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Cross-linguistic similarity in Japanese-English bilingual processing and representation

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Abstract

The present thesis is devoted to the analysis of how cognates are processed and represented in the minds of Japanese-English bilinguals. Cognates are an interesting and important category of words in languages as they are distinguished by their similarity across languages, which includes both formal and semantic features. This thesis presents the most comprehensive description and analysis of Japanese-English cognates and how they are processed and represented in the minds of bilinguals. A large number of rating and norming data are presented, which will be of use to researchers in the field of bilingualism who are interested in languages that differ in script, such as Japanese and English. Utilising measures of formal (phonological) and semantic cross-linguistic similarity derived from bilinguals' ratings, the present thesis presents evidence that cross-linguistic similarity impacts bilingual processing and representation in a variety of tasks, but is modulated by task type and language dominance. The findings of the present study complement previous research, which has often focused on languages that share script (e.g., Dutch-English), while advancing the use of continuous measures of formal and semantic similarity. Such measures are argued to be more appropriate in terms of current cognitive models of bilingual processing and representation. Following a review of previously documented cognitive models, the results are interpreted in terms of the most relevant models that address the issues of cross-linguistic similarity and language proficiency/dominance. The results are important for cognitive science, psycholinguistics and bilingual studies and may also feed into applied linguistics in terms of the potential implications for language learning and teaching.

List of Published Papers

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Chapter 1: Introduction

A key question for both psycholinguists and applied linguists is the role of 'cross-linguistic influence' or 'language transfer' in second language acquisition, representation and use (Ellis, 2008; Jarvis & Pavlenko, 2008; Odlin, 1989). In short, because the majority of language learners already have an established L1, the influence of the L1 is often evidenced in L2 use. This language transfer extends to all aspects of the language processing system: from perceiving sounds to producing them, and from comprehending lexical and syntactical items to selecting them when producing language. Applied linguists have typically been interested in whether such transfer is beneficial or disadvantageous to L2 learners (see Ellis, 2008 for an overview) and how teachers can deal with transfer in language teaching situations. Psycholinguists who research language processing, on the other hand, are more interested in what transfer can reveal about the organization of the mental lexicon and how it is accessed during language use.

In many L2 experimental tasks, including both word recognition and production, and sentence comprehension and production, when words share both formal and semantic features (i.e., are *cognate*) then processing is speeded relative to that for words that do not share these features across languages (see Dijkstra, 2007 for an overview). In applied linguistic terms this is known as 'positive transfer' because the L1 creates an advantage for using words in the L2. In psycholinguistics, this 'facilitation' reveals that the cross-linguistic similarity of words in terms phonology (P), orthography (O) and/or semantics (S) modulates the speed of processing. Thus, when a word's SPO features are shared across languages, there is a processing advantage, which strongly implicates activation of the L1 during L2 processing.

It is this cross-linguistic activation that is central to the present research. In general, the question is, when words share formal and semantic features are they processed more quickly (and accurately) in a variety of tasks? The answer to this question, at least with many languages, has already been partially provided by previous research (see Dijkstra, 2007). The *cognate facilitation effect* shows that when words are cognate (i.e., they share P/O and S) then processing in the L2 is speeded. In contrast, this effect is rarely observed when processing in the L1, suggesting an important role of language proficiency in modulating observable cross-linguistic transfer effects.

Whereas previous research distinguishes cognates from noncognates in order to investigate cross-linguistic influence on L2 processing, the present research views cognateness as definable using a continuum of cross-linguistic formal and semantic similarity. In other words, cognates can be *more* or *less* cognate across languages (not simply cognate or noncognate). A more specific question therefore is, when words have differing degrees of formal and semantic cross-linguistic similarity, does the advantage increase linearly as a function of this similarity? It is shown herein that speakers of more than one language are aware of this varying degree of cross-linguistic similarity and that these varying degrees of similarity across languages do modulate L2 processing.

Additional related questions that are addressed in this research pertain to whether L2 proficiency and other word characteristics, such as word frequency, interact with the cross-linguistic processes. Moreover, the tasks range from single word recognition and production tasks to reading sentences in which cognates are embedded in a fictional text. Importantly, using both single-word and in-context tasks allows assessment of the role of context as additional factor influencing cross-linguistic influences in processing.

