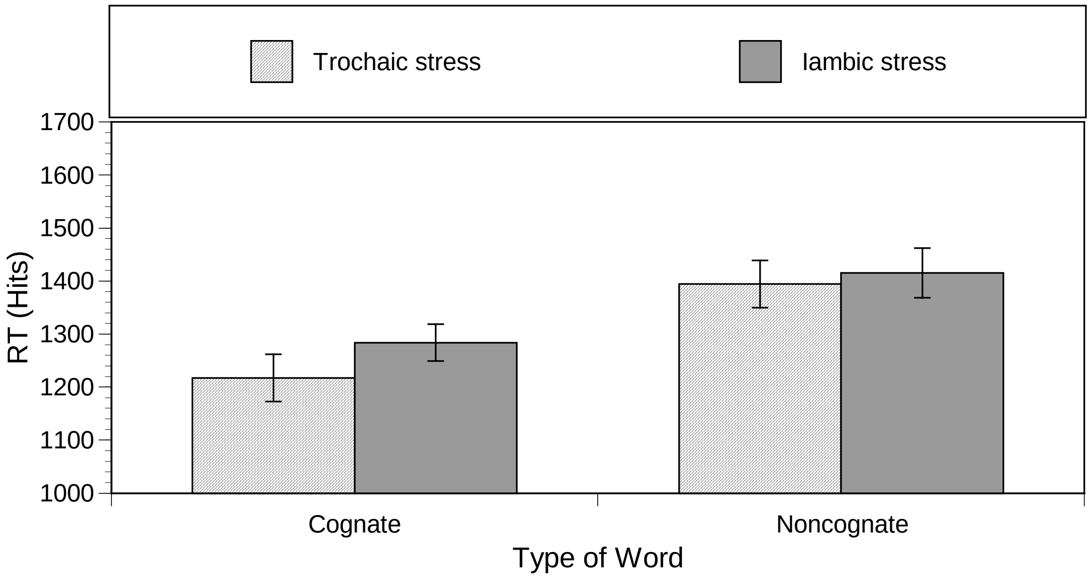

Figure 3.5. Average response latencies (+*SE*s) of correctly recognised cognates and noncognates (hits) with different lexical stress patterns, Experiment 1.

In relation to accuracy, the analyses revealed that the proportion of hits for cognates ($M = .83$, $SD = .15$) was higher than for noncognates ($M = .57$, $SD = 20$), $F(1,35) = 58.34$, $MSE = .05$, $p < .001$. However, lexical stress did not affect accuracy, $F(1,35) = 1.19$, $MSE = .034$, $p > .05$, and there was no interaction between type of word and lexical stress, $F < 1$. These results indicate that latencies are a more stringent indicator of the effects of lexical stress in lexical access than accuracy. Figure 3.6 shows the probability of accuracy for the different conditions.

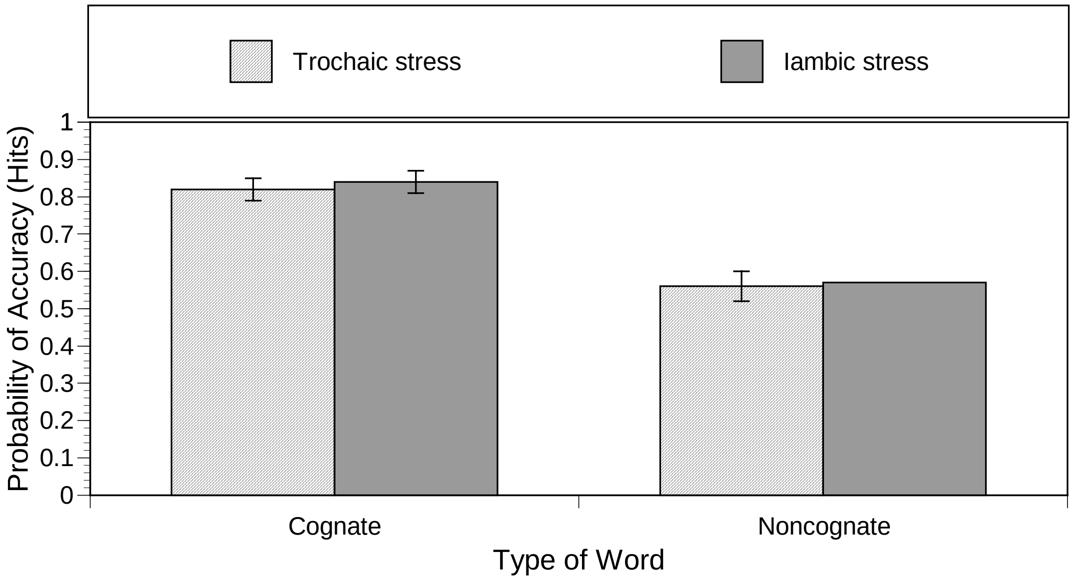

Figure 3.6. Average probability of hits (+*SE*s) of cognates and noncognates with different lexical stress patterns, Experiment 1.

However, these results have to be considered with caution because, during the debrief, many participants commented that they had expected segmental changes, such as changes in some vowels or consonants, when they were informed at test that they were about to hear words presented during the study phase *but some of them sounded different*. They reported that they did not realise that lexical stress changes were the critical difference at test. Also, some participants commented they had responded at random. Therefore, it is unclear whether lexical stress was the only critical cue used to recognise the words.

A new experiment was created in order to ensure that lexical stress was the main cue driving the participants' responses at recognition, by explaining to the participants that the lexical stress for some of the studied words had been changed in the test phase, and that this change required a *no* when responding. The information was provided *only* during the test phase. By informing the participants about the critical role of lexical stress for responding accurately, Experiment 2 ensured that their responses at recognition were based only on judgments about lexical stress and not due to the use of other features that might have guided recognition (e.g., particular phonemes or syllabic structure of the studied words). If other cues rather lexical stress had been used at recognition, this would invalidate the conclusions of Experiment 1 regarding lexical stress (i.e., it would indicate that there were confounds). Therefore, it was expected that Experiment 2 replicated Experiment 1 if lexical stress was the critical cue used at recognition.

Finally, although during the experiment's debrief many participants thought that the task was very difficult, reported not have paid attention to lexical stress at the study phase, and claimed to have answered mainly at random during the test phase, the results showed relatively good performance. Hence, it is likely that lexical stress might have been encoded implicitly, since the evidence clearly indicated that stress was encoded despite participants' claims to have responded at random.

Experiment 2

The procedure of Experiment 1 did not ascertain whether the participants were considering lexical stress when responding, since some of the participants mentioned that they had expected phonological differences (and not differences in lexical stress) in the recognition test, and they responded according to that expectation. Therefore, the results could have been due to other factors rather than the use of lexical stress as a cue in recognition. In Experiment 2, the participants again were requested to memorise 48 words without further explanation during the study phase, but in the recognition test phase they were informed about the critical role of lexical stress to differentiate among the words presented. Specifically, participants were asked to respond *no* when hearing a word that was presented during the study phase but in the test phase was presented with different lexical stress (i.e., to respond that the word was not recognised as a word studied previously, as in draGÓN [study phase] and *DRAgon [test phase]).

In addition, L1 activation for cognate words was further studied by analysing response latencies at recognition, since RT is a better index of automatic activation (Johnson & Hasher, 1987). Experiment 1 showed that cognate words activated L1 representations (higher probability of recognition), and that the lexical stress pattern of the cognate seemed to be critical in such activation.

Hypotheses

The first hypothesis, as in Experiment 1, was that if lexical stress had been encoded, then recognition would be better for words pronounced with the same lexical stress than with different lexical stress.

The second hypothesis predicted that because cognates with trochaic stress patterns (e.g., MANgo) match the most with English lexical representations, recognition for these words will be the fastest, followed by iambic stress cognate words (e.g., loCAL, which match on segmental features [phonemes], but not on suprasegmental features [lexical stress]), and finally by noncognate words (e.g., JUIcio [trial], which do not match with any English representation).

Method

Participants

Forty-two students from the National University of Singapore with no hearing impairment, and who had not participated in Experiment 1, participated for course credit or as volunteers. None of them had ever studied Spanish or another Romance language before.

Materials

The same stimuli used in Experiment 1 were used in Experiment 2. However, for the noncognate words, one iambic word was removed (riñón), and one trochaic word was added (tierno). This change was made so half of the stimuli were trochaic and half were iambic[25]. Table A2 in Appendix A shows the list of stimuli.

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[25] In Experiment 1, a codification error resulted in 17 trochaic noncognates and 19 iambic noncognates.

Table 3.6 shows words's exact durations (i.e., silent onsets have been removed), that is why durations are slightly shorter in Experiment 2 than in Experiment 1 (table 3.2). Spoken duration between same-stress and different-stress were not different, $F < 1$, eliminating the use of word length as a cue to discern between same-stress and different-stress words.

Table 3.6. Average number of phonemes and word duration of the stimuli used in Experiment 2.

		Word duration (ms)		
		Study phase tokens	Test phase tokens	
Words	No. of Phonemes		Same stress	Different stress
Cognates	5.28 (.85)	707 (127)	684 (116)	676 (134)
Noncognates	5.19 (.82)	682 (108)	654 (79)	664 (88)

Note. *SD*s in parentheses.

Design and Procedure

The same procedure as in Experiment 1 was followed. Participants were asked to indicate—by pressing the button YES or NO in a response box—whether each word presented in the test phase sounded as any word studied previously. However, in Experiment 2, participants were informed, only during the test phase, that some of the words were pronounced with different lexical stress; in that case, participants were instructed to press the button NO since that word was not exactly pronounced as in the study phase. One example was given with a cognate word not used in the study phase to ensure the participants understood the instructions. The experiment lasted approximately 20 minutes.

Results and Discussion

A preliminary data screening showed that no participant obtained an average probability of *yes* response below or above 2.5 *SD*s from the overall mean (overall $M = .49$, $SD = .09$). Table 3.7 summarises the probability of word recognition.

Table 3.7. Average probability of word recognition of Experiment 2.

	Type of word	
Test condition	Cognate	Noncognate
Same-stress (hit)	.82 (.13)	.63 (.16)
Different-stress (false alarm)	.70 (.15)	.47 (.21)
Nonstudied-word (false alarm)	.13 (.12)	.20 (.17)

Note. *SD*s in parentheses.

There was a significant main effect of type of word, $F(1,41) = 29.34$, $MSE = .03$, $p < .001$; a main effect of test condition, $F(2,82) = 264.72$, $MSE = .03$, $p < .001$, and a significant interaction, $F(2,82) = 37.67$, $MSE = .02$, $p < .001$. The pattern of results are shown in Figure 3.7.

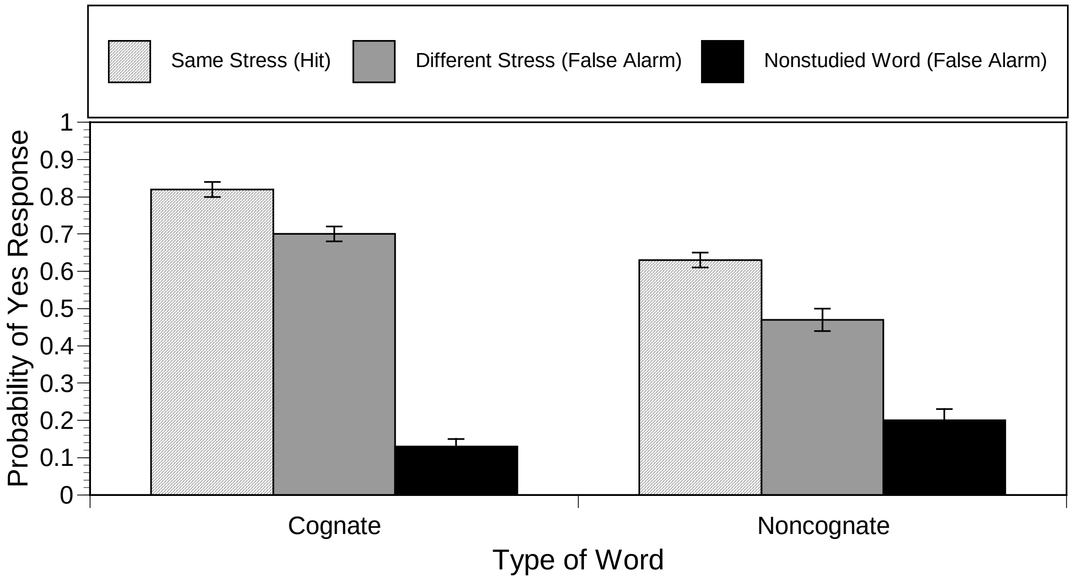

Figure 3.7. Average probability (+*SE*s) of *yes* responses to cognates and noncognates at the different test conditions of Experiment 2.

As in Experiment 1, simple main effects of test condition at cognate and noncognate words were carried out to study lexical stress codification. The simple main effects of test condition at cognate words, $F(2,82) = 295.14$, $MSE = .02$, $p < .001$, and at noncognate words, $F(2,82) = 90.42$, $MSE = .02$, $p < .001$, were both significant. Orthogonal planned comparisons tested whether lexical stress is codified when learning new FL words. For cognates, the probability of *yes* response for same-stress cognate words ($M = .82$, $SD = .13$) was significantly higher than the probability for different-stress cognate words ($M = .70$, $SD = .15$), $F(1,41) = 14.39$, $MSE = .04$, $p < .001$, indicating that lexical stress was codified. Likewise, the probability of *yes* response for same-stress noncognate words ($M = .63$, $SD = .16$) was higher than the probability for different-stress noncognate words ($M = .47$, $SD = .21$), $F(1,41) = 18.90$, $MSE = .06$, $p < .001$.

The second planned comparison had the purpose of checking that participants were studying the words during the study phase. If so, the probability of recognition measured through *yes* responses to studied words should be higher than for nonstudied words. The results showed that the average probability of *yes* response for studied cognate words (overall *M* = .76, *SD* = .10) was higher than for nonstudied cognate words (*M* = .13, *SD* = .12), *F*(1,41) = 608.02, *MSE* = .03, *p* < .001. The same can be said for noncognate words: The average probability of *yes* response for studied words (overall *M* = .55, *SD* = .15) was higher than for nonstudied words (*M* = .20, *SD* = .17), *F*(1,41) = 200.85, *MSE* = .03, *p* < .001. Therefore, participants were learning and the analysis of lexical stress codification was meaningful.

The results obtained in Experiment 1 were replicated here. It can be said that English speakers codify lexical stress and use it as a cue for recognition.

Moreover, the probability of *yes response* for cognates was higher than for noncognates as in Experiment 1. The simple main effect of type of word at the same-stress condition was significant, the probability *yes response* for cognate words (*M* = .82, *SD* = .13) was higher than for noncognate words (*M* = .63, *SD* = .16), *F*(1,41) = 37.49, *MSE* = .02, *p* < .001. The simple main effect of type of word at the different-stress condition was also significant, *yes response* for cognate words (*M* = .70, *SD* = .15) was higher than for noncognate words (*M* = .47, *SD* = .21), *F*(1,35) = 45.99, *MSE* = .02, *p* <. 001. That is, a higher proportion of cognate than noncognate words were recognised in the same-stress and different-stress conditions. However, in the nonstudied-word condition, *yes response* for cognates (*M* = .13, *SD* = .12) were lower than for noncognates (*M* = .20, *SD* = .17), *F*(1,41) = 6.62, *MSE* = .01, *p* <. 05, showing that the probability of erroneously recognising a noncognate was slightly higher than the probability of recognising a cognate. Overall, the results showed that the probability of recognition for cognates is higher than for noncognates.

To study L1 lexical access and activation, average response latencies for hit responses were computed for each participant, and latencies exceeding 2.5 *SD*s from each participant's respective means were removed. A 2 (Type of Word: Cognate, Noncognate) x 2 (Lexical Stress: Trochaic, Iambic) within-subjects ANOVA[26] showed a significant main effect of type of word, $F(1,40) = 11.99$, $MSE = 55427.89$, $p < .01$, but the main effect of lexical stress was not significant, $F(1,40) = 2.30$, $MSE = 50476.49$, $p > .05$. As shown in Figure 3.8, a significant interaction between type of word and lexical stress pattern was found, $F(1,40) = 9.62$, $MSE = 46125.92$, $p < .01$.

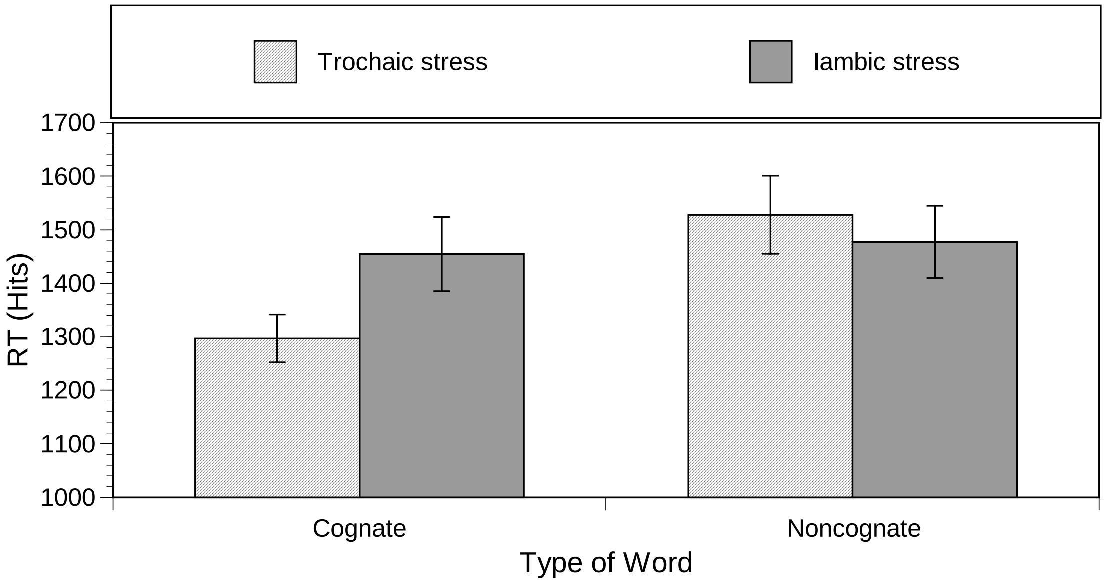

Figure 3.8. Average response latencies (+*SE*s) of correctly recognised cognates and noncognates (hits) with different lexical stress patterns, Experiment 2.

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[26] Forty-one participants obtained data for all cells. That is, one participant obtained latencies exceeding 2.5 SDs from his own mean for the iambic-stressed noncognate condition and was filtered out in the repeated-measures analysis.

Simple main effects analyses showed that trochaic-stressed cognate words (*M* = 1296.78, *SD* = 283.49) were responded to faster than iambic-stressed cognate words (*M* = 1454.06, *SD* = 444.44), *F*(1,40) = 13.14, *MSE* = 38594.07, *p* < .005. However, the lexical stress pattern of the word did not affect recognition of noncognates, so RTs were similar for trochaic stress noncognate words (*M* = 1528.09, *SD* = 467.91) and iambic stress noncognate words (*M* = 1477.33, *SD* = 433.10), *F* < 1. Moreover, trochaic stress cognate words (*M* = 1296.78, *SD* = 283.49) were recognised faster than trochaic stress noncognate words (*M* = 1528.09, *SD* = 467.91), *F*(1,40) = 17.90, *MSE* = 61279.87, *p* < .001. In contrast, when the stress was iambic, there were no differences between cognate (*M* = 1454.06, *SD* = 444.44) and noncognate words (*M* = 1477.33, *SD* = 433.10), *F* < 1.

Figure 3.9 shows the proportion of hits across type of stress and type of word. The average proportion of hits for trochaic cognate words was .84 (*SD* = .17), for iambic cognate words was .81 (*SD* = .18), for trochaic noncognate words was .68 (*SD* = .21), and for iambic noncognate words was .58 (*SD* = .23). Analyses showed a main effect of type of word, *F*(1,41) = 37.49, *MSE* = .04, *p* < .001, cognate words obtained more hits than noncognate words; and a main effect of stress, *F*(1,41) = 5.79, *MSE* = .03, *p* < .05, showing that trochaic words obtained more hits than iambic words. The interaction was not significant, *F*(1,41) = 1.15, *MSE* = .04, *p* > .05.

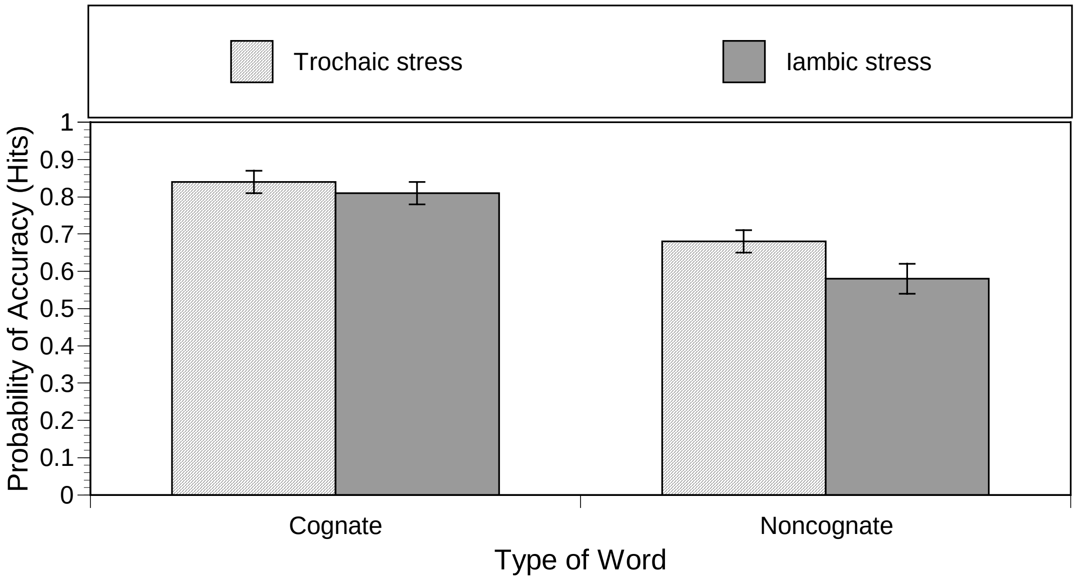

Figure 3.9. Average probability of hits (+*SE*s) of cognates and noncognates with different lexical stress patterns, Experiment 2.

The fact that the participants's RTs for trochaic cognate words were faster than for iambic cognate words, and RTs for iambic cognate words were similar to noncognate words, indicates that lexical stress contributes to lexical access to L1 representations. A better recognition for iambic cognate words than for noncognates, but not faster RTs, suggests that the phonological forms of the iambic-stressed cognates mapped L1 representations, but such representations might have not been activated as fast as the trochaic-stressed cognate representations, since RT is an index of automatic activation process (Johnson & Hasher, 1987). The activation may be slow for iambic cognate words because the match with the L1 representation is not complete (i.e., iambic cognate words do not match the lexical stress of the L1 representation). The data therefore provide evidence that lexical stress is a very important feature for full lexical access. The analyses of hit probability showed that trochaic words were recognised better than iambic words. This suggests that trochaic stress patterns might be more salient than iambic stress patterns, and this could hamper FL speech segmentation performance if participants do not encode iambic stress patterns as well as trochaic stress patterns, since many words have iambic stress in Spanish.

Overall, the results of Experiment 2 replicated those found in Experiment 1. However, there were some differences not discussed here such as a higher proportion of hits and false alarms in Experiment 2 in the noncognate condition, and better discrimination between same-stress and different-stress cognate words for Experiment 2 in comparison to Experiment 1. It may have happened that the different instructions at test in Experiment 1 and Experiment 2 (i.e., revealing that lexical stress was critical for recognition in Experiment 2) led to different discrimination strategies and/or bias at responding. In order to study lexical stress discrimination and response bias in FL word recognition, Signal Detection Theory (SDT) was employed to analyse the results of Experiment 1 and Experiment 2 as a whole. These analyses are presented in the next section.

Experiment 1 and Experiment 2 SDT Analyses

The objective of this section is to combine the results of Experiment 1 and Experiment 2 in order to gain a better understanding of how lexical stress is codified. Particularly, this chapter focuses on lexical stress discrimination abilities and response bias caused by the different instructions given to the participants in both experiments.

In Experiment 1, participants were not aware that lexical stress differences were critical in discriminating between studied words and words at test. Therefore, it was possible that the participants used lexical stress as well as other features in recognising studied words. In contrast, participants in Experiment 2 were aware that in the test phase some words had their lexical stress pattern changed and that, consequently, they were requested to consider them as nonstudied words.

The following analyses will consider only *yes response* for studied words (i.e., hits and false alarms for studied words) because these were the critical words for studying lexical stress codification. Hence, *yes responses* for nonstudied words were not analysed because their lexical stress (and their phonological form) was not codified during the study phase. Table 3.8 shows hits, false alarms, *d'*, and *C* values of Experiments 1 and 2.

Table 3.8. Average probability of hits and false alarms, *d'* and *C* values of Experiment 1 and Experiment 2.

Response	Cognate	Noncognate
Experiment 1 (N = 36)		
Same stress (Hit)	.83 (.15)	.56 (.20)
Different stress (False Alarm)	.74 (.20)	.40 (.22)
d'	.23 (.75)	.46 (.71)
C	-.84 (.45)	.04 (.48)
Experiment 2 (N = 42)		
Same stress (Hit)	.82 (.13)	.63 (.16)
Different stress (False Alarm)	.70 (.15)	.47 (.21)
d'	.40 (.68)	.41 (.62)
C	-.74 (.34)	-.13 (.40)

Note. *SD*s in parentheses.

Discrimination

Discrimination (*d'*)[27] measures the ability of participants to distinguish between words pronounced with same stress as they were studied and words with different stress in the test phase. The computation of it requires the use of hit and false alarm rates. A *d'* value of 0 means no discrimination. As *d'* increases, discrimination increases.

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[27] Corrected *d'* values (Snodgrass & Corwin, 1988) were employed because the probability of correct response of some cognates was 1 and for some noncognates was 0.

One-sample *t*-tests were performed to determine whether participants discriminated significantly above chance (the baseline criterion is 0). For experiment 1, the results showed that the difference for cognates was marginally significant, $t(35) = 1.85$, $p = .07$. The difference reached full significance for noncognate words, $t(35) = 3.84$, $p < .001$. For experiment 2, cognate and noncognate were clearly discriminated, $t(41) = 3.76$ and $t(41) = 4.24$, respectively, all *p*s < .01. That is, discrimination values were above chance probabilities.

Lower discrimination (although marginally significant) for cognate words in Experiment 1 ($d' = .23$) than in Experiment 2 ($d' = .40$) must have been due to the participants using lexical stress plus similarity with English words as criteria to respond *yes*. In Experiment 2, knowing about lexical stress changes improved discrimination of cognate words, indicating that the participant disregarded the cue of similarity between Spanish and English and used uniquely or mainly the lexical stress cue, resulting in better discrimination. When the cue to use at responding is not clear, responses are more diffuse because the participant does not know what cue is critical to solve the problem he or she is facing, giving the impression that the listener has not learnt, when, in fact, the participant has the knowledge. So, participants in both experiments did automatically codify lexical stress during the study phase, even though they were not aware that it was critical for the subsequent recognition test.

In addition, to studying whether lexical stress was codified regardless of the instructions given, the data of both experiments were analysed in a two-way mixed ANOVA with Type of Word (Cognate, Noncognate) as the within-subjects factor, and Experiment (Experiment 1, Experiment 2) as a between-subjects factor. The dependent variable was *d'*. The analysis showed that the main effect of type of word was nonsignificant, $F(1,76) = 1.26$, $MSE = .43$, $p > .05$, indicating that lexical stress codification was uniform across both cognate and noncognates, since there was no differential discrimination based on type of word. The main effect of experiment, $F < 1$, and the interaction, $F(1,76) = 1$, $MSE = .43$, $p > .05$, were both nonsignificant, which critically indicates that lexical stress was codified, independently from the instructions given at test regarding differences in lexical stress pronunciation. This supports the assumption that lexical stress was the feature critical to differentiate between same-stress and different-stress words, regardless of the impression that the participants had responded at random, particularly in Experiment 1.

C Response Bias

C response bias measures how conservative and liberal the participants are at responding in the different conditions. The different conditions refer to the instructions given in Experiment 1 and Experiment 2. The study of the *C* response bias indicates whether the instructions changed the strategies employed in responding. It compares the rate of false alarms with the rate of misses (or omissions). A value of 0 indicates unbiased responses since the rate of false alarms and misses are equated. Positive values indicate conservative bias settings, with the tendency to commit misses. In contrast, negative values indicate a liberal tendency or a tendency to commit more false alarms (Rotello & Macmillan, 2008, p. 63).

A two-way mixed ANOVA with Type of Word (Cognate, Noncognate) as a within-subjects factor, and Experiment (Experiment 1, Experiment 2) as a between-subjects factor showed a main effect of type of word, *F*(1,76) = 175.56, *MSE* = .12, *p* < .001. No differences were found between experiments, *F* < 1. However, there was a significant interaction, *F*(1,76) = 5.50, *MSE* = .12, *p* < .05. The pattern of results is represented in Figure 3.10.

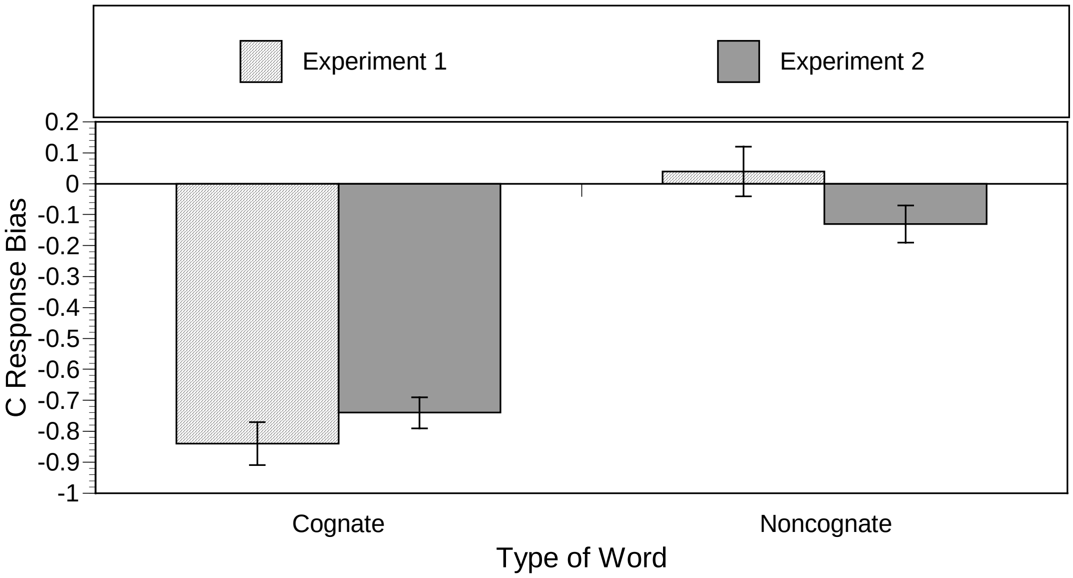

Figure 3.10. Average *C* response-bias values (+*SE*s) for Experiment 1 and Experiment 2.

Simple main effects showed that the difference between cognates and noncognates was significant for both experiments, *F*(1,35) = 98.22, *MSE* = .14, *p* < .001, and *F*(1,41) = 73.80, *MSE* = .11, *p* < .001, for Experiment 1 and Experiment 2, respectively. Hence, a more liberal tendency of responding was adopted to respond to cognate words in comparison to noncognate words.

Conservative criteria are set for easy tasks (Rotello & Macmillan, 2008, p. 72). In contrast, the values obtained indicate drastic liberal response bias for cognate words, suggesting that the task was not easy to perform when cognate words were used. The difficulty must have led the participants to lower the criterion at responding to allow for a higher probability of hit responses (and in consequence more false alarms too).

However, while the difference between cognates in Experiment 1 and Experiment 2 was not significantly different, $F(1,76) = 175.56$, $MSE = .12$, $p < .001$, the difference was marginally significant for noncognate words, $F(1,76) = 2.83$, $MSE = .19$, $p < .10$. A marginally significant difference between noncognates in Experiment 1 and Experiment 2 indicates that lexical stress at responding was slightly more difficult when the participant knew of its critical importance in the task.

Summary of Major Findings of Experiment 1 and Experiment 2

Results from Experiment 1, Experiment 2, and the SDT analyses indicate that FL lexical stress is codified. Moreover, there is access to L1 representations when FL and L1 words are similar. However, faster L1 activation occurs only for cognate words with the same lexical stress pattern in Spanish and English. Another interesting finding is that participants encoded lexical stress while studying Spanish words, largely unaware that lexical stress was important in performing the subsequent recognition task. This suggests that lexical stress codification occurs and is used implicitly. Moreover, the results indicated that although lexical stress was codified, participants discriminated slightly better between words and nonwords when they knew lexical stress was critical in the recognition task (Experiment 2) than when they were not informed of the lexical stress changes (Experiment 1), although the difference was not significant. This suggests that the lexical stress knowledge was present but it may not be always used at recognition when other cues (such as similarity with English words) are equally or more salient. The implications of these results will be discussed further in the General Discussion in the last chapter.

In order to further study implicit learning of lexical stress and awareness of lexical stress patterns, Experiments 3 and 4 were created. I will first discuss the literature on implicit learning of lexical stress rules in the next chapter before describing Experiments 3 and 4 in Chapter 5.

CHAPTER 4

IMPLICIT LEARNING OF LEXICAL STRESS RULES

The studies investigating the features underlying word recognition, such as lexical stress, have been predominantly carried out in L1. The previous chapters have shown that lexical stress is automatically codified and used in FL word recognition too. The next chapter will deal with the implicit learning of FL lexical stress rules, acquired by exposure to spoken FL words.

Different languages may have different lexical stress rules. Thus, while most disyllabic English words have trochaic stress (e.g., PANda, ACtor), Spanish words generally have trochaic stress when words end with a vowel (i.e., PANda), and iambic stress when they end with a consonant (i.e., acTOR). The knowledge of these patterns may affect word recognition as well as speech segmentation. To the best of my knowledge, there are no studies that have investigated whether FL learners acquire lexical stress rules or learn only the association between a word and its respective stress pattern. Thus, the purpose of the experiments presented in the next chapter is to investigate whether FL lexical stress rules can be acquired by mere exposure to spoken language.

Regarding the acquisition of lexical stress rules, it is believed that exposure to spoken language is critical for the acquisition of the rhythm of the language, which eventually will facilitate processes such as speech segmentation (Field, 2000; Ridgway, 2000; Rost, 1990). For Ellis (2007) and his CREED model, hearing language results in the induction (abstraction) of regularities modulated by frequency of occurrence at all levels (e.g., phonological, morphosyntactic, etc.). The induction of regularities tunes the perceptual system to the salient features of the language and the listener creates expectations according to such regularities, facilitating automatic processes such as word recognition and speech segmentation. This is assumed to occur implicitly. However, Ellis also acknowledges that when FL cues are not salient enough, the learner continues employing L1 cues and phonetic perceptual distortions occur. Moreover, models such as the Skill Acquisition Theory predict poor generalisation (or abstraction) and poor learning by simple exposure. So, predictions made by models and theories of FL acquisition are very general and inconclusive.

It is possible that exposure to spoken FL words leads to the abstraction of FL stress rules, but it is unclear whether this will occur or if FL lexical stress patterns will not be salient enough. Also, it is unclear how FL lexical stress rules are acquired: implicitly or explicitly. Although models and theories assume that lexical stress is acquired implicitly, to my knowledge, no study has experimentally tested if this is true. In particular, no experiments have delved into how stress rules are learnt by mere auditory exposure to FL words.

If an important aspect of a language such as lexical stress rules is acquired implicitly by mere exposure, then educators and learners could make use of it to facilitate learning. In addition, these experiments will provide experimental data useful for multilanguage word recognition modelling, implicit learning research, and FL acquisition theory.

Experiments 1 and 2 provided some evidence that implicit learning of lexical stress patterns may be occurring. After the recognition test was completed, participants explained that they had not considered lexical stress when responding (Experiment 1), and commented that they had not paid attention to it while studying the words (Experiments 1 and 2). Yet, the use of lexical stress for word recognition was apparent. The recognition task, however, is a direct memory test that measures explicit learning. Implicit learning is traditionally studied with indirect memory tasks such as the lexical decision task (LDT), which will be used in Experiments 3 and 4 to measure implicit learning of a lexical stress rule after exposure to spoken FL words. In a LDT, participants have to judge whether a stimulus is a word or not, as quickly and as accurately as possible.

Knowledge can be acquired implicitly and explicitly. The basic difference between implicit and explicit learning is that in implicit learning there is no conscious intention to extract rules from regularities in a particular input, while in explicit learning such intention occurs consciously. According to Hulstijn (2005), implicit and explicit learning processes depend on the regularity and complexity of the data, frequency and salience of such regularity, and learners' individual differences in information processing styles.

Concepts such as attention and awareness are closely related to implicit learning. However, there are controversies regarding their effects. A reason for such discrepancies is that different authors give different definitions to these concepts, another reason is that attention and awareness are frequently not controlled or measured experimentally.

The next section will provide definitions of attention, awareness, and implicit learning, and will shed light on the relationship between these terms. This is necessary in order to study the characteristics of implicit learning and determine whether FL lexical stress can be learnt implicitly by hearing.

Attention, Awareness, and Implicit Learning

Attention refers to alertness, orientation, detection, capacity, or maintenance. Out of these functions, detection is the one in which awareness may play a larger role (Leow, 1997). Traditionally, attention has been understood as a top-down controlled process, and as an automatic process driven by the salient features of the stimuli.

Regarding awareness, there are different definitions (Leow, 1997): Awareness has been defined as conscious attention, as a state of mind due to a subjective experience with particular stimuli, and as a behavioural or cognitive change due to experience.

Implicit learning refers to the acquisition of a rule that is not apparent, has not been explained explicitly during the presentation of stimuli, and which the learner has no explicit intention to capture or notice. Implicit learning is similar to implicit memory and it is likely that both are based on similar neurocognitive mechanisms (Toth, 2000). Therefore, what has been learnt implicitly can also be measured by implicit memory tests. Implicit memory tests reveal that unconscious recollection of previous experience facilitates performance on some tasks (for an exhaustive list of implicit tests of memory see Toth, 2000; and Richardson-Klavehn & Bjork, 1988). Implicit memory and explicit memory are the result of different mental processes and each one benefits from different types of processing during learning (Roediger III & McDermott, 1993). Memory tasks that measure implicit and explicit memory have been divided into indirect and direct tests, respectively (for criticisms of this classification see Richardson-Klavehn & Bjork, 1988). Examples of indirect memory tasks are the LDT (used in Experiments 3 and 4 in this thesis), word perceptual identification, word-stem completion, word-fragment completion, and word naming. In indirect memory tests, recollection of previous experience is not requested. In contrast, direct memory tests require recollection of previous experience. Direct memory (and explicit learning) is measured through recognition (used in Experiments 1 and 2 in this thesis), free recall, and cued recall tasks. Notwithstanding this classification, nowadays it is assumed that both implicit and explicit memory are implicated in direct and indirect memory tasks to some extent.

It is unclear what the relationship between attention, awareness, and implicit learning is in language acquisition. For researchers interested in language acquisition such as Schmidt and Robinson (as cited in Radwan, 2005) attention plus awareness are necessary conditions for learning to take place. In addition, Robinson pinpoints that awareness at the level of understanding is the factor that induces learning. However, the conscious knowledge that Schmidt and Robinson seem to refer to may depend on explicit learning. A feature such as a lexical stress rule may not require conscious intention to learn, in the same way that we “catch” the rhythm of a song without consciously wanting to learn it.

Leow (1997) was interested in the relationship between awareness and implicit learning of grammatical rules. His students had to complete a crossword puzzle with conjugated forms of Spanish regular verbs (known by the participants) and irregular verbs (unknown by the participants). The participants were aware that the crossword puzzle contained irregular verbs but the rules of conjugation were not made explicit. The dependent variable was implicit learning of the rules for conjugating irregular verbs. It was measured through performance in two subsequent tasks: multiple-choice task (in which one option was correct) and fill-in-blank task (fill the gap with an irregular conjugated verb). He found that awareness of the rule explained 78% of the variance in the ability to recognise target forms in multiple choice tasks, although awareness did help to a lesser extent in producing the correct rule in a fill-in-blank task. Therefore, awareness seems to be necessary for tasks that test explicit memory, such as recognition in the multiple-choice task and recall in the fill-in-blank task, in which the participant has to recognise and recall examples presented previously in order to respond. The results seem to indicate that implicit learning of grammatical rules did not take place. However, this experiment does not clarify whether implicit learning would occur in indirect measures such as a LDT, which is a more appropriate task for measuring implicit learning. The lack of implicit learning effects obtained in previous research on FL acquisition might be due to the inappropriate use of explicit tasks (or direct tasks) to measure implicit learning. Consequently, in Experiments 3 and 4 an indirect task, the LDT is employed to study implicit learning.