The findings of the present research combine to form the most comprehensive single analysis of Japanese-English cognates and how they are processed by Japanese learners of English (i.e., Japanese-English bilinguals). The results contribute to a clearer understanding of cross-linguistic similarity effects in a range of tasks, specifically advancing the field past a binary cognate-noncognate distinction and towards a continuous measures of formal and semantic similarity. The results are interpreted in regard to cognitive models of bilingual word recognition and production and suggestions are made for revisions to these models to incorporate the important continuous nature of cross-linguistic similarity. The results of this research are important because they add to our limited knowledge of how different-script bilinguals process languages. The results may also feed into applied linguistics in terms of the potential implications for language learning and teaching.

Organization of the thesis

Chapters 2 and 3 form the literature review for the research. In Chapter 2, definitions are provided to establish exactly what is meant by 'bilingual' (i.e., the participants in the present research) and 'cognate' (i.e., the linguistic feature that is focused on in this research). This involves providing an overview of previous measures of cognateness and discussing relevant features of Japanese-English cognates, specifically, the concepts of formal (primarily, phonological) and semantic similarity. Because readers may not be as familiar with the Japanese language as with English, information on how the Japanese language is similar to and differs from English and how this may impact perceived cognate similarity is discussed. The second part of the literature review, Chapter 3, focuses on a number of influential models of bilingual processing, both for word production and recognition. A number of models are reviewed with respect to how they account for cross-linguistic similarity effects as well as bilingual proficiency.

Chapter 4 summarizes the results of a series of rating and norming studies. Japanese-English bilinguals rated 193 Japanese-English word pairs, including cognates and noncognates, in terms of phonological and semantic similarity. Norming data was also collected for L1 (Japanese) age-of-acquisition, L1 concreteness and L2 (English) familiarity as such information is currently unavailable. Additional information on L1/L2 word frequency, L1/L2 number of senses, L1/L2 word length and number of syllables is also provided. Correlations and characteristics of cognate and noncognate items are detailed to provide a complete overview of lexical and semantic characteristics of the stimuli.

This chapter thus provides the basis for understanding the measures that are used to predict bilingual performance in tasks reported in the subsequent chapters.

Chapter 5 focuses on cross-linguistic similarity in L2 word production and recognition tasks. L2 picture naming reveals a significant interaction between phonological and semantic similarity and demonstrates that degree of overlap modulates naming times. In lexical decision, increased phonological similarity (e.g., *bus* /basu/ vs. *television* /terebi/) leads to faster response times. Interestingly, in this study increased semantic similarity speeds response times in picture naming, but slows them in lexical decision. Additionally, the studies indicate how L2 proficiency and lexical variables modulate L2 word processing. The findings are explained in terms of current IA models of bilingual lexical processing, specifically Costa et al's (2005) model for picture naming and the BIA+ for word recognition (Dijkstra & Van Heuven, 2002).

Chapter 6 focuses on language proficiency and cross-linguistic similarity in L1 word production. This is a first-language partial replication of the picture naming experiment reported in Chapter 5. Whereas cross-linguistic effects are often observed in L2 tasks, they are rarely observed in L1 tasks when bilinguals are unbalanced, and L1 dominant. The present chapter provides evidence for the limited role of cross-linguistic similarity effects in L1 production, but reveals an interesting effect of L2 proficiency that is explained in terms of models of relative frequency of language use.

Chapter 7 focuses on cross-linguistic similarity, particularly S representations, and language proficiency/dominance by conducting bi-directional masked priming lexical decision tasks. Many studies have reported that L1 translation primes speed responses to L2 targets, but L2 translation primes do not speed responses to L1 targets in lexical decision (e.g., Duñabeitia, Perea & Carreiras, 2010; Duyck, 2005; Gollan, Forster & Frost, 1997; Grainger & Frenck-Mestre, 1998; Jiang, 1999; Jiang & Forster, 2001). The Sense Model (Finkbeiner, Forster, Nicol & Nakamura, 2004) assumes that the total activation of senses is the key determinant of this translation priming asymmetry. Because Japanese-

English cognates have few senses in Japanese and either few or many senses in English, they are ideal for testing whether total activation of senses is the key factor in cross-linguistic priming. Thus, the number of senses that words have in each language is manipulated in the present experiment, thereby manipulating the proportion of activated senses across the two languages. Contrary to the predictions of the Sense Model, these results replicate the typical asymmetrical priming effects, suggesting that it is not the total activation of senses that drives the priming effect. Rather the results are more in line with theories that postulate slower, and thus ineffective, activation of semantics by L2 primes (i.e., BIA+).