Dual tasks have been usually used to study implicit learning because it is assumed that divided attention reduces conscious recollection (explicit learning) but does not affect automatic influences of memory (implicit learning) (Jacoby, Toth, & Yonelinas, 1993). Jacoby et al.'s experiments showed that automatic processes of memory play an important role when explicit and conscious memory processes are reduced by dividing attention. In other words, implicit knowledge influences behaviour regardless of the intention of avoiding such an influence. This illustrates the existence of automatic and unconscious processes driving behaviour.

Employing a dual task, studies on probabilistic phonotactics have shown that learning can occur implicitly with no attention and without awareness. Thus, in Saffran et al.'s (1997) experiment, in which continuous speech made of nonsense concatenated syllables was segmented successfully according to phonotactic probabilities between syllable pairs, participants were told that the objective of the experiment was to study the influence of auditory stimuli on creativity, and the main task was to colour an illustration in the computer while hearing the nonsense stream of sounds during 21 minutes. Saffran et al. found that the participants recognised significantly more words (stimuli made of syllables which were presented contiguously during sequence of nonsense speech) than nonwords (stimuli made of syllables that were not presented contiguously during the sequence of nonsense speech) in a two-alternative forced-choice task, concluding that no attention was necessary to carry out speech segmentation, and that learning occurred implicitly. Thus, it is probable that a lexical stress rule can also be learnt just by exposure to words that follow that rule. This learning could for example later facilitate word discrimination skills, or speech segmentation.

Toro et al. (2005) argue that Saffran et al.'s (1997) experimental design could not control whether the participants were or were not paying attention to the speech stream (i.e., the participants could have paid attention to the speech stream while performing the colouring task). Furthermore, Toro et al. established that speech segmentation by statistical regularities is only possible if some attention is paid to the speech. They showed that segmentation performance was impaired whenever participants had to pay attention to a complex secondary task. They carried out three experiments; in each experiment, half of the participants were requested to passively listen to the stream of nonwords, the other half heard the same stream of nonwords but were prompted to attend to other stimuli in order to notice repeated sounds in an stream of sounds (first experiment), repeated images presented very quickly (second experiment), or changes in pitch in the stream of nonwords (third experiment). Focusing attention on a secondary task was detrimental to segmentation capability.

Hence, Saffran et al. (1997) concluded that speech segmentation could be achieved with no attention directed to the acoustic stimuli. They also found that level of awareness of learning during the exposure period did not correlate with performance. Moreover, they concluded that passive exposure is sufficient for learning from statistical regularities between syllables; no motivation or instructions to learn are required. On the other hand, Toro et al.'s (2005) results show that some level of attention is required for this type of learning. As Toro et al. argued, attention was not manipulated experimentally in Saffran et al.'s experiments; level of attention was simply inferred from the tasks being performed with no control over it. Consequently, conclusions regarding learning without attention could not be firmly supported.

However, both studies cannot be directly compared. One important difference is that, in Toro et al.'s (2005) experiment, the control group was requested to listen to the stream of nonwords, and the experimental groups were requested to attend to another attention-demanding task. In Saffran et al.'s (1997) experiment, however, participants were not asked to perform a very attention-demanding task which required filtering out the auditory input. Consequently, Toro et al.'s experiments cannot fully show whether learning occurs in conditions where attentional resources are not completely depleted. Moreover, it is very probable that Toro et al.'s participants did not learn because they focused full attention on the secondary task. Therefore, it cannot be concluded that divided attention compromised implicit learning. Indeed, Jacoby et al. (1993) indicated that automatic processing—which is presumed to occur in implicit learning—takes place only if the stimuli are not totally ignored. So, it is possible that Toro et al.'s participants did not divide attention among the concurrent tasks, but changed the focus of attention towards the secondary task. This could be the reason why Toro et al. did not find implicit learning effects when attention was "supposedly" split.

Related to the importance of attention in implicit learning, Crump, Vaquero, and Milliken (2008), using the Stroop paradigm, found that implicit learning occurs when the feature to be learnt (contextual cues predicting likelihood of Stroop colour congruency) is on the focus of attention and is task relevant (or salient). In addition, they found that awareness of the contextual cues as a means of forecasting Stroop colour congruency is not necessary for implicit learning. Crump et al.'s results support Jacoby et al.'s (1993) idea that for implicit learning to occur, the stimuli cannot be completely ignored. Taking these results into account, in Experiment 4 attention was manipulated in order to study how full attention (and split attention) affected implicit learning, but it was made sure that the lexical stress of the words could not be totally ignored. Thus, if the results yield no implicit learning of lexical stress rules, it can be ascertained that the null effects are not due to all of the attentional resources being deployed onto the secondary task, or that the participants completely ignored the spoken words.

The results of Experiments 3 and 4 of this thesis will shed light on whether implicit learning of a lexical stress rule occurs, as well as whether attention is necessary for implicit learning to take place (Experiment 4). If exposure to spoken language leads to implicit lexical stress learning, then it is reasonable to recommend exposure to spoken FL language even when the listener cannot understand the meaning of what is being heard, or cannot pay full attention to what is being heard.

Overview of Implicit Learning Experiments

Can lexical stress rules be learnt implicitly by exposure to spoken words? Experiment 3 was designed to answer this question. In the experiment, participants were exposed to real Spanish words that followed a general lexical stress rule that can be applied to many disyllabic words in Spanish: Words have trochaic stress patterns when they end with a vowel (e.g., MANgo), and iambic stress patterns when they end with a consonant (e.g., loCAL). Afterwards, the participants had to perform a LDT, in which new words (words pronounced with correct lexical stress) and nonwords (words pronounced with incorrect lexical stress) were presented, and they had to decide whether the stimuli were or were not real Spanish words.

Being able to extract and explicitly explain a lexical rule based on lexical stress patterns after hearing and studying only 36 words (approximately six minutes) may be too difficult for the participants. It is likely that this rule can only be learnt explicitly. However, if lexical stress makes the endings of the words salient enough, it is possible that the participants grab this feature implicitly, without being aware of it, and apply it to perform the LDT. Experiments 1 and 2 showed that lexical stress was encoded in long-term memory. The purpose of Experiments 3 is to find out whether this information can be generalised to a rule.

Furthermore, can lexical stress rules be learnt implicitly without paying attention to the spoken words? Whether attention is necessary or not for implicit learning to occur will be studied by manipulating it in Experiment

4. As reviewed previously, it is unclear whether attentional demands will jeopardise implicit learning (Toro et al., 2005) or not (Dienes & Scott, 2005; Jacoby et al., 1993; Jacoby, 1991; Johnson & Hasher, 1987).

If in the LDT, accuracy is above chance but the participant cannot report any rule or knowledge acquired during the study phase, then it can be concluded that implicit learning has occurred. However, if they can report the rule underlying the lexical stress pattern of the Spanish words, then we can infer that explicit learning has occurred.

The LDT is considered an indirect test because it does not require explicit recollection (awareness) of previous knowledge. However, indirect tests cannot ensure that participants are not using explicit knowledge too. In the same way, explicit learning may be affected by implicit processes. Actually, it is likely that the participants make use of any knowledge acquired during the study phase, by explicitly remembering studied words and comparing them to the new stimuli, for example. By using completely different words during the study phase and the LDT, it is expected to minimise the use of episodic retrieval and maximise the use of intuition in lexical decision.

CHAPTER 5

IMPLICIT LEARNING OF LEXICAL STRESS RULES EXPERIMENTS

Measuring Implicit Learning

Implicit learning has been extensively studied in the context of artificial grammar learning. In this paradigm, and during the exposure to the stimuli or training phase, participants look, memorise, or search for rules in strings of letters that follow grammatical rules; then, they are informed about the existence of grammatical rules and have to judge new strings of letters for grammaticality. Dienes and Scott (2005) found that after a few minutes of exposure, grammatical accuracy was above chance even when participants were not aware of having learnt anything. In order to measure the consciousness of what had been learnt during the exposure of the stimuli, Dienes and Scott asked the participants to report after each grammaticality judgment (i.e., after answering *yes* or *no* to a new stimulus in the test phase) whether the response was based on a guess, an intuition, a rule, or on memory. Guess and intuition responses reflect unconscious knowledge because the participants cannot report any knowledge. However, while guessing reflects no confidence in the response judgment, intuition indicates that the participant is not aware of having learnt anything but has some confidence in his or her response, that is, implicit learning occurs without awareness of having learnt anything. Rule and memory responses depend on explicit learning because the participant can describe the knowledge acquired during the training phase. In sum, implicit learning is charaterised by a lack of awareness of having learnt, and in explicit learning the participant is aware of having learnt something.

Dienes and Scott (2005) showed that the distinction between implicit learning (guess and intuition) and explicit learning (rule and memory) was supported by dissociations regarding confidence ratings (the more confident, the more explicit is the learning), the pattern of errors (i.e., if the participant believes to have acquired a grammatical rule after the exposure to the artificial language, he keeps making the same response judgment error consistently), and response accuracy (the more explicit is learning, the more learning is acquired). Moreover, attention (full or split) affected only explicit learning but not implicit learning. These dissociations, theoretically driven, validate the distinction between unconscious knowledge (implicit) and conscious knowledge (explicit) as measured by the guess, intuition, rule, and memory attributions. So, the use of the guess, intuition, rule, and memory response categories could be useful in the study of the implicit learning of lexical stress rules.

It is important to point out that although Dienes and Scott (2005) found levels of learning above chance for guess responses, Scott and Dienes (2008) could not replicate implicit learning for guess responses. Hence, implicit learning does not always occur when participants respond by guessing.

As Dienes and Scott (2005) suggest (p. 338), the subjective measures of conscious and unconscious knowledge can be applied to any task that requires subjects to make decisions. Thus, in Experiments 3 and 4, words pronounced with correct lexical stress, and which followed a lexical stress rule, were presented during the study phase, and in the test phase new words pronounced with correct lexical stress (words) and incorrect lexical stress (nonwords) lexical stress were presented for lexical decision. Implicit and explicit learning were measured through the guess, intuition, and rule attributions in relation to response accuracy. The memory attribution was not employed in the experiments due to reasons that will be explained in the next section.

Experiment 3

The main aim of Experiment 3 is to explore whether lexical stress rules can be learnt implicitly. To do so, participants memorised a list of words that followed a lexical stress rule (words ending with a vowel are trochaic, e.g., MANgo [mango]; and words ending with a consonant are iambic, e.g.

laDRÓN [thief]). Participants were not informed of this rule. At test, new words with correct lexical stress (words) and with incorrect lexical stress (nonwords) were presented for lexical decision. Table 5.1 shows the design of Experiment 3 and some of the words used.

Table 5.1. Design and examples of words used in Experiment 3.

Study phase	Test phase	
	Word	Nonword
	Cognate	
BINgo	FOto	*manGO
salMÓN	draGON	*CUpon
	Noncognate	
volVER	meJOR	*LLEgar
DUcha	NUNca	*ceJA

Following Dienes and Scott's (2005) and Scott and Dienes (2008) measures of implicit and explicit learning, in the present experiment participants were requested to report after each lexical decision whether the response was based on a guess, an intuition, or a language rule. When the participant reports responding with a guess, it means that the participant is not aware of the lexical stress rule (i.e., no conscious knowledge) and the participant thinks that he/she responded *yes* or *no* randomly. When the participant declares that the response was based on intuition, it means that the participant is not aware of the lexical stress rule (i.e., no conscious knowledge) but the participant feels that he/she has responded properly. Finally, if the participant explains that he or she responded according to a rule, it means that the participant is aware of a rule (i.e., conscious knowledge), can describe it, and is confident about the response made.

According to this classification, implicit learning will be assumed whenever participants respond accurately above chance, yet they are unable to report conscious knowledge. That is, participants respond on the basis of a guess or an intuition. In contrast, explicit learning will be manifested by learning the lexical stress rule (i.e., words ending with a vowel are stressed on the first syllable [trochaic stress], and words ending with a consonant are stressed on the second syllable [iambic stress]).

In comparison to Dienes and Scott's (2005) first experiment, in the present experiment, the response based on memory (of stimuli's fragments) was not implemented. Dienes and Scott reported doubts about the difference between explicit learning due to rule and memory (p. 343) since, for example, if the participant remembered a studied item having a particular feature, that feature must have followed the rule. In contrast to the artificial grammar learning experiments, in which remembering a sequence that follows a rule is useful, in Experiment 3 (and Experiment 4), allowing the participants to respond according to memory could have prompted them to look for identical items (repeated words) or phonological similarities (repeated phonemes or syllables), affecting their responses and hampering the salience of lexical stress cues. That is, the memory response category was discarded to minimise the use of memory for phonological forms (phonemes or syllables) as a strategy to respond in the LDT. Another difference between this and Dienes and Scott's and Scott and Dienes's (2008) experiments is that the participants of this experiment were not informed at test that the words followed one or more language rules. The objective was to avoid having participants make up rules and allow them to use guess and intuition responses if they thought they had not learnt any rule.

It is noteworthy to highlight that in artificial grammar learning, implicit learning is measured by responses attributed to guess and intuition when accuracy is above chance. According to Dienes and Scott (2005), this way of measuring implicit learning can be applied to any task that requires a subjective judgment. Following this logic, in the present experiments implicit learning will be evident if correct responses (hit plus correct rejection) are reliably above chance level.

SDT was also employed to analyse the pattern of results. On one hand, *d'* values measuring discrimination can support the findings regarding response accuracy above chance. On the other hand, *C* response bias values may provide support for the argument that different mental processes (i.e., implicit and explicit learning) underlie the guess, intuition, and rule response categories. So far, dissociations between these response categories have been provided by correlational studies correlating the response categories with confidence ratings and with response accuracy. Dienes and Scott (2005) found correlation between response category, confidence (how confident is the person with his judgment), and response accuracy. Their results showed higher confidence ratings for responses based on rules than on intuition; and higher confidence ratings for responses based on intuition than on guess. Also, response accuracy was higher for responses based on rules, followed by intuition, and finally by guess. This shows that responding with a rule may be easier than responding by guessing. In addition, Rotello and Macmillan (2008) reported that easier tasks result in more conservative criteria bias. In the following experiments, *C* response bias will be used to support the use of these different response categories as reflective of different mental processes (i.e., implicit and explicit processes). If guess, intuition, and rule response categories differ from each other, then this should be reflected in a different response biases. Responding to the LDT based on rule responses should result in a more conservative response bias than responding based on guess or intuition, because if the participant is aware of the rule, he or she can respond easily since the participant believes he or she has acquired a rule. So, a more conservative response bias is expected for rule responses in comparison to responses based on guess and intuition.

Note that implicit and explicit learning have not only been studied with the guess, intuition, and rule response categories. Previously, confidence ratings or the remember-know paradigm (whether the judgment is based on recollection or familiarity) were employed to ascertain the different mental processes that led to each response. According to Rotello and Macmillan (2008) participants can shift their response criterion on a trial-by-trial basis due to different types of mental processing for each trial. The *remember* responses are high-confidence “old” judgements and are due to the use of explicit memory, and *know* responses depend on familiarity. Rotello and Macmillan proposed a one-dimensional SDT remember-know judgments model, in which the criterion for *remember* responses was higher (more conservative) than for *know* responses. A higher criterion reflects a more conservative response bias and conservative criteria are set for easier tasks. In other words, responses due to recollection are easier to perform than those due to familiarity. In the same way, it can be proposed that *C* response bias has to reflect criterion shifts for the rule (explicit learning), intuition, and guess responses (implicit learning) if these categories depend on different types of mental processing.

Hence, *C* response bias were employed to study whether the response categories (guess, intuition, and rule) depend on different mental processes and provide evidence based on SDT. If different response biases are found for the different response categories, this will be additional evidence that implicit (guess and intuition) and explicit (rule) learning is implicated. This will support the interpretations given to results obtained from response accuracy and discrimination regarding implicit and explicit learning of lexical stress rules.

Hypotheses

The main hypothesis was that if foreign lexical rules are learnt, overall correct response (i.e., hit + correct rejection) will be above chance (i.e., 50%) and *d'* will be significantly greater than 0 (0 indicates no discrimination). Only if overall learning occurs, can implicit and explicit learning be analysed. Implicit learning will be evidenced if the probability of correct responses based on the guess and intuition response categories is significantly above chance and discrimination between words and nonwords (*d'*) is significantly above 0. In addition, if foreign lexical stress rules are learnt explicitly, then correct response probability for answers based on rule will be above chance and *d'* will be above 0. Moreover, the participants will be able to state the lexical stress rule.

Figure 5.1 shows the hypothesised results for correct responses if implicit and explicit learning occurs. The probabilities were predicted based on the results of Dienes and Scott's (2005) first experiment. If learning does not occur, the bars will be at the dashed line, which indicates 50% chance probability level.

A secondary aim was to study whether the different response categories (guess, intuition, and rule) require different processing. If so, it was hypothetised that SDT would provide additional support for the differentiation between these responses which measure implicit and explicit learning. More conservative criteria are set for easier tasks. Thus, responses attributed to rules should be more conservative than responses based on guess and intution because the participant believes he/she knows the answer and responds with confidence. In contrast, reporting no knowledge (guess and intuition: implicit learning) should be related to less conservative responses because those types of responses imply that the participant does not have the appropriate knowledge to respond accurately. In addition, guess responses should show less conservative response bias than responses based on intuition because when a participant guesses, he or she is showing that the stimulus is too difficult so he or she has no choice but to respond at random. Figure 5.2 shows the predicted results.

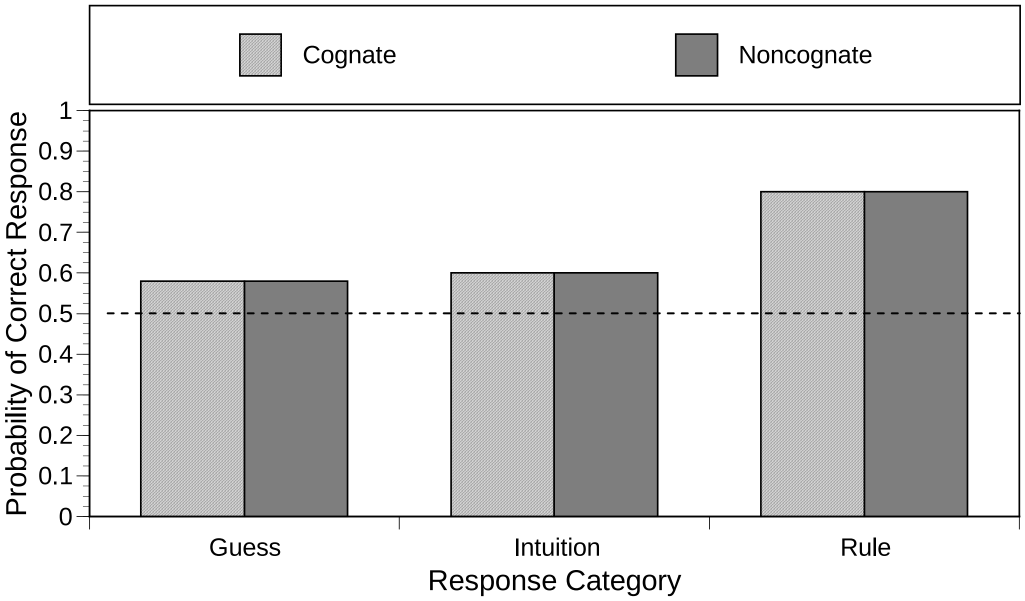

Figure 5.1. Possible proportion of correct responses assuming implicit and explicit learning of Experiment 3. The dash line indicates chance probability level.

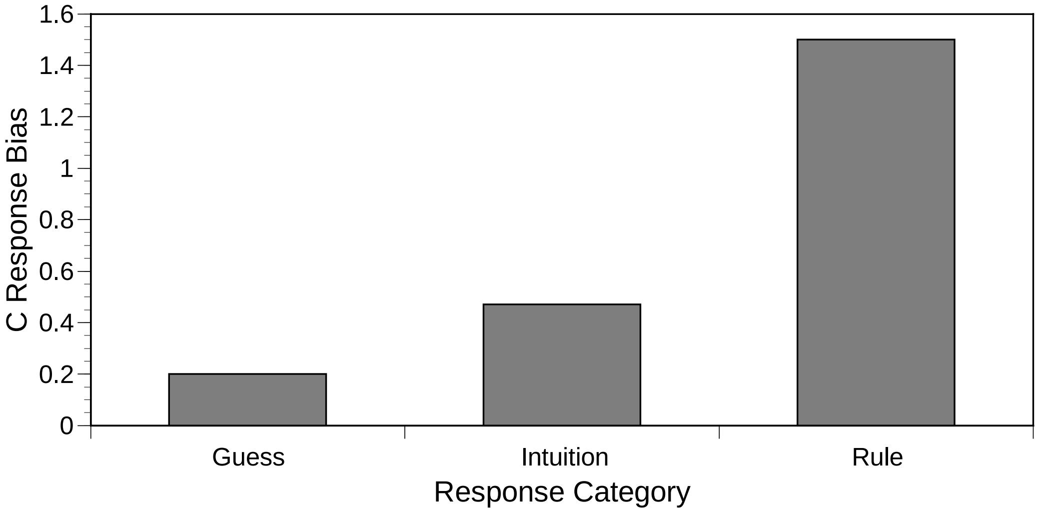

Figure 5.2. Predicted average of *C* response values for the different response categories of Experiment 3.