Chapter 8 contains three monolingual control experiments (picture naming, lexical decision, and masked priming lexical decision). The purpose of this chapter is to provide a monolingual baseline with which to interpret the findings from the bilingual experiments. In general, these studies provide further evidence in support of the conclusions drawn in the bilingual experiments and show that the materials in the previous chapters were well designed.

Chapter 9 extends the findings of previous experiments by testing the influence of cross-linguistic similarity and language proficiency in an authentic reading task. In this study, Japanese-English bilinguals read an extended text while their eye-movements are recorded. The critical predictor variables of interest are P and S similarity. A host of other variables, such as word frequency and language proficiency, as well as collocational and context effects, are evaluated in the mixed-effects modelling of the data. The P and S similarity effects observed in single-word tasks in previous chapters are not replicated in this L2 free reading task, which provides greater linguistic and semantic context. Thus, the influence of L1 cross-linguistic similarity is minimized in more natural reading tasks. This finding is likely to be in part due to the lack of shared-script between Japanese and English.

Finally, Chapter 10 provides a brief discussion of the results of the experiments reported in this thesis, particularly with a view to synthesizing the results and applying them to current models of bilingual processing. The requirements of future work, particularly that focusing on integrating P and S similarity into current models of lexical processing are discussed.

Chapter 2: Bilingualism, cross-linguistic similarity and Japanese-English cognates

Why studying bilingualism is important

The present thesis is concerned with the cognitive processes that govern bilingual's language use. Studying bilinguals' language performance provides the opportunity to investigate the cognitive architecture of the bilingual language processing system. Moreover, insights from bilingual language use can also shed light on the language processing system in general. Over the last ten years, research focusing on the psycholinguistic aspects of bilingualism has grown at a 'dizzying pace' (Kroll & De Groot, 2005). One compelling reason for studying bilingualism is quite simply that most of the world's population speak more than one language (Traxler, 2012, p.416). Moreover, due to the popularity and necessity of learning second languages, it is essential to gain a better understanding of how second languages are acquired and used, and how the first language may help or hinder these processes.

Research interest in bilingualism spans a number of subject areas, not only psychology and applied linguistics but also education, literature and translation studies, amongst others. As a feeder discipline for applied linguistics, evidence from psychology is regularly drawn upon to inform theories of language acquisition, which in turn guide language teaching methodologies and materials design. The present thesis focuses on bilingualism primarily from the perspective of cognitive psychology and psycholinguistics, though the implications of the research for language learning are also considered in various parts of the thesis. In the following sections I define more precisely the focus of the research, beginning with what it means to be 'bilingual'.

Defining bilingualism

A bilingual in this thesis refers to *a person who is able to use two languages, regardless of their relative ability in those two languages*.

This definition is thus inclusive of second language learners and is not restricted to persons who are highly proficient or native-speaker level in both languages (as per the layperson's definition). The bilingual's ability to use each language is of course critical for further specifying the definition. A speaker of two languages may not be equally proficient in her languages. In fact, it is unlikely that any bilingual is equally proficient in both languages. Thus, further discussion of what it means to be proficient in a language is required in order to better understand the concept of bilingualism. In the following section I briefly discuss how bilingual ability is more precisely defined, specifically in regard to language proficiency and age-of-acquisition.

Language proficiency

Language proficiency is essentially a synchronic measure of language ability that provides an overall snapshot of language ability at a particular time. Ellis (2008) defines (L2) proficiency as "a learner's skill in using the L2. It can be contrasted with 'competence'. Whereas, competence refers to the knowledge of the L2 a learner has internalized, proficiency refers to the learner's ability to use that knowledge in different tasks". (p.976). Thus, language proficiency can be viewed as an inclusive measure of both language knowledge and skills, or the ability to use language knowledge. It is most useful to view proficiency as a continuum or scale ranging from zero ability in a language to completely proficient in a language. In reality, a speaker will never know every word in a language; therefore, complete proficiency refers to the ability to use language effectively as a native speaker of otherwise similar characteristics (age, education, and so on). Proficiencies in specific areas of language (e.g., grammar) or context (e.g., proficiency in *academic* English, as in the IELTS or TOEFL tests) may depend on the focus of research or application, but many definitions classify a person's proficiency by referring to speaking proficiency, listening proficiency, reading proficiency and writing proficiency.