Method

Participants

Twenty-four students from the National University of Singapore, with no hearing impairment and no previous knowledge of Spanish or any other Romance language, participated for course credit. All of them were Singaporeans.

Materials

The stimuli employed in Experiment 3 were the same 72 disyllabic Spanish words used in Experiment 2. The total stimuli comprised 36 cognates (18 trochaic stress and 18 iambic stress) and 36 noncognates (18 trochaic stress and 18 iambic stress), as listed in Table A2 of Appendix A. The words followed the lexical stress rule by which words ending with a vowel had trochaic stress pattern, and words ending with a consonant had iambic stress pattern. Word tokens pronounced with correct lexical stress (words) and tokens of the same words pronounced with incorrect lexical stress (nonwords) were used.

The 72 words were divided into two lists made of 36 words each. One list of words was presented in the study phase and the other list of words was presented in the test phase (LDT). Each list contained 18 cognates (half of them trochaic, and the other half iambic) and 18 noncognates (half of them trochaic, and the other half iambic). A one-way between subjects ANOVA showed that both lists did not differ in number of phonemes, and word durations, all *F*s < 1. Table 5.2 shows the number of phonemes and word durations for the two lists of words.

Table 5.2. Average number of phonemes and word duration of the stimuli used in Experiment 3.

List	No. of phonemes	Word duration (ms)	
		Correct pronunciation (word) tokens	Incorrect pronunciation (nonword) tokens
1	5.25 (.69)	716 (75)	726 (121)
2	5.22 (.95)	713 (112)	705 (128)

Note. *SD*s in parentheses.

Design and Procedure

As Table 5.3 shows, the study phase comprised 18 cognates (nine trochaic stress and nine iambic stress words) and 18 noncognates (nine trochaic stress and nine iambic stress words). All were spoken with the correct lexical stress. In the test phase, the rest of the cognate words (18) and noncognate words (18) were presented for lexical decision. Half of them were presented with their correct lexical stress pattern (words), and the rest of them with incorrect lexical stress (nonwords).

Table 5.3. Number of stimuli in Experiment 3.

	Number of stimuli			
	Cognate		Noncognate	
	Trochaic	Iambic	Trochaic	Iambic
Phase				
Study	9	9	9	9
Test				
Word	4	5	5	4
Nonword	5	4	4	5

Four versions were created in order to counterbalance the stimuli in the study and test phases, and words (correct lexical stress) and nonwords (incorrect lexical stress) in the test phase, using a balanced latin-square procedure. Table 5.4 shows, with a few words, how the stimuli were assigned to the different conditions in the different versions.

Table 5.4. Versions of Experiment 3.

Study phase	Test phase (LDT)	
	Word	Nonword
	Version I	
MANgo (cognate) loCAL (cognate) SAStre (noncognate) viaJAR (noncognate)	CObra (cognate) volVER (noncognate)	*FIlial (cognate) *buiTRE (noncognate)
	Version II	
MANgo (cognate) loCAL (cognate) SAStre (noncognate) viaJAR (noncognate)	fiLIAL (cognate) BUItre (noncognate)	*coBRA (cognate) *VOLver (noncognate)
	Version III	
CObra (cognate) fiLIAL (cognate) BUItre (noncognate) volVER (noncognate)	MANgo (cognate) viaJAR (noncognate)	*LOcal (cognate) *sasTRE (noncognate)
	Version IV	
CObra (cognate) fiLIAL (cognate) BUItre (noncognate) volVER (noncognate)	loCAL (cognate) SAStre (noncognate)	*manGO (cognate) *VIAjar (noncognate)

Note. Asterisk (*) denotes incorrect lexical stress according to Spanish pronunciation and violation of the lexical stress rule.

Groups of five or fewer participants took part in each experimental session. Each participant was randomly assigned to one of the four versions of the experiment programmed with E-prime 1.2. In the study phase, participants were requested to memorise 36 words presented binaurally through Beyerdynamic DT150 headphones at approximately 70 db SPL. Each word was presented randomly and for three consecutive times to ensure that each word was heard and to familiarise the participant with the new language, with one second between repetitions, and three seconds between different words. Participants were asked to pay attention to each word and to try to memorise it.

In the test phase, participants listened to 36 new words presented only once and in a random order. For each word, participants had to indicate whether that word could be a real Spanish word. They used a PST Serial Response Box to respond, with the right-most button labelled YES (real word), and the left-most button labelled NO (not a real word). Immediately after the response, a message on the screen prompted them to respond whether the answer (yes or no) was based on guessing, on intuition, or on one or more language rules. Following Dienes and Scott's (2005) descriptions, a guess was explained as a decision made randomly, in which the response could have been with equal probability *yes* or *no*. An intuition was defined as a response done with some certainty that it was correct, but the reason why it was correct could not be explained. A language rule was explained as having noticed that the Spanish words followed a particular pattern or rule. As an example for language rule, it was said that if they had heard normal English words in the study phase followed in the test phase by English words with Chinese tones, they will have to say that the word could not be a real English words because English words have no tones. It was also explained that such an example was not necessarily applicable in the present experiment. If they responded *yes* or *no* according to a language rule, they were to type a description of the rule using the keyboard .

The study phase lasted approximately 6 minutes, while the full session lasted approximately half an hour.

Results and Discussion

Table 5.5 summarises the results across cognate and noncognate words.

Table 5.5. Average probability of correct response[28], *d'* and *C*[29] values for type of word and response category of Experiment 3.

Response Category	Proportion of Correct Response	*d'*	*C*
		Cognate	
Guess	.50 (.09)	.01 (.72)	1.05 (.32)
Intuition	.55 (.10)	.24 (.50)	.49 (.44)
Rule	.48 (.08)	-.16 (.62)	1.33 (.37)
		Noncognate	
Guess	.49 (.10)	-.09 (.69)	.79 (.44)
Intuition	.52 (.11)	.07 (.67)	.47 (.47)
Rule	.53 (.06)	.18 (.53)	1.37 (.29)

Note. *SD*s in parentheses.

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[28] Correct response refers to the proportion of hits plus correct rejection responses, relative to all responses *within* each response category.

[29] *d'* and *C* based on corrected values (Snodgrass & Corwin, 1988) because some participants did not make any hit, and/or false alarm, in one or more of the different response categories.

Implicit and Explicit Learning Analyses

An analysis of overall correct responses (i.e., all three response categories collapsed) showed that learning did not take place. That is, participants could not discern between real Spanish words and nonwords. The proportion of correct response was not significantly above chance level ($M = .53$, $SD = .09$), $t(23) = 1.42$, $p > .05$. In addition, overall discrimination was not significantly above 0 ($d' = .15$), $t(23) = 1.51$, $p > .05$. Therefore, no further analyses were carried out for the different response categories.

In contrast to Dienes and Scott's results, participants in this experiment showed no evidence of learning. Even when they responded based on rule/s, the descriptions of the rules showed that the participants considered word similarity with English as a possible rule. Thus, when facing words such as *taxi* and *piano*, for example, some participants considered them as words if they thought these words could be cognates in different languages, and considered them as not real Spanish words when they thought those words were just English words pronounced with a Spanish accent. Also, participants reported phonological features such as /θ/ and /x/ as being phonemes that were very salient, therefore any stimulus containing these phonemes had to be a real Spanish word. Moreover, 59% of the rules were given to cognate words, indicating the salience of this type of words. No lexical stress patterns were considered as rules.

The results indicate that participants are not discerning between words and nonwords. It seems that participants are paying attention to irrelevant cues such as similarity with English and salient Spanish phonological features, instead of lexical stress. Probably, the use of cognate words shifted attention to cues not related to lexical stress. Ellis (2007, 2006a. 2006b, 2001) and Hulstjin (2005) indicated that implicit learning depends on the salience of features in the input. The use of cognates must have overshadowed the salience of lexical stress. Consequently, in Experiment 4, noncognate words were exclusively employed in order to obtain learning rates free from the "noise" produced by the use of cognates. If learning of lexical stress rules occurs when noncognates are employed as stimuli, then exposure to spoken words will be beneficial to the FL learner.

Response Categories Implicating Different Mental Processes

Although no learning took place, participants employed the different response categories (guess, intuition, and rule) to perform the LDT, suggesting that they approached words in different ways. Response bias and discrimination are independent measures. As Hautus, Van Hout, and Lee (2009) explain, one of the most important benefits of SDT is that it can measure discrimination free from the effects of response bias, and that the analysis of response bias can help to describe the decision strategies that the participants used in the process of responding. Moreover, Feenan and Snodgrass (1990) showed that experimental conditions with almost equal *d'*s can differ on *C* response bias. Therefore, despite the finding that there was no discrimination, the following analysis was carried out on response bias.

In order to study how SDT (particularly, *C* response bias) can provide support for the different type of mental processing that the guess, intuition, and rule response categories require, a 2 X 3 within-subjects ANOVA was perform with Type of Word (Cognate, Noncognate) and Response Category (Guess, Intuition, Rule) as main factors. The dependent variable was *C* response-bias values. Analyses showed a nonsignificant main effect of type of word, *F*(1,23) = 2.05, *MSE* = .11, *p* > .05, a significant effect of response category, *F*(2,46) = 34.73, *MSE* = .26, *p* > .001, and a nonsignificant interaction between these two variables, *F*(2,46) = 2.76, *MSE* = .12, *p* > .05. Figure 5.3 shows the results.

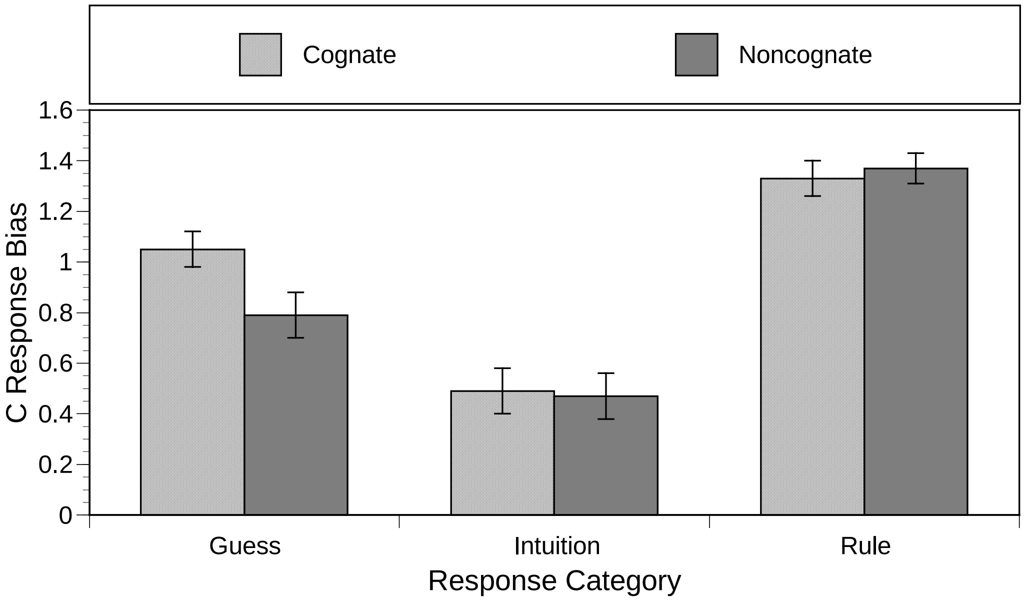

Figure 5.3. Average *C* response-bias values (+*SE*s) for cognates and noncognates at each response category of Experiment 3.

The significant main effect of response category was analysed further. To do so, values for cognate and noncognates were collapsed within each response category. Orthogonal planned comparisons showed that, as expected, participants adopted a significantly more conservative criterion for rule responses (*M* = 1.35, *SD* = .27) than for guess and intituition combined (overall *M* = .70, *SD* = .16), *F*(1,23) = 73.71, *MSE* = .12, *p* < .001. However, contrary to what was predicted, responses for guess (*M* = .92, *SD* = .34) were significantly more conservative than for intuition (*M* = .48, *SD* = .33), *F*(1,23) = 13.85, *MSE* = .34, p < .01.

The analyses support the hypothesis that predicted that rule responses should show a more conservative response bias if the participant believes that he/she had acquired knowledge relevant to perform the LDT, in comparison to when the participant guesses or responds by intuition. Because guess and intuition responses should reflect more difficulty (that is why the participant responded based on guess and intuition, and not on rule) it was expected that there would be less conservative bias for these response categories. However, guess responses were significantly and unexpectedly more conservative than intuition responses.

The results can be interpreted by assuming that guess responses do not reflect difficulty at responding as much as intuition requires, because when the participant is guessing, he or she is aware of having no knowledge to respond appropriately. That is, a guess may be an easier response than an intuition because a guess may not require further considerations or contemplations on the part of the participant. The response bias analyses for the different response categories (guess, intuition, and rule) generally support Dienes and Scott’s (2005) classification. This is, to my knowledge, the first experiment using SDT to support the guess, intuition, and rule responses as indices of implicit and explicit learning.

To sum up, the data indicated that the use of cognates may have diverted attention from lexical stress to similarity with English words. Consequently, another experiment (Experiment 4) was designed without cognates in order to study implicit learning. In addition, dissociations between response-bias for guess, intuition, and rule suggest that these subjective different response categories measuring implicit and explicit learning require different mental processes, as reflected by differences in response bias. Experiment 4 should replicate these patterns of results if they are reliable.

Experiment 4

The results of Experiment 3 showed that lexical stress patterns were not learnt implicitly nor explicitly. It was suggested that the use of cognate words could have been responsible for the null effects. Particularly, their similarity with English words probably overshadowed the salience of lexical stress cues. Therefore, in Experiment 4 implicit learning of lexical stress patterns was studied employing noncognate words exclusively.

Additionally, one of the main motivations driving this thesis was to investigate how much attention towards the spoken input is necessary for learning to take place. Dienes and Scott’s (2005) second experiment, in the context of artificial grammar learning, showed that when the participants applied full attention to the study of artificial grammar strings, or split attention by studying artificial grammar strings and announcing random numbers between 1 and 10, they could learn the artificial grammar rules despite not being conscious of having learnt anything. That is, implicit learning is not affected by split attention probably because it depends on automatic processes of memory which are not disrupted by processing demands (Johnson & Hasher, 1987). Therefore, it seems reasonable to use the split attention task to manipulate attention and apply it to the study of implicit learning of FL lexical stress. This has not been done previously. Moreover, in the context of FL acquisition, this is very important because we usually hear language while performing other tasks simultaneously.

The results of Experiment 4 will clarify whether lexical stress rules can be abstracted from hearing, and whether this knowledge is implicitly or explicitly learnt. If lexical stress rules are learnt implicitly, this learning probably will facilitate the process of language acquisition by tuning the perception system to the salient features of the language, providing the listener with the capability of detecting and predicting lexical stress cues, which are important for word recognition and speech segmentation (Ellis, 2007). The results will also clarify whether split attention impairs implicit learning (Toro et al., 2005) or not (Dienes & Scott, 2005; Jacoby, 1991; Jacoby et al., 1993; Johnson & Hasher, 1987). Since most of the time we hear language while performing other tasks, if full attention to what is being heard is not necessary for implicit learning of lexical stress rules, then we will recommend the FL learner to hear FL language even when he cannot extract meaning or cannot pay full attention to it, expecting that this knowledge will facilitate some processes implicated in FL recognition and segmentation (in the same way that the implicit learning of phonotactic probabilities facilitates segmentation).

The literature review carried out in Chapter 4 showed that for implicit learning to occur, it may be that the feature to be learnt must be salient enough to be captured automatically, and that the to-be-learnt material needs to be on the focus of attention.

To examine these possibilities, Experiment 4 was designed such that a group of participants was requested to memorise auditorally-presented words while searching for one or more lexical stress rules (*focus on lexical stress* group; attention directed to the critical cue), another group was asked to only memorise the auditorally-presented words (*focus on word* group; attention to the stimulus containing the cue rather than the cue itself, as in Experiment 3)[30], and the last group was instructed to memorise the auditorally-presented words while performing a concurrent visual task (*split attention* group). The different experimental groups were created to manipulate attention.

Hypotheses

As in Experiment 3, implicit learning and explicit learning was analysed only if overall learning occurred. If learning occurred, the main hypothesis was that the overall probability of correct responses (hit + correct rejection) would be significantly above chance level (i.e., 50%), and word-nonword discrimination (*d'*) would be significantly greater than 0. Implicit learning could be inferred if the probability of correct response for guess and intuition responses was significantly above chance, and discrimination is significantly above 0. In the same way, if explicit learning occurred, the

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[30] I had initially only run this condition with the noncognate stimuli to determine if learning could take place without the presence of cognate words. Having found that learning took place, it is more coherent to present this condition with the other two as a single experiment so as to avoid repetition of findings.

probability of correct response for rule responses would be above chance, discrimination would be significantly above 0, and the description of the lexical stress rule would be accurate.

The second hypothesis was that if implicit learning did not depend on attention, *d'* values for the implicit learning response categories (guess and intuition) would be similar for the three experimental groups (focus on lexical stress, focus on word, split attention). In contrast, if explicit learning depended on attention, *d'* values for responses based on rules would be significantly lower in the split attention condition, compared to the focus on lexical stress and the focus on word conditions, because explicit learning is impaired by lack of attention. Figure 5.4 represents this hypothesis.

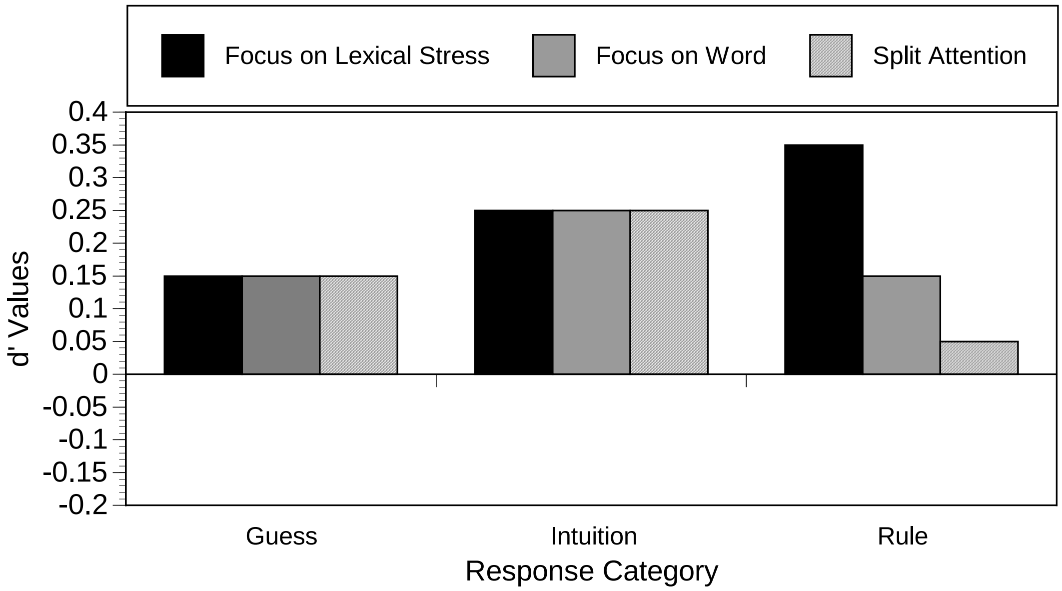

Figure 5.4. Possible average of *d'* values for the different response categories and experimental groups of Experiment 4.

Finally, if the different response categories (guess, intuition, and rule) reflect different mental processes, it is expected that responses based on rules will be the most conservative, followed by guess responses, and finally followed by intuition responses. It is not expected that the trend of *C* response bias for each response category will differ between the experimental groups. Figure 5.5 shows the expected results.

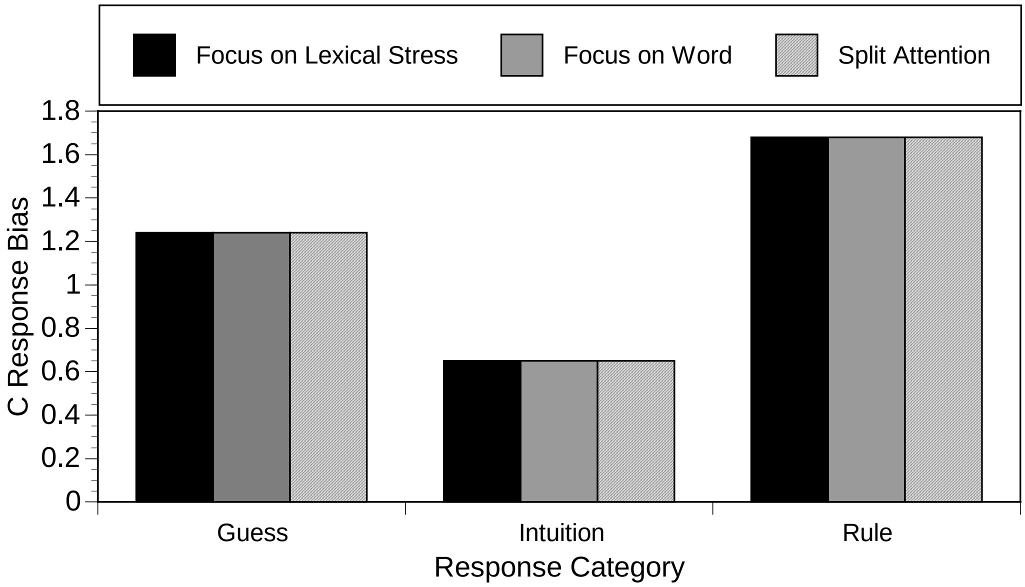

Figure 5.5. Predicted average of *C* response values for the different response categories and experimental groups of Experiment 4.

Method

Participants

One-hundred and twenty students from the National University of Singapore, with no hearing impairment and no previous knowledge of Spanish or any other Romance language, participated for course credit. All the participants were Singaporeans or had been educated in Singapore for many years.

Materials

Sixty-four noncognates were employed as stimuli. Based on a pool of 355 words which 21 participants rated for similarity with English words (see Experiment 1), the average correct identification of the words as noncognate words was .82 (*SD* = .11). This means that in 82% of the responses, participants could not relate the Spanish words to an English word. Out of the 64 noncognate words, 32 words had trochaic stress patterns and 32 had iambic stress patterns[31], as listed in Table A3 of Appendix A.

The stimuli were split into two lists of words. One list was presented in the study phase and the other list during the test phase (LDT).Thirty-two words (16 trochaic stress and 16 iambic stress words) were used in the study phase. Thirty-two different words (16 trochaic stress and 16 iambic stress words) were used in the test phase. A one-way between subjects ANOVA showed that both lists did not differ in number of phonemes, and word durations, all *F*s < 1. Table 5.6 shows the number of phonemes and word durations for the two lists of words. Words in the study and test phase were equated for number of words ending with consonants d, z, s, r, n, and vowels a, e, o. That is, the only reason why a word could be a real Spanish word or not depended on its lexical stress pattern and not any other variable.

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[31] Nine participants, who did not take part in the main experiment, listened to the words employed in the experiment. For each word, they indicated the more stressed syllable. The average correct response was .77 (*SD* = .18), indicating that trochaic stress and iambic stress words were perceived as intended.

Table 5.6. Average number of phonemes and word duration of the stimuli used in Experiment 4.

List	No. of phonemes	Word duration (ms)	
		Correct pronunciation (word) tokens	Incorrect pronunciation (nonword) tokens
1	5.13 (.75)	685 (75)	693 (96)
2	5.03 (.78)	681 (108)	677 (97)

Note. *SD*s in parentheses

Design and Procedure

The study phase comprised a list of 32 words (16 trochaic and 16 iambic). All were spoken with the correct lexical stress. In the test phase, the other list of words (32) were presented for lexical decision. Half of them were words, and the rest of them were nonwords, according to Spanish lexical stress rules. The distribution of words between the study and test phases is shown in Table 5.7.

Table 5.7. Number of stimuli of Experiment 4.

Phase	Number of stimuli	
	Trochaic	Iambic
Study	16	16
Test		
Word	8	8
Nonword	8	8

Four versions were created in order to counterbalance the stimuli among the study and test phases, and words (correct lexical stress) and nonwords (incorrect lexical stress) in the test phase, using a balanced latin-square procedure like in Experiment 3.

The procedure was identical to the one employed in Experiment 3, except for the instructions at the study phase. The instructions at the study phase determined the independent experimental groups. The focus on lexical stress group (40 participants) was requested to memorise the words presented auditorally, and to focus on the lexical stress of each word because the lexical stress followed a rule that they had to ascertain. The focus on word group (40 participants) was instructed to memorise the words. Finally, the split attention group (40 participants) was requested to perform a dual task. These participants were asked to memorise the words and to press a button in a PST Serial Response Box whenever an *odd* number was presented on the screen of the PC unit. In order to ensure attention to both tasks, participants were told that the objective of the experiment was to measure their concentration on both tasks. Even and odd numbers (1 to 9) and presentation durations for each number (500 to 950 ms) were visually presented in a random order. The stream of visually presented numbers occurred concurrently with the auditory presentation of the spoken words.

As in Experiments 1, 2, and 3, participants were requested to pay attention to each word and avoid rehearsal of previously studied words in order to assure attention and codification of each trial.

After the participants had studied the words, they performed a LDT with new words (correct lexical stress) and nonwords (incorrect lexical stress) and reported for each response the strategy employed at answering (i.e., guess, intuition, and rule).

Results and Discussion

Attention Manipulation Checks

Split attention. Even-odd task performance: Half of the numbers displayed were odd numbers. The average quantity of *odd* numbers appearing on the screen for each participant was 277, each participant pressed the button an average of 263 times. Mean accuracy for odd numbers was .83 (i.e., proportion of responding *odd*, by pressing a button on a response box, when an odd number was presented). Mean accuracy for even numbers was .88 (i.e., the proportion of no response [i.e., not pressing any button] when an even number was presented). As accuracy was high, assuming that participants were also memorising words as instructed, it can be said that attentional resources were split. A data screening revealed that one participant (*M* = .58) was below 2.5 *SD*s from the mean of this task and was deleted from all analyses.

Focus on lexical stress. Participants in this experimental group were instructed to search for one or more rules during word presentation. If they followed the instructions, it was expected that they would report more lexical decisions based on rules compared to the other two experimental groups (i.e., focus on word, and split attention). A one-way between-subjects ANOVA on the proportion of rule responses showed that groups differed, *F*(2,117) = 6.86 *MSE* = 141.84, *p* < .01; orthogonal planned comparisons revealed that the focus on lexical stress group (*M* = .14, *SD* = .16) made more responses based on rules than the average of the other two groups combined (overall *M* = .06, *SD* = .09), *p* < .001, and the proportion of rule responses was similar between the focus on word group (*M* = .06, *SD* = .08) and the split attention group (*M* = .06, *SD* = .10), *F* < 1, as shown in Figure 5.6. So, participants in the focus on lexical stress group thought to have acquired some lexical rules and provided more rule responses.

These analyses indicated that the differences across the conditions were appropriately manipulated.

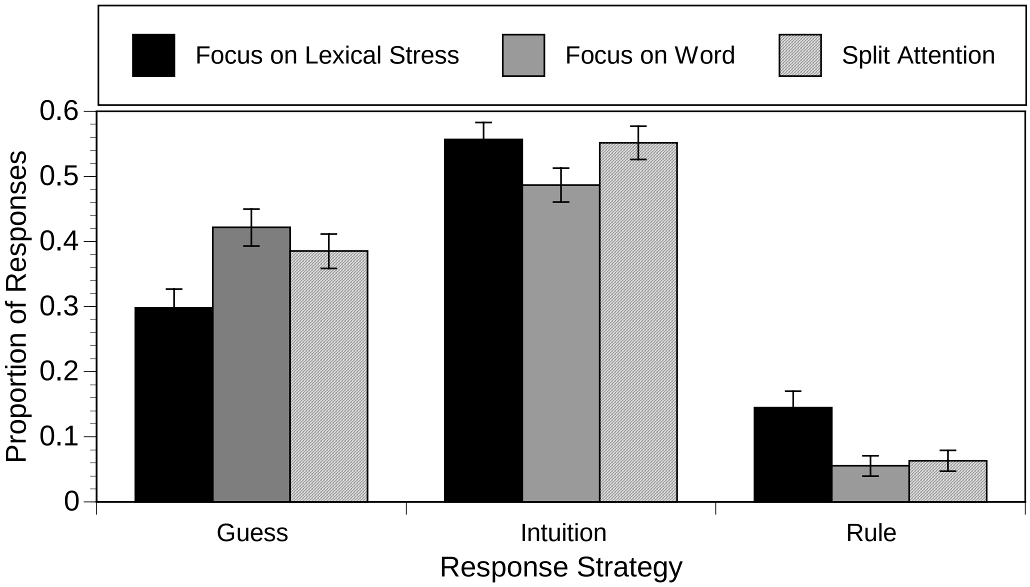

Figure 5.6. Average probability (+*SE*s) of responses for the different experimental groups at each response category of Experiment 4.

Implicit and Explicit Learning Analyses

Table 5.8 shows the average proportion of correct responses and *d'* values collapsed across the three experimental groups. The proportions refer to the number of correct response divided by the total number of responses given in each response category. Thus, a proportion of .53 for the guess response means that from the total number of responses attributed to guess, 53% of them were correct[32].

Table 5.8. Average probability of correct response[33], and *d'*[34] values for the different response categories of Experiment 4.

Response category	Proportion of correct response	*d'*
Guess	.53 (.16)*	.01 (.53)
Intuition	.57 (.13)**	.22 (.48) **
Rule	.63 (.34)*	.13 (.41) *

Note. *SD*s in parentheses. ** $p < .001$, * $p < .005$.

One-sample *t*-tests for correct response probability with a criterion of .50, as well as for discrimination with a criterion of 0, were employed to study overall learning probability and learning for each type of response strategy.

The overall average probability of correct responses was .56 (*SD* = .08), which was significantly above chance, $t(118) = 8.06$, $p < .001$. Moreover, the average probability of correct response for responses based on guess was .53 (*SD* = .16), significantly above chance, $t(115) = 2.23$, $p < .05$. The proportion of correct response for intuition was also significant (*M* = .57, *SD* = .13), $t(118) = 6.17$, $p < .001$. Likewise, the proportion of correct responses based on rule responses was significant (*M* = .63, *SD* = .34), $t(71) = 3.25$, $p < .01$.

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[32] The proportion of each response category based on *all* responses was .38, .53, and .09, for guess, intuition, and rule, respectively. Intuition was the most used response category, which replicated Dienes and Scott's (2005) experiments, whose participants responded mainly based on guess and intuition too.

[33] Correct response refers to the proportion of hits plus correct rejection responses, relative to all responses *within* each response category.

[34] *d'* based on corrected values (Snodgrass & Corwin, 1988) because some participants did not make any hits and/or false alarms in one or more of the different response categories.

Overall discrimination (*d'*) reached significance, *M* = .32 (*SD* = .44), *t*(118) = 7.93, *p* < .001. However, *d'* values did not reach significance for all the different response categories. *d'* was not significantly higher than 0 for guess responses (*M* = .01, *SD* = .53), *t* < 1, but reached significance for intuition responses (*M* = .22, *SD* = .48), *t*(118) = 5.06, *p* < .001, and for rule responses (*M* = .13, *SD* = .41), *t*(118) = 3.56, *p* < .005.

The discrimination results indicate that implicit learning is not reflected in the participants's guessing responses. This finding is contrary to Dienes and Scott's (2005) results, but replicated Scott and Dienes's (2008) findings of no implicit learning for responses based on guess. This may be due to the fact that when participants report guessing they are really guessing. That is, they know that they do not know the answer. The knowledge does not exist, and they are aware they do not have it.

In contrast, implict learning occurred when intuition was used at responding. Accuracy and discrimination for responses based on rules were above chance too, indicating that explicit learning occurred. However, a closer look at the rule/s descriptions showed that participants provided rules based on familiarity (e.g., "It sounded like a word presented before"), or based on the recollection of studied words ("words in Spanish have a rolling of the tongue sound", "letter *t* in the middle", "Spanish words do not have the sound /th/", etc.). That is, they seemed to have consciously remembered particular words or particular segments of the words. Responses related to lexical stress were not accurate. Participants reported that particular words had been pronounced with no stress, with more than two syllables, or that the stress was wrong without reporting the rule. One participant in the focus on lexical stress group reported the existence of vowels at the end of the word to indicate that the word was correct or incorrect, and only one participant reported the ending of the word (consonant and vowel) to justify whether the stimulus could be a real Spanish word or not; this participant was also in the focus on lexical stress group. These two participants made more correct responses than mistakes, increasing the probability of hits for this experimental group. So, in general, the rule was not learnt and the participants provided responses based basically on familiarity or recollection of stimuli presented during the study phase to support their answers based on rules.

Overall, it can be said that a few minutes of exposure to spoken Spanish words led to learning, and that the results of Experiment 4 confirmed that the null learning effects found in Experiment 3 were due probably to the salience of the cognate words, whose similarity with English words outweighed lexical stress cues.

Levels of Attention in Implicit and Explicit Learning Analyses

Results obtained by crossing experimental group with response category are summarised in Table 5.9.

To study whether attention to lexical stress is unnecessary to learn lexical stress rules implicitly, the pattern of *d'* values depicted in Figure 5.7 were analysed with a mixed ANOVA in which Response Category (guess, intuition, rule) was the within-subjects variable and Experimental Group (focus on lexical stress, focus on word, split attention) was the between-subjects variable. It was predicted that levels of attention towards lexical stress would affect *d'* values for explicit learning but not implicit learning.

The main effect of response category was significant, *F*(1.4, 220.78) = 5.10 *MSE* = .28, *p* < .05 (with Huynh-Feldt correction due to violation of sphericity), but the main effect of experimental group was not significant, *F* < 1. Finally, the interaction was marginally significant, *F*(3.8, 220.78) = 1.95, *MSE* = .28, *p* = .10.

Table 5.9. Average probability of correct response, *d'* and *C* values for each experimental group and response category of Experiment 4.

Response category	Proportion of correct response	*d'*	*C*
	Focus on lexical stress		
Guess	.52 (.20)	-.06 (.53)	1.24 (.48)
Intuition	.59 (.12)	.23 (.54)	.55 (.34)
Rule	.69 (.28)	.28 (.40)	1.38 (.56)
	Focus on word		
Guess	.54 (.14)	.02 (.53)	1.01 (.44)
Intuition	.58 (.13)	.30 (.47)	.65 (.37)
Rule	.52 (.38)	.03 (.31)	1.67 (.32)
	Split atttention		
Guess	.54 (.15)	.08 (.53)	1.07 (.41)
Intuition	.55 (.13)	.14 (.43)	.51 (.29)
Rule	.68 (.34)	.08 (.46)	1.60 (.37)

Note. *SD*s in parentheses.

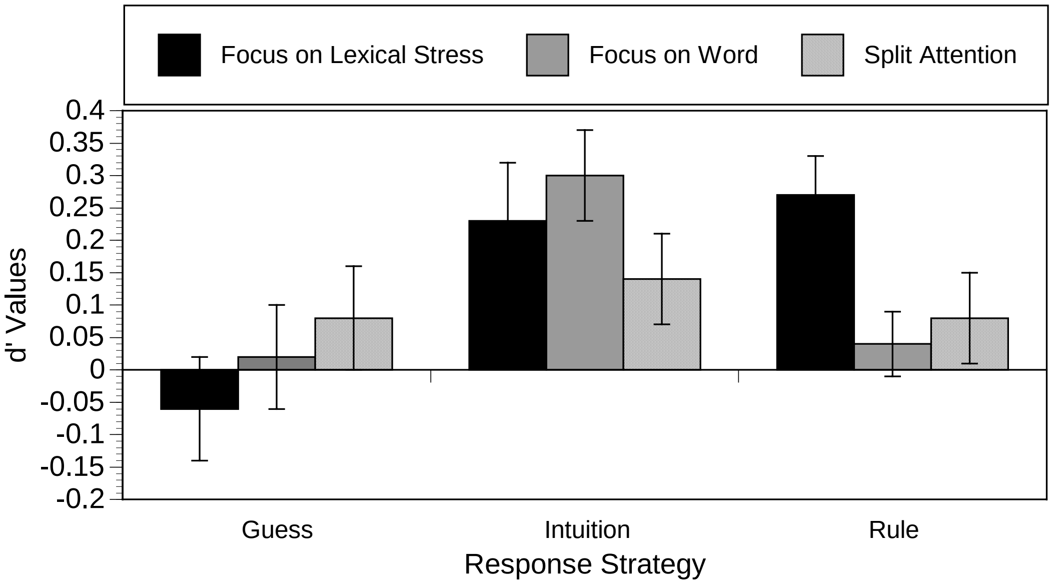

Figure 5.7. Average *d'* values (+*SE*s) for the different experimental groups at each response category of Experiment 4.

Simple main effects of experimental group on the guess response category showed that *d'* values did not differ between groups, *F* < 1. Considering the results obtained previously showing no implicit learning for the guess response category, it can be said that implicit learning did not occur in any experimental group when the participants reported that they were guessing.

However, as tested previously, implicit learning occurred when participants were responding based on intuition. The current analyses showed no differences between groups, *F*(2,116) = 1.18, *MSE* = .23, *p* > .05. This shows that implicit learning of lexical stress rules is independent of the level of attention applied to lexical stress.

Level of attention was important for rule responses; that is, there were differences among the different experimental groups, *F*(2,116) = 4.13, *MSE* = .16, *p* < .05. Orthogonal planned comparisons showed that rules seemed to be explicitly learnt for the focus on lexical stress group. Thus, *d'* values for the focus on lexical stress group (*M* = .28, SD = .40) were significantly higher than for the focus on word and split attention groups combined (overall *M* = .06, *SD* = .39) *p* < .05. In contrast, the split attention (*M* = .08, *SD* = .46) and focus on word conditions (*M* = .04, *SD* = .31) did not differ from each other, *p* > .05. Therefore, it can be said that attempts at explicit learning of lexical stress rules only happened when the participant were paying attention to the critical cue (lexical stress), but not when the critical cue was present but attention was not focused directly on it (focus on word group).

However, it is important to point out that the number of rule responses was scarce, and only one participant could explicitly state the correct lexical stress rule. An alternative mixed ANOVA was performed without the critical subject, who could explain the rule, and the results indicated that the interaction between response category and experimental group did not reach significance, *F*(3.80,218.31) = 1.79, *MSE* = .28, *p* > .05. However, discrimination in the rule response category for the focus on lexical stress group (without the critical subject) was still very high (*M* = .26, *SD* = .39), in comparison to the focus on word (*M* = .04, *SD* = .31) and split attention (*M* = .08, *SD* = .46) groups, suggesting that although the participants could not explicitly state the lexical rule, this group was using other helpful cues that the other groups were not employing. Interestingly, a detailed look at the responses given showed that the rules provided, in fact, could not differentiate a word from a nonword, and that almost all the participants who responded based on rule could not give consistently one or two rules, but a variety of different rules. It seems that the participants in the focus on lexical stress group, because they were prompted to search for rules during the study phase, provided as many rules as they could. For example, a participant said that a stimulus is a word if it has an /r/ sound, and also reported that a stimulus is not a word because it sounded like a Japanese word, and reported familiarity as a rule, or memory of similar instances. Actually, many participants reported familiarity as a rule, and to have heard similar words during the study phase, suggesting that the rule response category included a continuum of explanations based on implicit knowledge (as indicated by the sense of familiarity with the stimuli) and explicit knowledge (by the use of episodic memory of previous stimuli).

To sum up, the second hypothesis stated that levels of attention towards lexical stress would not affect implicit learning but only explicit learning. The results confirmed the predictions. Basically, implicit learning measured by the intuition response category showed that focusing attention on lexical stress, on the words, or splitting attention between two tasks did not affect the level of implicit learning.

Response Categories Implicating Different Mental Processes

The last hypothesis predicted that explicit learning measured by rule responses should show a more conservative bias than guess responses, followed by intuition responses.

A mixed ANOVA in which the within-subjects variable was Response Category (guess, intuion, rule) and the between-subjects variable was Experimental Group (focus on lexical stress, focus on word, split attention) was performed on *C* response-bias values. The analyses (corrected with Huynh-Feldt) showed a main effect of response category, $F(1.92,223.06) =$

132.99, *MSE* = .23, $p < .001$. The main effect of experimental group was not significant, *F*(2,116) = 1.9, *MSE* = .06, $p > .05$, but there was a significant interaction (corrected with Huynh-Feldt), *F*(3.85,223.06) = 3.71, *MSE* = .23, $p < .05$. Figure 5.8 shows the pattern of results.

Simple main effects analyses of response category on the focus on lexical stress group showed significant differences, *F*(1.73, 67.38) = 25.87, *MSE* = .35, $p < .001$ (corrected with Huynh-Feldt). Orthogonal planned comparisons showed that, as predicted, rule responses were characterised by more conservative responses (*M* = 1.38, *SD* = .56) than the guess and intuition responses combined (overall *M* = .90, *SD* = .27), p < .001. As expected, guess responses (*M* = 1.24, *SD* = .48) were more conservative than intuition responses (*M* = .55, *SD* = .34), p < .001.