In applied linguistics and language testing, the construct of language proficiency is probably the most well developed of all fields. Comprehensive language proficiency examinations such as IELTS or TOEFL used for placement of international students in universities include four separate tests, one for each skill, and can take up to a full day to complete. In psycholinguistics, language proficiency is treated as an important source of individual variation in performance in bilingual studies. However, it is typically measured using much simpler means than in language testing situations, for example by using self-ratings of language proficiency in the four skill areas. Self-assessment questionnaires can range from a handful of proficiency rating scales to more comprehensive questionnaires, such as the Language Experience and Proficiency Questionnaire (LEAP-Q; Marian, Blumenfeld, & Kaushanskaya, 2007: 942), which includes self-rating tasks for each of the four language skills as well as questions about the bilinguals' language learning history. The decision to use the more comprehensive measure depends on the type of information required for the study in question. While the measures typically used in psycholinguistics may be seen to be crudely oversimplified in comparison to the comprehensive examinations used in language testing situations, previous research supports that 'bilinguals are able to assess their own proficiency in a way that is consistent with their behavioural performance' (Marian et al., 2007). Of course, a major advantage of using self-assessment tasks is that they are quick and simple to administer in experimental situations.

Age-of-acquisition

While language proficiency is the most important measure of a bilingual's language ability because it provides a synchronic measure that can be used in experimental situations, the time a person begins to acquire a language, in other words the age-of-acquisition (AoA), is another critical factor in language development. While AoA is not a measure of language ability, it is a very strong predictor of ultimate language attainment. It is well known that late (post-puberty) L2 learners are less successful at acquiring language than early L2 learners. The *critical period hypothesis* states that there is a critical period during human biological development at which it becomes difficult, if not impossible, to acquire a language up to native-like proficiency (see Birdsong, 2006 for a review). While the actual period may not be as well defined as originally thought (Tomasello, 2003, p.286), it is undisputed that bilinguals who begin learning an L2 pre-puberty are more likely to develop native-like language ability than those learning post-puberty. This early-AoA advantage extends not only to competence in grammatical manipulations but also to phonological (Archila-Suerte et al., 2011) and lexical processing (Ellis & Lambon Ralph, 2000).

Children's flexibility in learning languages, as well as other skills such as playing musical instruments, is a key reason determining their success in acquiring language to a native-like proficiency (Hernandez & Li, 2007; Tomasello, 2003). Early learning flexibility often overcomes any issues of L1 entrenchment: while both pre- and post-puberty learners may have an entrenched L1, the former are still more likely to end up with native-like language ability. While AoA is important for understanding the cognitive processes behind the use of multiple languages, measures of proficiency may ultimately serve as the most use for psycholinguistic research. This is because they should, in principle, reflect actual language ability, which will in turn be partly determined by the AoA. For example, if a bilingual rates herself as native-like proficiency, and this is an accurate measure of her real proficiency, then it is likely that she learned language at an early-AoA. Regardless of actual AoA, current proficiency should be a sufficient measure of language ability. In the present thesis, both proficiency and AoA were measured for all bilingual participants; however, as AoA was not predictive as a measure of performance in any of the experiments (probably due to the fact that almost all bilinguals were late L2 learners), only proficiency is reported and discussed in detail.

Bilingual memory, representation and processing

One of the main issues that has been tackled recently in the field is the extent to which a bilingual's lexicons are shared. Essentially, are all of the words from language A stored together with or separately from language B? Does the bilingual have two functionally distinct lexicons (i.e., that work independently) or is there a single lexicon that stores information about all words regardless of language affiliation? The question of whether words are located in a single, shared store or if they are located in language-specific, separate stores is a question of *representation* (or a *structure-oriented* issue, Dijkstra, 2007). The representation of words in the mind is of central importance for understanding how languages are used and how they are acquired. Recent research supports the argument for a single lexicon in which all words, regardless of language, are stored (e.g., Dijkstra & Van Heuven, 2002). However, Kroll et al. (2010) have contended that while multiple stores are still a theoretical possibility, the degree of cross-linguistic activation observed in bilingual tasks suggests that even if there was a distinction between the lexicons for each language, there is no functional distinction. In other words, any such distinction between language-specific lexicons does not appear to affect processing in either language.

A second issue of central importance is whether lexical candidates from both languages become activated during language processing. The opposing views arising from this question form the basis of the selective vs. non-selective activation/access debate. This question forms part of a research agenda that asks how words are *processed* by bilinguals, and whether processing differs by language (or a *process-oriented* issue, Dijkstra, 2007). Recent research suggests that when bilinguals communicate in one language, lexical representations from both languages are actually activated. This finding has been demonstrated conclusively through the use of single language tasks that contain words that share some similarity with the other language, for example, interlingual homographs (*die-die* in German-English), interlingual homophones (*cinq-sank* in French-English) and cognates (*beer-bier* in English-German/Dutch). For example, cognates, which share both form and meaning across languages, are processed faster in tasks even when only one language is being used (Dijkstra, 2007). This *cognate effect* has been found in numerous tasks, both for language production and comprehension, which suggests that non-selective cross-linguistic activation is a hallmark of bilingual processing.

Cognates as tools and objects of study

Cognates and other words that share features across languages (e.g., homographs and homophones) have been of great use in helping researchers to answer important questions related to bilingual processing and representation, particularly those pertaining to cross-linguistic activation. It is precisely because they share features across languages that they can be used as critical stimuli in tasks that seek to investigate whether more than one language is activated during single-language tasks. However, cognates are not simply a means to an end in bilingual research. As will be described in this chapter, loanwords (Japanese-English cognates) are ubiquitous in the Japanese language and form a growing part of Japanese speakers' vocabularies. Moreover, there are a huge number of Japanese-English bilinguals, thanks to compulsory English education. This situation makes the question of how loanwords are processed an interesting one in its own right, particularly regarding the implications that cognates may have for learning and teaching Japanese and English languages. While cognates can be used to investigate questions related to the mind in general (i.e., How are words organised in the mental lexicon? How do bilinguals process languages?), they can also become the object of study themselves because of their potential importance in language learning and thus by extension, teaching situations. For instance, if the finding that cognates are processed faster than other words (e.g., Dijkstra, 2007) holds outside of the laboratory, this may be something that teachers should know when presenting new language for learners and designing a lexical syllabus for students. If cognates are easier to process, are there strategies that can improve learners' use of them and thus lead to improved learning and language proficiency? Due to the potential of such information to improve current understanding of learning and teaching of languages, the study of cognates can be said to be important in its own right. It is in this vein that the present thesis approaches the study of cognates: not only will this thesis test a number of central assumptions of bilingual processing, it will also consider the application of cognates in more authentic tasks.

The focus of the present thesis is cross-linguistic influences in bilingual processing. More specifically, this thesis investigates how Japanese-English cognates are processed by Japanese-English bilinguals. In the following sections of this literature review, I present details of how cognateness has been assessed in past bilingual research and how this cross-linguistic similarity can be assessed specifically for Japanese-English cognates. Included in this chapter is a brief introduction to the orthographic, phonological and semantic characteristics of the Japanese language as it is assumed that readers of this thesis may not be completely familiar with Japanese.

Cross-linguistic similarity

The focus of the present thesis concerns cross-linguistic similarity and its impact on bilingual processing. Cross-language word similarity has been shown to be an important factor influencing bilingual language processing (Christoffels, Degroot, & Kroll, 2006; Costa, Caramazza, & Sebastian-Galles, 2000; De Groot, Dannenburg, & Van Hell, 1994; De Groot & Nas, 1991; Dijkstra et al., 1999; Gollan et al., 1997; Kroll & Stewart, 1994; Sánchez-Casas, Davis, & Garcia-Albea, 1992; Schwartz, Kroll, & Diaz, 2007) Numerous studies have shown that interlingual homographs and homophones (words having similar form but different meanings) increase response times in bilingual tasks (e.g., Dijkstra et al. 1999). In contrast, when meaning and form are very similar, as in the case of cognates, faster response times are observed. The cognate facilitation effect has been shown to be robust across a wide range of tasks and languages such as word naming (Schwartz et al., 2007) picture naming (Costa et al., 2000), word translation (Kroll & Stewart, 1994;

Christoffels et al., 2006; De Groot et al., 1994; Sánchez-Casas et al., 1992), lexical decision (De Groot & Nas, 1991; Dijkstra et al., 1999), masked priming (Gollan et al., 1997) and progressive de-masking (Dijkstra et al., 1999). However, the degree of similarity, in other words, the degree of overlap in terms of formal and semantic features is variable across studies and definitions of cognates (and homographs and homophones) often differ. In their review of previous measures of cognate status, Tokowicz, Kroll, de Groot, and Van Hell (2002) note that many measures of word similarity are unsatisfactory and 'ignore the continuous nature of similarity that could be used to predict performance on cross-language tasks' (p.437).