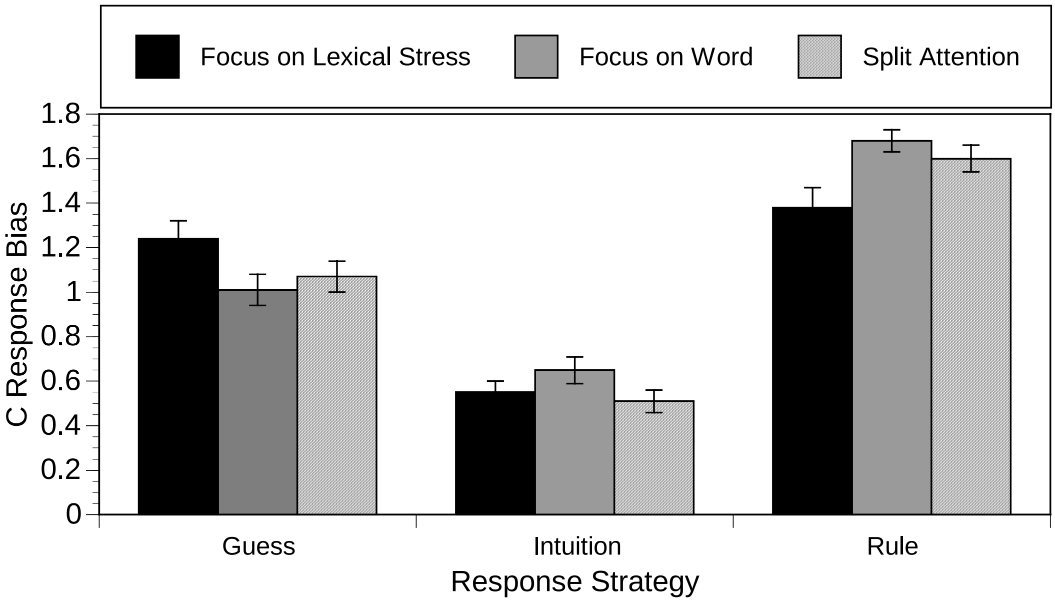

Figure 5.8. Average *C* response-bias values (+*SE*s) for the different experimental groups at each response category of Experiment 4.

Differences in *C* values for the different response categories also occurred in the focus on word group, *F*(2,78) = 60.31, *MSE* = .18, *p* < .001. Orthogonal planned comparisons showed that as expected, *C* response-bias values for rule responses were significantly higher (*M* = 1.68, *SD* = .32) than for the average value of guess and intuition responses combined (overall *M* = .83, *SD* = .22), p < .001. Also, values for guess responses (*M* = 1.01, *SD* = .44) were more conservative than for intuition (*M* = .65, *SD* = .36), *p* < .05.

Finally, *C* response-bias values differed for the different response categories in the split attention group, *F*(2,76) = 71.12, *MSE* = .16, *p* < .001. As in the previous groups, rule responses (*M* = 1.60, *SD* = .37) were more conservative than the average of guess and intuition responses (overall *M* = .79, *SD* = .19), *p* < .001, and guess responses (*M* = 1.07, *SD* = .41) were more conservative than intuition responses (*M* = .51, *SD* = .29), *p* < .001.

The results replicated the findings obtained in Experiment 3 regarding different response biases employed for the different response categories, providing further evidence that the different categories implicated different mental processes, although rule responses could not lead to the real rule underlying the lexical stress patterns. However, the participants thought so and responded with different response biases.

The interaction was due to the lack of significant differences in *C* response bias between groups for the guess response category (*F*(2,116) = 2.85, *MSE* = .20, *p* > .05) and intuition response category (*F*(2,116) = 1.98, *MSE* = .11, *p* > .05), but a less conservative bias for the rule response for the focus on lexical stress group (*M* = 1.38, *SD* = .56) in comparison to the other two groups (overall $M = 1.64$, $SD = .34$), $p < .05$. However, this result was not important for the hypothesis and was not further explored.

Summary of Major Findings of Experiment 3 and Experiment 4

The results showed that hearing FL words that follow a lexical stress rule provides the hearer with knowledge about FL lexical stress patterns that can be used to differentiate real words from nonwords, which differ only in their possible lexical stress patterns. This knowledge is acquired implicitly and is not affected by the level of attention paid to the words. In addition, the analyses of the response biases supported the assumption that implicit and explicit learning depend on different mental processes.

The implications of these results will be discussed further in the General Discussion in the last chapter.

CHAPTER 6

LEXICAL STRESS IN SPEECH SEGMENTATION

Existing work on lexical stress centers on its role in word recognition and speech segmentation in L1, or the comparison of lexical stress between different languages, but relatively few studies have investigated how lexical stress affects word recognition and speech segmentation in bilinguals or FL learners. Regarding word recognition, Experiments 1 and 2 showed that lexical stress is stored in long-term memory and is used for FL word recognition. Experiment 4 indicated that the lexical stress patterns of a FL are learnt implicitly and this knowledge can be applied to previously unfamiliar words. However, it is unclear whether the lexical stress patterns stored in long-term memory will be employed beyond FL word recognition and in lexical decision, and can be used in an on-line task such as a FL speech segmentation task. Speech segmentation refers to identifying words within a continuous acoustic signal in which the boundaries between words are not clear. Lexical stress seems to be an important cue in speech segmentation. Due to the fact that exposure to spoken FL words facilitated lexical decisions of new words, then exposure to spoken FL words could also provide the listener with implicit knowledge of FL lexical stress patterns that facilitate the process of speech segmentation.

Research on speech segmentation shows that lexical stress is critical for L1 speech segmentation to occur. For example, Cutler and Norris (1988) requested participants to spot embedded real words (e.g., mint) in nonsense strings (e.g., mintayve or mintesh), and manipulated the lexical stress of the nonsense strings: *mintayve* having two strong syllables, and *mintesh* having only the first one (min). The results showed that participants recognised *mint* inserted in two-strong-syllable words (mintayve) more slowly than in words with a strong-weak syllable pattern (mintesh). The explanation for those results was that the two strong syllables—as in mintayve—triggered syllabic segmentation, so the phoneme /t/ could pertain to both syllables (mint or tayve), hampering recognition of the target word (mint). Based on these results, they proposed the Metrical Segmentation Strategy (MSS): Lexical access and speech segmentation in English starts with the word's strongest syllable.

Jusczyk, Houston, and Newsome (1999) showed that seven-and-a-half month old babies use the strong syllable in disyllabic words (e.g., king in the word kingdom) to identify these words within continuous speech. Due to the fact that 90% of the words in English start with a strong syllable, that cue would be very salient and predictive.

Toro-Soto, Rodríguez-Fornells, and Sebastián-Gallés (2007) hypothetised that if lexical stress was important, then Spanish listeners would use it as a cue to segment three-syllable words in artificial continuous speech (as English speakers do). However, in contrast to English, in which 90% of the words start with a stressed syllable (Jusczyk et al., 1999), Spanish words are mainly stressed on their penultimate syllable in three-syllable words (Harris, 1983). Toro-Soto et al. employed continuous syllabic streams made of three-syllable words, and manipulated stress by a pitch change on the first, the second, or the third syllable (different experimental conditions). In addition, they also created a random stream with random pitch changes—embedded in each experimental condition—to control for undesirable effects of rhythm (i.e., to avoid predictable syllabic stress every three syllables). The results showed that stress, on any of the three syllables, did not facilitate segmentation, contrary to other studies in which stress was found to be a reliable cue for segmentation, for example when stress is on the first syllable (e.g., English and Finnish), or on the last syllable (e.g., French). They suggested that those studies assessed languages in which stress and word boundaries match (as English and French). Stress would lead the listener to pay more attention to the word boundary facilitating segmentation. In the case of Spanish, however, the stress would bring the attention to a syllable that does not mark a word boundary, interfering with segmentation. So, in terms of speech segmentation, stress may be even more important in stress-timed languages like English than syllable-timed languages like Spanish.

In order to study further lexical segmentation by phonotactic probabilities and suprasegmental cues, Toro, Sebastián-Gallés, and Mattys (2009) created an experiment very similar to the experiment described previously (Toro-Soto et al., 2007). Basically, they inserted in the continuous speech stream pitch changes—as a simulation of lexical stress—on the first, middle, or last syllable of the concatenated words. The objective was to compare the interaction between suprasegmental cues in segmentation and segmentation styles in different languages (English, Spanish, or French). It was expected that pitch change on the first syllable facilitated segmentation in English, pitch change of the middle syllable facilitated Spanish segmentation (because the lexical stress of multisyllabic words in Spanish tends to be on the middle syllable, the pitch change would indicate that that syllable is not the end of a possible word, but the next syllable is), and pitch change on the last syllable eased speech segmentation in French. However, English and Spanish speakers responded identically. Basically, pitch changes on the first or last syllable did not facilitate segmentation further than flat pitch (no pitch). That is, pitch changes did not add extra cues for segmentation, and segmentation could be performed uniquely based on phonotactic probabilities. For English and Spanish, pitch change on the middle syllable hampered segmentation, probably because it attracted attention towards inappropriate word boundaries (e.g., the participants may have used the pitch change as an indication of the beginning or end of a disyllabic word). The French speakers showed that pitch changes in any of the syllabic positions did not facilitate or hinder segmentation, and as the other groups, only phonotactic probabilities were useful for segmentation. Considering these results together with Toro-Soto et al.'s (2007), it seems that pitch changes *simulating* lexical stress do not ease segmentation above phonotactic probabilities computations. It is not clear whether more *natural* correlates of lexical stress would lead to different results. Natural speech uses frequency, amplitude, and intensity to indicate syllabic stress. Therefore, natural syllabic stress provides more than one cue (i.e., not only pitch change) for speech segmentation.

Overall, it can be said that a language like Spanish (in comparison to English) seems to make greater use of lexical stress to cue word recognition than English, and English (in comparison to Spanish) seems to make greater use of lexical stress as a cue for segmentation. In addition, experiments carried out with artificial lexical stress indicate that it may not be a good correlate of natural speech, which contains other features such as change in syllabic duration and intensity. Experiment 5 will study speech segmentation employing natural lexical stress, and will study whether the knowledge of FL lexical stress patterns stored in long-term memory can facilitate speech segmentation.

Experiment 5

Speech segmentation involves locating word boundaries in a continuous acoustic signal in which physical cues are not obvious. English speakers seem to use a word’s strong syllable to locate its beginning. In contrast, a language such as Spanish cannot rely on this regularity since the probability of trochaic and iambic stress (in disyllabic words) is much more balanced than in English.

The previous experiments have shown that lexical stress is perceived, codified, and implicitly learnt even though the exposure to the FL was relatively brief. In this experiment, the objective is to find out whether such knowledge can facilitate speech segmentation of a spoken sequence in which unfamiliar words are concatenated. To do so, three experimental groups were used. One group studied correctly-pronounced trochaic and iambic words (lexical stress group, as in the study phase of the previous experiments), another group studied words with no lexical stress (flat stress group), and another group did not study any Spanish word before performing the speech segmentation task (control group). Table 6.1 shows the different experimental groups defined by the stimuli they study during the study phase.

Table 6.1. Experimental groups in Experiment 5.

	Experimental group		
Word	Lexical stress	Flat stress	Control
brujo	BRUjo	BRUJO	-
crear	creAR	CREAR	-
tierno	TIERno	TIERNO	-
desliz	desLIZ	DESLIZ	-

Hypothesis

If implicit learning of FL lexical stress rules (or patterns) occurs, this knowledge probably may be employed to segment continuous speech into words—measured by the number of correctly spotted word boundaries—only when participants have been exposed to FL words with correct lexical stress, in comparison to participants who are exposed to words pronounced with no lexical stress (flat-stress) or have never studied FL words before.

Method

Participants

Ninety students from the National University of Singapore, with the same characteristics as the previous experiments, took part in this experiment for course credit. None of them had participated in any of the previous experiments.

Materials

All the stimuli were spoken by the same native female Spanish speaker of the previous experiments. Stimuli were digitally recorded in 16-bit mono, 44.1 kHz, .wav format; with the overall root-mean-square amplitude levels for each token digitally levelled to ensure equal presentation levels.

A preliminary pool of 111 noncognate words was created[35]. These words were assessed by 11 independent participants—who did not take part in the main experiment—so that the words did not resemble any English word (i.e., to avoid cognates in the list). For the 60 words eventually selected, the average probability of correct recognition as a noncognate was .79 (i.e., in 79% of the cases, the word could not be related to any known English word).

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[35] Not all the 64 words employed in Experiment 4 could be used in Experiment 5 due to the Spanish speaker's incapability of pronouncing some words with flat stress. Therefore, a large pool of words was created to be able to choose, later on, words that could be pronounced with both normal and flat stress.

All the words were recorded twice, once pronounced correctly (e.g., CASco), and the second time pronounced with flat lexical stress pattern (i.e., no lexical stress distinction between both syllables)[36]. Producing words with flat stress was difficult, and 29 students, who did not participate in the main experiment, listened to the words and were requested to signal the strongest syllable: First, all the words were presented with flat-stress (one block), followed by normal lexical stress (second block). Re-recordings were performed until the desirable criterion was reached: more than 80% of correct stress assignment for normal-stress words, and 50% of probability (chance) that a listener assigned stress on the first or second syllable for flat-stress words, as shown in Table 6.2.

Table 6.2. Characteristics of the words used in the study phase of Experiment 5.

Pronunciation at study phase	Correct lexical stress assignment	Word duration
Normal-stress	.83 (.09)	700.77 (105)
Flat-stress	.50 (.09)	1401.77 (212)

Note. *SD*s in parentheses.

Eventually, 60 disyllabic noncognate words, 30 trochaic-stress and 30 iambic-stressed, were chosen as stimuli. Words pronounced with normal lexical stress and flat-stress words differed in the probability of correct lexical stress assignment, $F(1,59) = 398.05$, $MSE = .01$, $p < .001$, and word duration $F(1,59) = 639.47$, $MSE = 23162.10$, $p < .001$. Moreover, visual analyses of the

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[36] Natural speech was employed to manipulate lexical stress and to obtain words as natural as possible (same speaker, adequate coarticulation effects, voice onset effects, etc.).

waveforms of the flat-stress words assured that both syllables were similar regarding duration, and amplitude, as shown in Figure B1 in Appendix B.

The 60 words were split into the study and test phases. In each phase, there were 15 trochaic-stressed words and 15 iambic-stressed words, and in both phases words had a similar proportions of letter endings (-a,-e, -o, -n, -d, -z, -l, -r).

The 30 words used in the test phase were embedded in sentences. There were 10 sentences in total; each sentence contained 3 concatenated words plus one filler word attached at the beginning of the sentence, and one filler word attached at the end of the sentence, as shown in Figure 6.1.

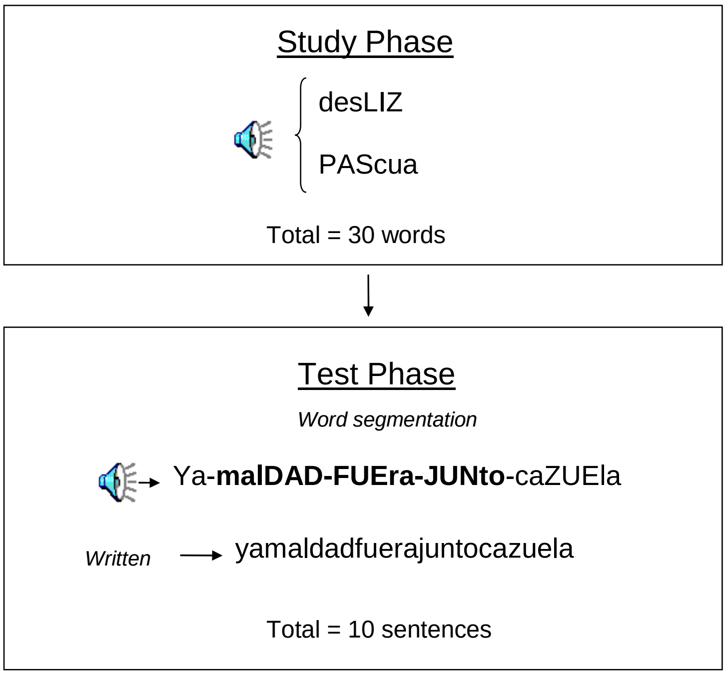

Figure 6.1. Examples of stimuli in Experiment 5.

In no sentence did three trochaic or three iambic words appear consecutively. Filler words were monosyllabic words or three-syllable words (e.g., *ya* and *cazuela*). Note that the target words (i.e., the 30 target words used in the test phase) were all disyllabic. The use of the fillers had the purpose of preventing the participants from correctly segmenting the critical words every two syllables (since the studied words were all disyllabic). Three-syllable fillers were stressed on the middle syllable, half of them ended with a consonant, and half of them ended with a vowel. Thirty-three students who did not take part in the main experiment and who had not studied Spanish before, were requested to segment these sentences. Sentences with pauses or other cues that clearly indicated the beginning or ending of a word were re-recorded and re-tested by small groups of participants until reaching, for the 10 recoded sentences, an average probability of 7.6 correct word segmentations (the maximum is 40), which was considered the baseline. Table A4 in Appendix A shows the foils, words, and sentences used in this experiment. Sentences had no meaning as they were a concatenation of words and their rhythm was determined by the lexical stress of the words they were made of. The average duration of the spoken sentence was 2,269.65 ms (*SD* = 241.56).

Design and Procedure

Two versions were created to counterbalance the stimuli among the study and the test phases. Moreover, because the critical words of the sentences could not be randomised within each sentence, another two versions were created in order to semi-randomise the words in the sentences. So, in total four versions were created and participants were assigned randomly to one of the versions using a balanced latin-square procedure.

Each participant was randomly assigned to one experimental condition (lexical stress, flat stress, control) and one version of the experiment, programmed with E-prime 1.2.

Except the control group, which engaged in speech segmentation directly, the other two groups (lexical stress and flat stress) were requested to memorise 30 words presented binaurally through Beyerdynamic DT150 headphones at approximately 70 db SPL. Words were presented randomly and each word was repeated three times, with one second between repetitions, and three seconds between different words. Participants were asked to memorise each word, and to try to focus on each word. Emphasis was made on not trying to keep rehearsing previous trials, but to focus and study each word while it was heard.

In the test phase, ten sentences were presented randomly one at a time in a random order. Participants performed the speech segmentation of the sentence written on a booklet, in which each page had one of the 10 sentences. All sentences were numbered. Before hearing each sentence, a message displayed on the screen announced to the participant which sentence number was about to be played, so he or she could look for that sentence in the booklet. Once the booklet was open on the appropriate page showing the sentence, the participant pressed a button on a response box to start the auditory presentation of the sentence. Participants could perform the sentence segmentation in the booklet after or while listening to the sequence. After they responded, they were allowed to hear the same sentence only one more time and make changes to their responses if needed. They pressed the same button to continue to the next sentence. The participants responded at their own pace. The session lasted approximately half an hour.

Results and Discussion

Three participants, one in each experimental group, were eliminated from the database because they segmented the sentences by syllables and not by words. In addition, one participant with scores lower than 2.5 *SD*s from the mean was eliminated. The analyses were performed with a total of 86 participants.

The maximum number of correct segmentations for each sentence was four. For each sentence, performance was assessed by scoring correct-boundary word segmentations and deducting incorrect-boundary word segmentations. Only target words were considered. That is, segmentations performed within filler words were not scored as correct or incorrect segmentations. Some examples are shown below:

Sentence: ya**maldadfuerajunto**cazuela

Targets: / maldad / fuera / junto /

Filler words:/ ya / cazuela /

Full correct segmentation: ya**/maldad/fuera/junto/**cazuela.

↑ ↑ ↑ ↑

Total score: 4 (correct segmentation) - 0 (incorrect segmentation) = 4

Incorrect segmentation: ya/**mal/dad/fuera/junto**/cazuela.

↑ x ↑ ↑ ↑

Total score: 4 (correct segmentation) - 1 (incorrect segmentation) = 3

Incorrect segmentation: ya/**maldadfuera/junto**/cazue/la.

↑ ↑ ↑

Total score: 3 (correct segmentation) - 0 (incorrect segmentation) = 3

Incorrect segmentation: ya/**maldadfuera/jun/to/**cazuela.

↑ ↑ x ↑

Total score: 3 (correct segmentation) - 1 (incorrect segmentation) = 2

Incorrect segmentation: ya/**maldadfu/era/jun/to/**cazuela.

↑ x ↑ x ↑

Total score: 3 (correct segmentation) - 2 (incorrect segmentation) = 1

The total number of sentences was 10. Therefore, there were 40 possible correct segmentations in the experiment.

A one-way between subjects ANOVA was performed on the data. Experimental group with three levels (lexical stress, flat stress, and control) was the independent variable, and the dependent variable was word-boundary segmentation accuracy (i.e., sum of correct segmentations minus incorrect segmentations for the ten sentences).

The results showed no significant differences between groups, $F < 1$. Participants who studied normal-stressed words obtained a total score of only 9.07 ($SD = 6.59$), those who studied flat-stressed words got 8.93 ($SD = 6.46$), and those who did not study any word during the study phase made 10.55 (*SD* = 6.59) correct segmentations.

Implicit learning of lexical stress patterns was assumed for the lexical stress group based on to the results of Experiment 4. However, listeners could not make use of this knowledge to segment continuous speech. The previous experiments showed that studying a few FL words provided the learner with knowledge about the lexical stress features of the language that could be used in future word recognition of studied words and in LDTs. However, this knowledge was not applied to speech segmentation. The fact that segmentation may be a more complex task than word recognition and lexical decision of unfamiliar words is not completely surprising. That is why native speakers tend to slow down the rate of speech, and make more pauses, when talking to FL learners. This is also observed in directed-infant speech to young children.

So, exposure to FL words did not facilitate speech segmentation. Further discussion will be carried out in the General Discussion in the next chapter.

CHAPTER 7

GENERAL DISCUSSION

Summary of the Main Findings

The first objective of this thesis was to study the role of lexical stress in FL word codification. The results showed that lexical stress was perceived, codified, and used in FL word recognition. The results also showed that the probability of recognition for FL cognate words was higher than for noncognate words, suggesting that L1 lexicon was accessed while hearing FL. Moreover, activation of L1 lexical representations occurred faster for cognate words with identical stress patterns in Spanish and English than for cognate words with dissimilar lexical stress patters, suggesting that lexical stress is very important in lexical activation. The fact that the participants encoded lexical stress unintentionally suggested that this was carried out implicitly. In addition, a different pattern of *C* response bias for cognates and noncognates suggested different recognition processes: a very liberal response bias for cognate words and less of a liberal response bias for noncognate words; since conservative bias is set for easy tasks according to Rotello and Macmillan (2008), the results indicate that recognising cognates must have been more difficult than noncognates.

The second objective was to provide experimental evidence that FL lexical stress rules could be learnt implicitly by exposure to spoken words, that is, that the rhythm of the words is learnt implicitly. The results showed that implicit learning of lexical stress rules occurred since the participants could apply this implicit knowledge to discern new FL words from nonwords. Importantly, implicit learning of lexical stress patterns occurred independently from the level of attention paid to the spoken words. The SDT analyses also supported the view that the different response categories of guess, intuition, and rule, were appropriate indices of implicit learning (guess and intuition) and explicit learning (rule) since they seemed to rely on different mental processes, according to the pattern of *C* response bias. However, although participants may have believed they had acquired some rules and could describe them, the rules were not decribed correctly and the participants mainly used recollection and familiarity with the previously studied FL words to judge new words.

Finally, given the importance of lexical stress in segmentation, the last hypothesis proposed that since lexical stress patterns or rules could be learnt by exposure to spoken FL words, and facilitated lexical decisions of new words, this knowledge could also facilitate speech segmentation of sentences composed of new words. However, the results did not support this hypothesis.

The following sections discuss each of these findings in more detail.

Is FL Lexical Stress Codified?

The results confirmed that FL lexical stress is automatically codified. It could not be easily predicted whether Singaporeans could perceive FL lexical stress and encode it when learning new words since Singaporeans show lexical stress patterns different from standard British English (Low & Brown, 2003; Deterding, 2001; Low et al., 2000; Chang & Lim, 2000; Low & Grabe, 1999). Moreover, most of the students spoke Mandarin, and stress distinctions seem very difficult for speakers of tone languages (Akker & Cutler, 2003). Most importantly, the literature review showed contradictory results: Dupoux et al. (2008) found that French speakers showed poor Spanish lexical stress codification. Archibald (1993) found that Spanish learners of English filtered lexical stress according to L1 patterns. González (2002) reported negative transfer for cognate words by English speakers learning Spanish. In contrast, Sanders et al. (2002) showed that English lexical stress patterns were used automatically in different phoneme identification tasks, even by late Spanish-English bilinguals, indicating that lexical stress patterns could be rapidly acquired. Finally, Guion et al. (2004) found that Spanish-English bilinguals correctly attributed the lexical stress of English words, implying that lexical stress for FL is codified.

Finding no codification, or use of L1 lexical stress patterns, would have not been extremely unexpected, though. In fact, the phenomenon of foreign-accented speech has been explained by the filtering of the FL through the L1 phonological system and articulatory habits (Flege, Bohn, & Jang, 1997), although perceptual training can dramatically improve perception (e.g., the differentiation of /l/ and /r/ by Japanese speakers) and production (Samuel & Kraljic, 2009). The results in Experiments 1 and 2 suggest that the codification of lexical stress is automatic and does not require perceptual training or a recalibration of the perceptual system. Moreover, the learner seems to register each example, which explains why lexical stress of cognate words was retained in memory and used for word recognition. However, these results are not definitive or universal regarding the encoding of lexical stress by FL learners. An interesting open question is why French adult speakers do not seem to encode Spanish lexical stress (Dupoux et al., 2008). Other studies (e.g., Goetry et al., 2006; Toro et al., 2009) agree that French speakers have poor lexical stress perception. This is due to French language not using contrastive lexical stress. Further research is required to establish whether FL lexical stress is codified regardless of the type of L1 and associated lexical stress.

The results also inform us that lexical stress is a word attribute that has to be implemented in models of word recognition. Moreover, for languages with different weights for lexical stress in lexical access, such as English and Spanish, the parameters for lexical stress may be different. This needs to be included in modelling and computational simulations.

It could be argued that same-stress words were recognised better than different-stress words because of phonological priming. Priming lowers the threshold in perceptual identification and recognition of an existing representation. To avoid priming, different tokens were used during the study and test phases. Moreover, even assuming that priming effects can occur over long lags in duration (Jacoby & Brooks, 1984), noncognate words have no existing representations in the mental lexicon, so it is likely that recognition is not due to priming.

Another important point is that lexical stress is codified but it may not be used at retrieval if the learner is not aware of its importance. For example, when the participants did not know that differences in lexical stress were important for recognition, participants may have used other salient cues (in this case, similarity with English words) to respond. This is interesting because FL accent has been attributed to limitations of the perceptual system (Flege et al., 1997). In this study, however, it has been shown that lexical stress is perceived and codified with little interference from L1 lexical stress patterns. FL accent may occur because of the articulatory habits and the lack of awareness of the importance of lexical stress for intelligibility, and not because the speaker cannot perceive the FL properly.

The Unified Competition Model (MacWhinney, 2005) predicts that more salient and familiar cues will be used first. However, this model also predicts that transfer from L1 to L2 will occur. The first two experiments showed that trochaic stress words seemed to be more accurately codified than iambic stress words, which could suggest that typical English lexical patterns would be easier to process. It is also the case that familiarity with a L1 word facilitated cognate recognition in comparison to noncognate recognition, and that L1 lexical stress transfer did not occur. Overall, it can be said that the results suggest that familiar cues are used at recognition, but FL lexical stress patterns were not overridden by the lexical stress structure of L1.

From a pedagogical perspective, Experiment 1 and Experiment 2's results suggest that English speakers codify lexical stress. Therefore, exercises focusing exclusively on lexical stress perception are not recommended. If an English speaker does not appropriately use lexical stress when recognising Spanish words, it is not because of poor lexical perception abilities, but because he or she is not aware that lexical stress is important for intelligibility and is using other cues that are probably more salient. If this is the case, the learner has to be alerted. Lightbown and Spada (2001) state that errors in production become habits, so it is important to learn correctly.

Regarding access to the L1 lexicon, the higher probability of recognition for cognate words in comparison to noncognate words shows that cognate words may have tapped L1 representations. The Input Processing model (Van Patten & Williams, 2007a) states that learners process input for meaning before form. The results of this thesis cannot assure that meaning was searched first, but they suggest that meaning for cognate words was accessed. According to Van Donselaar et al. (2005), word recognition consists of segmental and suprasegmental match between the acoustic form and the stored lexical representations, which activate meaning. The overlap with words in the English lexicon must have activated meaning, as predicted by Cohort, TRACE, Short-list, and BIMOLA. Access to meaning probably produced a better and deeper memory trace in comparison to the so-called *shallow* memory trace for only phonological codes (Craik & Tulving, 1975). Since cognate words seemed to be easily codified, and considering that Spanish and English share many cognates, teaching them at early stages of FL learning may increase the acquisition of vocabulary as well as the acquisition of FL lexical stress.

If we assume that probability of recognition for cognate words was higher because they tapped L1 representations and have a full lexical entry in the lexicon, we have to accept that noncognates are not yet completely lexicalised, that is, they can be learnt but probably they do not match any mental representation. This is what Gaskell and Dumey (2003) found: Although exposure to nonwords created a durable episodic memory trace, those words did not show lexical competition (used as a test of lexicalisation) at word recognition. Lexicalisation also requires a period for consolidation of about one week, in which lexical competition effects between the new learnt words and other phonologically similar words in the lexicon arise. The lack of full lexicalisation may explain why recognition was worse for noncognates than for cognates in this experiment.

Furthermore, analyses of RTs and accuracy for trochaic stress and iambic stress cognates provide a more accurate measure of lexical access. Results showed that lexical activation was critical for trochaic stress cognates, which maximally match the English representation, indicating that cognates with different lexical stress in both languages are not fully represented in the lexicon. This affected word recognition latencies, but not accuracy. This data is useful for future simulations of word recognition in bilinguals.

It can be highlighted that participants recognised most of the studied words and rejected almost perfectly nonstudied words. Although learning 48 new foreign words in such a short time cannot be considered an easy task, phonological traces appear to be strongly encoded in long-term memory. This suggests that the great capacity for phonological codification may be the basis for language acquisition. Gaskell and Dumay (2003) found that after a brief exposure to nonwords, more than 90 % of them were recognised afterwards, however they used 26 nonwords, and each one was repeated 12 times. It could have been expected that if each word had been repeated more times (not only three times), recognition would have improved, as many memory models predict (e.g., Atkison & Shiffrin, 1968; Baddeley, 2001, 2000).

Furthermore, many noncognate words were learnt despite no meaning being associated with them. This supports the view that long-term memory holds representations for phonological form and for meaning at different levels of representation (Norris, Cutler, McQueen, & Butterfield, 2006). This finding also shows that long-lasting memories, at least for phonological forms, can occur without access to meaning.

To sum up the results of Experiment 1 and 2, lexical stress is automatically codified in FL word acquisition. Recognition seems to make use of lexical stress implicitly since participants codified it without explicit instructions to do so, and despite reporting that they had not codified lexical stress and had responded at random. There is access to L1 representations when FL and L1 words are similar. L1 activation occurs faster for cognate words with the same lexical stress pattern in Spanish and English. Despite lexical stress being codified, it may not be always used as a cue for recognition when other cues are more salient and the participant does not know which cues are critical to solve the discrimination task. This suggests that lexical stress is codified but it may not be evident when the participant is not aware that lexical stress is an important cue for recognition of otherwise identical words.

Can Lexical Stress Rules Be Learnt Implicitly?

Experiment 4 illustrated that hearing FL language facilitates acquisition of lexical stress.

It is assumed that the rhythm of the language is implicitly acquired, and that this learning tunes the perceptual system to the characteristics of the FL language, produces chunking of phonological sequences, the induction of regularities, the prediction of informative cues, and overall facilitating the processes of word recognition and speech segmentation (Ellis, 2007, 2006a, 2006b; MacWhinney, 2005; Ridway, 2000). The experiments of this thesis have shown that lexical stress patterns can be learnt by hearing FL words, and that lexical stress is a feature used in word recognition (Experiments 1 and 2) and lexical decision (Experiment 4).

Regarding acquisition, the results indicated that lexical stress rules of a FL can be acquired implicitly, as proposed in CREED (Ellis, 2007) and the Unified Competition Model (MacWhinney, 2005). It is possible that the correlation of lexical stress with the segmental structure of a word (ending with a consonant or a vowel) is salient enough for learners to implicitly acquire this regularity (Experiment 4). Moreover, implicit learning at the suprasegmental level seems not to depend on comprehensible or meaningful input. This result shows that at some level—lexical rhythm in this case—learning occurs implicitly and for this type of acquisition meaningful input is not necessary. However, the saliency of lexical stress was slightly overshadowed by the saliency of the cognates, when these were used in Experiment 3. So, the saliency of one feature is relative to the saliency of the rest of the features being processed.

The Skill Acquisition Theory (DeKeyser, 2007) as well as other perspectives such as the Input, Interaction, and Output perspective (Gass & Mackey, 2007), and the McLaughlin's Information Processing Model and Anderson's ACT model (as cited in Mitchell, 2004) agree on the importance of explicit learning. DeKeyser emphasised that exposure leads to exemplar-based learning and poor generalisation, and this seems to be the case. One participant could explicitly abstract and explain the lexical stress rule, but many participants seemed to use remembered instances (examples) as models to compare with, when performing the LDT. So, if the objective of teaching is that the learner explicitly learns a rule, then we should teach it directly and provide examples that follow the rule. However, knowledge of the rule does not always ensure its use. For example, as a bilingual, I found myself saying *finger* for *toe* frequently because Spanish uses the word *finger* for both fingers and toes, even while being aware of this type of discrepancy. So, if the aim is for the learner to use the rule automatically (and not explain it), implicit learning is as effective as explicit learning, and implicit learning just depends on exposure to spoken language. Moreover, such exposure will facilitate the induction of other segmental and suprasegmental regularities, tuning the perceptual system, and in general facilitating cognitive processing of new input.

Furthermore, Experiments 3 and 4 showed that the guess, intuition, and rule response categories were adequate measures of implicit and explicit learning due to the dissociations produced by attentional levels, as previous research had established (Dienes & Scott, 2005; Jacoby, 1991; Johnson & Hasher, 1987; Scott & Dienes, 2008). Thus, discrimination between words and nonwords for intuition responses (implicit learning of lexical stress rules) was not affected by the level of attention paid to lexical stress, and relied on unconscious knowledge. However, discrimination for responses based on rules (explicit learning of lexical stress rules) was affected by attention; discrimination was much better when the participant searched for rules and focused on lexical stress than when he or she focused on words or split attention. The distinction was further supported by differences in *C* response-bias, indicating that when the participants thought they were responding accurately because of the acquisition of a rule, they showed more conservative responses than when responding by intuition. While response bias was shown to reflect different types of mental processing in the remember-know paradigm, Experiment 3 and 4 showed that different types of mental processes underlie the guess, intuition, and rule response categories.

On the whole, the experiments have provided evidence that listeners can learn lexical stress rules implicitly. Moreover, it has been shown that the measures used to test implicit learning are supported by theoretical dissociations regarding attention and response biases.

Although research comparing implicit and explicit learning have concluded that explicit learning is more effective than implicit learning (Lightbown & Spada, 2001; Norris & Ortega, 2006; Radwan, 2005; Takahashi, 2005), the results of Experiment 4 indicate that implicit learning occurred and it seemed to be as effective as explicit learning (knowledge of the rule or recall of similar words) to respond in a LDT. Implicit learning in previous experiments may have not been measured with indirect tasks, which are more appropriate to capture implicit learning. For example, Radwan (2005) compared how learners of English would notice the rules of dative alternation[37]. Participants were requested to read a text containing the critical dative alternation rule. He found that the rule was learnt only when the rule was explained a priori, but not when the critical dative verbs and complements were visually enhanced or simply presented in the text (implicit conditions). To measure acquisition, he used a grammaticality judgment task (sentences were given and the participant had to report *correct* or *incorrect*. The sentences included the verbs used in the text), a preference task (rate 1 to 5 how natural sentences containing the target forms sounded), and a controlled writing task (describing actions represented by pictures containing the target dative verbs). These tasks are direct tasks because they require recognition and production of examples previously learnt, and this may have been the reason why Radwan did not find implicit learning effects.

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[37] Dative alternation refers to the fact that some verbs in English allow the direct object to be immediately after the verb (as in Tom bought *a book* for Jane) or after the indirect object (as in Tom bought Jane *a book*). However, note that some verbs do not allow such syntactic change (*Tom purchased Jane a book). The rule incidentally presented in this experiment was that monosyllabic verbs (such as buy) allowed dative alternation, and disyllabic verbs (such as purchase) did not.

So, the use of direct tests underestimates or does not detect implicit learning. Since language exams mainly test explicit knowledge, it could be that the benefits of being exposed to spoken language, such as in facilitating word recognition, has been neglected in classroom settings yet. The time employed in teaching grammar may result in less time to expose learners to spoken language. Exams usually test vocabulary and grammatical knowledge and also listening and speaking skills. Usually these four tasks have the same weight in the final score for proficiency. However, listening skills depend greatly on automatic processes of word recognition and speech segmentation. These skills are negatively affected by the lack of exposure to spoken language. This is in contrast to explicit tests requiring vocabulary (translation) and grammar knowledge (sentence completion or composition) which are not influenced as much by exposure to spoken FL. Furthermore, although intelligence is related to reading, grammar, and vocabulary acquisition, implicit learning is not correlated to intelligence (Lightbown & Spada, 2001). Therefore, hypothetically, tasks that promote implicit learning such as listening to FL songs, films, texts, tales, and so on, as well as tasks that measure implicit learning, may be very useful for teaching FL to special students, who because of their cognitive characteristics cannot acquire complex grammatical rules.

Can FL Lexical Stress Rules (or Patterns) Stored in Long-term memory Be Used in Speech Segmentation?

Exposure to spoken FL words facilitated lexical decisions of new words (words that had not been heard before), but did not facilitate speech segmentation of sentences made of new words. One plausible explanation for these findings is that the listener can make use of lexical stress in segmentation only after he or she has previously heard the stimulus in isolation (with their corresponding lexical stress) before it can be segmented. Presenting the stimuli in isolation may create a trace which can be recognised later on in continuous speech from its segmental and suprasegmental features. For example, Jusczyk et al. (1999) exposed children repeteadly to target words presented in isolation, and found that children recognised these same words inserted in continous spoken sentences. In contrast, in Experiment 5 the participant heard different words in the study and segmentation phases. Similarly, in Cutler and Norris's (1988) word spotting task, the participants had to identify known words (i.e., words they had experienced, e.g., mint) within nonwords (mintesh). According to McQueen (2007) in segmentation, the listener relies on the assessment of multiple lexical candidates competing for recognition. On the whole, it seems that for lexical stress to affect speech segmentation, the listener needs to have had previous experience with the stimuli to be segmented.

However, in experiments on speech segmentation by phonotactic probabilities participants are exposed to an artificial language and yet can recognise words in a two-alternative forced-choice task, just by implicitly calculating the probability of syllables occurring contiguously. Toro et al. (2009) found that artificial lexical stress (by pitch changes) did not provide further useful information for segmentation than the one provided through calculation of phonotactic probabilities. I suggested that artificial pitch changes may be not representative of lexical stress, which employes differences in pitch, duration, and intensity. Experiment 5 used natural lexical stress, but exposure to it did not facilitate segmentation, since the participants performed equally after having studied and not studied Spanish words. So, it may be that to perform segmentation successfully the words have to be either presented earlier in isolation or in continuous speech. In the latter case, phonotactic probabilities are more important than lexical stress. In fact, Mattys, White, and Melhorn (as cited in Toro et al., 2009) considered that suprasegmental cues had less weight in speech segmentation than lexical and segmental cues.

Furthermore, the segmentation task may have required many cognitive resources. Thus, at segmentation, the participants had to listen to a full sentence at the same time as reading a continuous stream of letters in a booklet. A recent study carried out by Mattys, Brooks, and Cooke (2009) has shown that cognitive load, due to concurrent attentional or mnemonic processing, negatively affects segmentation. When listeners are required to perform concurrent tasks, they rely more on lexical-semantic structure of the speech than on sublexical cues (such as acoustic cues), because lexical and semantic features have higher communicative value. If this is the case, cognitive load (at listening and reading the sentences) and lack of lexical-semantic information could be the reason why participants could not segment continuous speech.

On the whole, it seems that lexical stress can be implicitly learnt and be used in word recognition and lexical decision, but not in speech segmentation, at least not after only a brief exposure to a few examples. Overall, in segmentation, it seems that word identification, followed by phonotactic cues, and finally followed by suprasegmental cues are important in that order.

This indicates that to perform segmentation the FL learner has to initially increase his or her vocabulary first. So, teaching should focus on vocabulary learning and exposure to the sounds of the words before longer grammatical structures are learnt.

This does not mean that learners cannot take advantage of listening to FL, but improvements in speech segmentation abilities will probably become evident after the listener has sufficient vocabulary, when processes are more automatic and do not require many cognitive resources. Hence lexical knowledge may aid speech segmentation.

One way in which segmentation by lexical stress could be improved is by recommending that participants start to read the FL overtly, so that learner increases his or her awareness of lexical stress patterns in continuous speech. The efficacy of this suggestion is still open to investigation.

Implications

The aim of the thesis was to provide useful data for word recognition modelling, FL acquisition theory, and for FL education. Results related to lexical stress codification (Experiments 1 and 2) indicate that lexical stress is an attribute of the word, critical for lexical access and word recognition, not only in L1, but also in FL. Hence, it is important to incorporate this feature into speech recognition models and speech recognition machines.

Moreover, recognition probabilities and RT differences between cognates and noncognates were informative regarding how new words can be integrated into the existing lexicon. It was found that the probability of word recognition was higher for cognates than for noncognates. In addition, cognates with equal lexical stress patterns in English (e.g., BINgo) and Spanish (BINgo) were recognised faster than cognates with different lexical patterns (DRAgon vs. draGÓN, in English and Spanish, respectively). Furthermore, recognition latencies for cognates words such as draGÓN were equal to noncognates, indicating that FL cognates with different lexical stress in English and Spanish might not be tapping the same lexical representation, and a new representation needs to be created. This is interesting because it suggests that word recognition may predominantly be a bottom-up process. Features such as lexical stress are critical for lexical access. This research provides support for buttom-up models such as the Shortlist model (Norris, 2004; Norris & McQueen, 2008).

So, any FL word recognition simulation in bilinguals must incorporate the feature of lexical stress, as well as attribute different recognition thresholds for cognates with equal lexical stress patterns in L1 and FL, cognates with different lexical patterns, and noncognates. The parameters must simulate not only different RTs, but also different levels of accuracy.

The results also showed that FL acquisition theory has to selectively predict which features are likely to be affected by interference from L1. There is a general belief that interference will occur at all levels due to the existence of prototypes. Moreover, studies have shown that in some cases learners have codified FL stress (e.g., Goetry et al., 2006), and others show the opposite (e.g., Dupoux et al., 2008). The results of this thesis show that lexical stress is perceived and codified without being completely filtered through L1 lexical stress patterns. The results also support that, for learning, implicit and explicit processes are implicated. Lexical stress rules can be implicitly learnt. Therefore, theories of FL acquisition must incorporate how implicit learning affects the process of acquisition. Also, saliency was an important feature critical in implicit learning, so theories must be able to explain or predict which features will be more or less salient and whether each of these features can be learnt or not implicitly.

Finally, the results have pedagogical implications. Lexical stress is codified automatically, so no special emphasis on this feature is necessary. Hence, it is not necessary to overstress words so lexical stress can be codified. Also, the results suggest that exposing the learner to spoken FL is beneficial for acquiring lexical stress rules that are applied later on (as seen in a LDT). Explaining the rules explicitly may result in better performance, but without exposure to the language, the student will not obtain the benefit of tuning his or her perceptual system to the features of the language necessary for automatic processesing to occur.

Limitations of the Study and Possible Follow-ups

Experiments 1 and 2 were created with the objective of studying lexical stress codification of FL cognate and noncognate words. To run the analyses, trochaic and iambic words were collapsed resulting in 12 words per condition (six trochaic and six iambic words; so, 12 cognate words for the same-stress condition, 12 cognate words for the different-stress condition, 12 cognate words for the nonstudied-words condition, 12 noncognate words for the same-stress condition, 12 noncognate words for the different-stress condition, and 12 noncognate words for the nonstudied-words condition). The decision to study the role of lexical stress in L1 lexical access (i.e., whether trochaic-stress Spanish cognate words were recognised faster than iambic-stress Spanish cognate words due to the first ones having the maximum similarity with English words) was made a posteriori. The study of accuracy and response latencies for cognate words with different lexical stress patterns could only be performed on hits (i.e., correct recognition in the same-stress condition), resulting in the analysis of six words per condition (i.e., six trochaic cognates pertaining to the same-stress condition and six iambic cognates in the same-stress condition). Analyses based on responses to six trials per condition limited the amount of variance and therefore the inferences derived from the statistical analyses based on it. A follow-up study should include more stimuli to confirm the results obtained in Experiments 1 and 2 regarding L1 lexical access.

Also, the overall discrimination between words and nonwords was not significant in Experiment 3. However, in Experiment 3 only 24 participants were employed. In contrast, in Experiment 4, 40 participants participated under the same instructions given in Experiment 3 (but Experiment 4 used noncognate words). The differences in sample size might have affected levels of significance. A study employing more participants will ascertain whether FL lexical stress patterns can be learnt implicitly by exposure to spoken cognate words.

Future Directions

The results have shown the necessity for word recognition modelling to incorporate data obtained from bilinguals and from FL learners. Different languages attribute different weights to sublexical features at the segmental (e.g., vowel duration) and suprasegmental (e.g., lexical stress) level in the process of recognition and segmentation. How the cognitive system extracts all these sublexical features in order to activate the cohort of lexical candidates, and how words of different languages interact in the process is still to be explored. Moreover, research on foreign-accented speech is revealing that the perceptual system is flexible, recalibrating continuously by exposure to different pronunciations and rhythms by different speakers with different accents. This is not only important for understanding human speech, but also to be able to create robots capable of transforming speech into written form, and translating.

Future studies are the study of which Spanish lexical stress features (pitch, length, or intensity) are acquired by learners at different stages. It is also important to study in depth the responses given by the participants in the implicit learning experiments (Experiment 3 and 4). Participants reported a sense of familiarity to judge whether a new stimulus could be a real Spanish word or not. Further study is necessary to examine exactly which segmental and suprasegmental features motivated such feelings of familiarity. Scott and Dienes (2008), using artificial grammar learning, reported features such as chunk strength, chunk novelty, specific similarity, and repetition structure. It is necessary to know whether the same variables are affecting speech. Future studies can request participants describe what made the stimulus familiar.

The literature review and the results of Experiment 5 also indicate that the relationship between lexical stress and speech needs further research. It is not clear yet whether speech segmentation of Spanish words does not depend on word's lexical stress (e.g., Toro et al., 2009; Experiment 5 of this thesis). It is open to investigation whether longer training sessions in Experiment 5 (i.e., longer exposure to Spanish words) would affect word segmentation. Also, it will be interesting to find out whether segmentation is facilitated by using the same words during the study phase and the segmentation task (i.e., segmentation due to word recognition), and whether the suprasegmental cues facilitate segmentation on top of segmental cues (i.e., if lexical stress rules are used together with word recognition to segment speech).

From an educational perspective, the results also indicate that more research has to be done to gauge the positive potential that implicit learning may have in facilitating the acquisition of automatic processes of language perception and production. Furthermore, theories of FL need to incorporate what can be achieved through implicit learning.

This thesis has focused on lexical stress acquisition of Spanish words by English speakers. Many papers have been dedicated to investigate Spanish-English bilinguals, and Spanish or English monolinguals acquiring English and Spanish, respectively. However, to my knowledge this is the first study that has focused exclusively in FL codification and implicit learning of lexical stress by auditory exposure, when the learner has never had formal exposure to the FL, and fills up a gap in the English-Spanish research of FL acquisition. The fact that the learners in this experiment had no previous formal exposure to Spanish, provide us with an opportunity to study how lexical stress starts being assimilated, and how L1 influences such learning. Future studies should be carried out with other languages in order to be able to generalise the results of this thesis.

Conclusion

Exposure to the rhythm and lexical stress of a language facilitates automatic processes of word recognition and speech segmentation. This is the first study that has attempted to systematically study whether this is true in relation to lexical stress. Particularly, FL lexical stress was studied regarding its perception, codification, learning, and use in speech segmentation. The results show that English speakers perceive and encode Spanish lexical stress automatically when hearing new FL words. More importantly, hearing a FL, even without full attention, and access to meaning, results in implicit learning of lexical stress rules. However, this learning cannot be applied to more complex processes such as FL speech segmentation, which depends on greater experience with the vocabulary and words to be segmented. Considering that participants studied only 32 or 36 words and that the period of exposure was less than 9 minutes, the results are striking since such a brief exposure affected word recognition and responses in a lexical decision task. This suggests that learners can benefit greatly from hearing the FL even when they cannot understand fully what is being said. In addition, they do not need to pay full attention to it, or to have previous lexical representations in the lexicon.

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APPENDICES

Appendix A

Words used in the Experiments

Table A1. Words employed in Experiment 1.

Word							
Cognate				Noncognate			
Trochaic	IPA	Iambic	IPA	Trochaic	IPA	Iambic	IPA
bingo	'biŋgo	actor	ak'tor	bajo	'baxo	cajón	ka'xon
cobra	'koβra	boicot	boi̯'kot	buitre	'bwi̯tre	ciudad	θju̯'ðad
delta	'de̦lta	cristal	kriș'tal	ceja	'θexa	cojín	ko'xin
diva	'diβa	cupon	ku'pon	cifra	'θifra	cubrir	ku'βrir
extra	'ekștra	doctor	dok'tor	cubo	'kuβo	detrás	de'tras
foto	'foto	dragón	dra'ɣon	cuerpo	'kwerpo	fijar	fi'xar
husky	'xuski	factor	fak'tor	diario	'djarjo	ladrón	la'ðron
kilo	'kilo	filial	fi'ljal	ducha	'duʧa	llegar	ʎe'ɣar
kiwi	'kiɣwi̯	latín	la'tin	fuego	'fweɣo	lograr	lo'ɣrar
mango	'mãŋgo	licor	li'kor	gallo	'gaʎo	lugar	lu'ɣar
panda	'paņda	local	lo'kal	grado	'graðo	mejor	me'xor
piano	'pjano	manual	mã'nwal	hacia	'aθja	mujer	mu'xer
plasma	'plazma	salmón	sal'mõn	horno	'orno	pedir	pe'ðir
polo	'polo	salón	sa'lon	joya	'xoǰa	riñón	r̄i'ɲon
pony	'poni	sensual	sen'swal	juicio	'xwi̯θjo	seguir	se'ɣir
taxi	'taksi	sexual	sek'swal	nunca	'nũŋka	sutil	su'til
whisky	'guiski	solar	so'lar	sastre	'saștre	también	tam'bjen
yoga	'ʤoɣa	total	to'tal			viajar	bja'xar
						volver	bol'βer

Note. IPA obtained from http://www.respublicae.net/lengua/silabas/descomponer.php. Lexical stress and allophones represented.

Table A2. Words employed in Experiments 2 and 3.

Word							
Cognate				Noncognate			
Trochaic	IPA	Iambic	IPA	Trochaic	IPA	Iambic	IPA
bingo	'biŋgo	actor	ak'tor	bajo	'baxo	cajón	ka'xon
cobra	'koβra	boicot	boi̯'kot	buitre	'bwi̯tre	ciudad	θju̯'ðad
delta	'deḷta	cristal	kriṣ'tal	ceja	'θexa	cojín	ko'xin
diva	'diβa	cupon	ku'pon	cifra	'θifra	cubrir	ku'βrir
extra	'ekṣtra	doctor	dok'tor	cubo	'kuβo	detrás	de'tras
foto	'foto	dragón	dra'ɣon	cuerpo	'kwerpo	fijar	fi'xar
husky	'xuski	factor	fak'tor	diario	'djarjo	ladrón	la'ðron
kilo	'kilo	filial	fi'ljal	ducha	'duʧa	llegar	ʎe'ɣar
kiwi	'kiɣwi̯	latín	la'tin	fuego	'fweɣo	lograr	lo'ɣrar
mango	'mãŋgo	licor	li'kor	gallo	'gaʎo	lugar	lu'ɣar
panda	'paṇda	local	lo'kal	grado	'graðo	mejor	me'xor
piano	'pjano	manual	mã'nwal	hacia	'aθja	mujer	mu'xer
plasma	'plazma	salmón	sal'mõn	horno	'orno	pedir	pe'ðir
polo	'polo	salón	sa'lon	joya	'xoǰa	seguir	se'ɣir
pony	'poni	sensual	sen'swal	juicio	'xwi̯θjo	sutil	su'til
taxi	'taksi	sexual	sek'swal	nunca	'nũŋka	también	tam'bjen
whisky	'guiski	solar	so'lar	sastre	'saṣtre	viajar	bja'xar
yoga	'ʤoɣa	total	to'tal	tierno	'tjerno	volver	bol'βer

Note. IPA obtained from http://www.respublicae.net/lengua/silabas/descomponer.php. Lexical stress and allophones represented.

Table A3. Words employed in Experiment 4.

Word							
Trochaic	IPA	Trochaic	IPA	Iambic	IPA	Iambic	IPA
bajo	'baxo	fuera	'fwera	azar	a'θar	lugar	lu'ɣar
brujo	'bruxo	gallo	'gaʎo	borrar	bo'r̄ar	maldad	mal̪'dad
buitre	'bwi̯tre	grado	'graðo	cajón	ka'xon	mejor	me'xor
burro	'bur̄o	hacia	'aθja	camión	ka'mjon	mujer	mu'xer
carta	'karta	hongo	'oŋgo	ciudad	θju̯'ðad	negar	ne'ɣar
casco	'kasko	horno	'orno	cojín	ko'xin	nivel	ni'βel
ceja	'θexa	joya	'xoǰa	crear	kre'ar	olor	o'lor
cifra	'θifra	juicio	'xwi̯θjo	cubrir	ku'βrir	pedir	pe'ðir
cinta	'θin̪ta	nunca	'nũŋka	deber	de'βer	poder	po'ðer
cubo	'kuβo	padre	'paðre	detrás	de'tras	razón	r̄a'θon
cuerpo	'kwerpo	pascua	'paskwa	feliz	fe'liθ	rincón	r̄iŋ'kon
cuervo	'kwerβo	pavo	'paβo	fijar	fi'xar	riñón	r̄i'ɲon
dedo	'deðo	rezo	'r̄eθo	ladrón	la'ðron	sutil	su'til
diario	'djarjo	sastre	'sas̪tre	llegar	ʎe'ɣar	también	tam'bjen
ducha	'duʧa	tierno	'tjerno	llevar	ʎe'βar	viajar	bja'xar
fuego	'fweɣo	torre	'tor̄e	lograr	lo'ɣrar	volver	bol'βer

Note. IPA obtained from http://www.respublicae.net/lengua/silabas/descomponer.php. Lexical stress and allophones represented.

Table A4. Sentences employed in Experiment 5.

First and Last Filler words	Target Words	Written Sentence
	Version A	
soPLEte-YO	BRUjo-creAR-TIERno	sopletebajovotartorreyo
LUZ-esTIÉRcol	deBER-BUNque-riÑÓN	luzlaconburrolacarestiercol
paRAdo-SAL	PAvo-leGAR-CINta	paradosastresutilcartasal
RO-anDÓbal	lloVER-CEja-viaJAR	ronivelpadremejorandobal
alFÉIzar-VE	CUbo-PAScua-lleGAR	alfeizarcasconucallorarve
POR-venTAna	CUERpo-poDER-oLOR	porjuicioladronvolverventana
noDÁtil-SED	fiJAR-ciuDAD-CUENco	nodatilazarcojindiariosed
YA-caZUEla	venCER-DUcha-FUEgo	yamaldadfuerajuntocazuela
visCOso-LO	HARta-JOya-peDIR	viscosohaciafelizcubrirlo
DAR-caMÍbar	desLIZ-luGAR-HORno	darnegarhongogallocamibar
	Version B	
soPLEte-YO	BAjo-voTAR-TOrre	sopletebrujocreartiernoyo
LUZ-esTIÉRcol	laCÓN-BUrro-laCAR	luzdeberbunqueriñonestiercol
paRAdo-SAL	SAStre-suTIL-CARta	paradopavolegarcintasal
RO-anDÓbal	niVEL-PAdre-meJOR	rollovercejaviajarandobal
alFÉIzar-VE	CASco-NUca-lloRAR	alfeizarcubopascuallegarve
POR-venTAna	JUIcio-laDRÓN-volVER	porcuerpopoderolorventana
noDÁtil-SED	aZAR-coJÍN-DIArio	nodatilfijarciudadcuencosed
YA-caZUEla	malDAD-FUEra-JUNto	yavencerduchafuegocazuela
visCOso-LO	HAcia-feLIZ-cuBRIR	viscosohartajoyapedirlo
DAR-caMÍbar	neGAR-HONgo-GAllo	dardeslizlugarhornocamibar

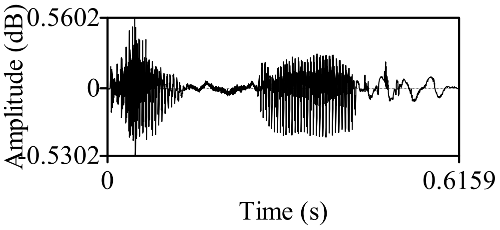
Note. Stressed syllables in upper case.

Appendix B

Waveforms of Some Words Employed in Experiment 5

Normal Stress

Flat Stress



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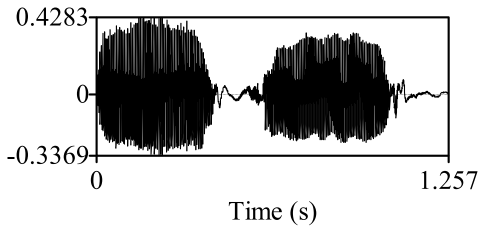

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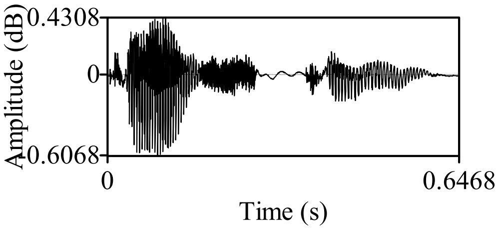

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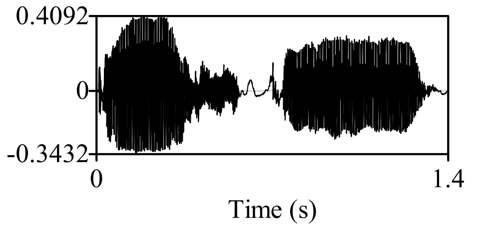

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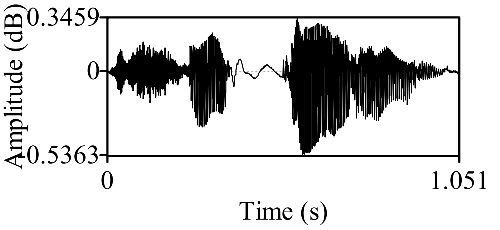

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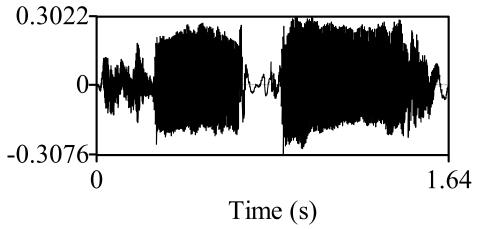
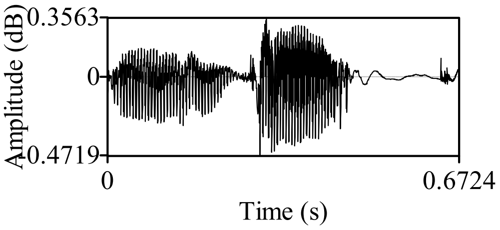
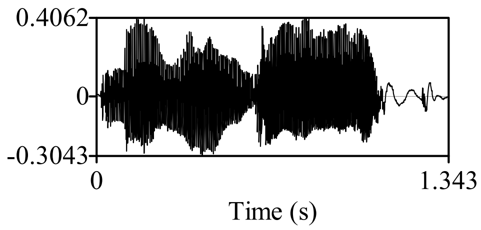


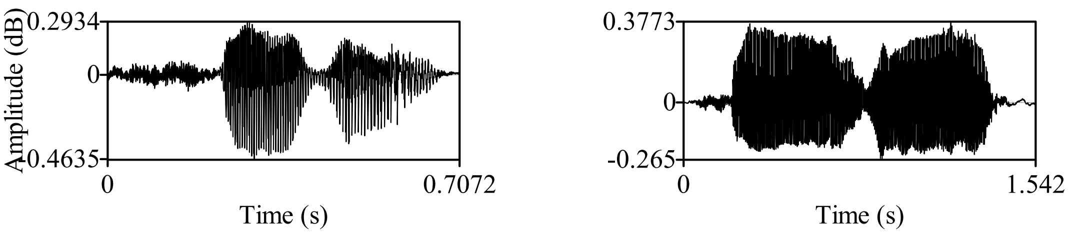
sutil



maldad



maldad



joya Joya

Figure B1. Waveforms for the words *azar, casco, sutil, maldad,* and *joya* pronounced with normal lexical stress and with flat lexical stress.