It is important to clarify the definition of 'cognates' as a category of words as they will be the central concern of this thesis. Cognates are defined differently depending whether researchers are coming from a more formal linguistic or etymological perspective, or a psycholinguistic one. An etymological definition states that cognates are words of languages that have descended from a common source e.g., *father*, *vater* (English, German). Psycholinguists, on the other hand, define cognates without regard to etymological relationships (Dijkstra, 2007, p.252), but with regard to shared meaning and form in two languages. The typical psycholinguistic definition of cognates refers to words that are semantically (S) similar as well as orthographically (O) and/or phonologically (P) similar across languages. This definition is not restricted to *identical* sound, spelling or meaning across pairs of words; in fact, many cognates vary considerably in their correspondences in these features. The vast majority of research conducted into the psycholinguistic processing of cognates has utilised cognate pairs from languages that share O (e.g., Spanish-Catalan, Dutch-English). Some recent studies seeking to empirically distinguish between cognates and noncognates have utilised S and O similarity as the primary metric of overlap and/or cognate status, with less regard to P similarity (Schepens, Dijkstra, & Grootjen, 2011). When investigating same-script languages, a difficulty lies in differentiating between P and O similarity, because any measures of these features will be highly correlated; naturally, words that share more O similarity typically share P similarity as well. In languages that differ in script, such as Japanese and English, cognateness must be determined based on shared S and P features, because these languages do not share O.

Researchers have been criticized for defining cognates without recourse to bilinguals' perceptions of the similarity across word pairs in terms of S, P and O features (Tokowicz et al., 2002). Tokowicz et al. (2002) suggested that the continuous nature of similarity for S, P and O features should be considered when defining 'cognateness' from a psycholinguistic perspective. Moreover, bilinguals from the sample population should provide indications of the perceived similarity, rather than relying on one or two expert opinions.

In the present thesis, Japanese-English cognates are defined as words that are translation equivalents that overlap in P and S. Crucially, the cognate status and degree of P and S overlap will be established based on measures derived from bilinguals' perceptions of similarity. While Japanese employs a script, *katakana,* to write loanwords and thus cognates are easy to identify, using continuous measures of similarity will undoubtedly provide a more fine-grained measure of cognateness that can be used to more effectively predict cognitive processing.

In the following sections I will briefly discuss the formal and semantic measures that have been used to investigate and define cognate status in previous research with other languages (e.g., Dutch-English). Also, a concise overview is provided of the similarities and differences between Japanese and English cognates in terms of their formal (P, O, and syntactic) and S shared features across the languages. This information is essential for an understanding of the factors that influence how bilinguals may perceive similarity across languages. Thus, the formal characteristics of Japanese-English loanwords will be examined to provide basis for the actual cross-linguistic similarity ratings collected in the present research and the experiments that are subsequently conducted to test them.

Formal similarity measures

For words sharing the same meaning across languages, O similarity has been widely used to establish cognate status (e.g., Dijkstra, Miwa, Brummelhuis, Sappelli, & Baayen, 2010; Duyck, Assche, Drieghe, & Hartsuiker, 2007; Friel & Kennison, 2001; Schepens, Dijkstra, & Grootjen, 2011). Cognates can be defined as orthographically identical or non-identical (e.g., Duyck et al., 2007). In Duyck et al. (2007) identical and non-identical cognates were distinguished using the formula for 'graphemic similarity' developed by Van Orden (1987). This formula computes a score for two words (in this case two cognates, such as *beer* and *bier*) by taking into account the number of letters that are the same, the number of pairs of adjacent letters that are in the same order, or reverse order, and the ratio of the number of letters between the words (see Van Orden, 1987, for more details and the formula for this measure). More recently, Levenshtein Distance has been employed as an automated measure of O similarity in a study of cognates in European languages (Schepens et al., 2011); this measure is normalised to account for word length by dividing the computed result by the maximum length of both of the words (Normalized Levenshtein Distance; see Schepens et al., 2011, for more details). Finally, ratings can be used to establish O similarity (e.g., Tokowicz et al., 2002; De Groot & Nas, 1991; De Groot, 1992; Dijkstra et al., 1999; Dijkstra et al., 2010). Typically this method involves bilinguals rating word pairs for the degree of perceived O similarity along a 7-point scale (1=identical, 7=completely different). Schepens et al. (2011) compared their Normalized Levenshtein Distance scores with participant-rated scores taken from Tokowicz et al. (2002) for around a thousand items and found a high correlation (r=.88); an even higher correlation was found for a second, smaller set of items taken from Dijkstra et al. (2010; 318 items, r=.96). Because the resulting similarity scores for both automated and rated word pairs are comparable, the merits of these approaches lie primarily in the time required to conduct and analyse the data: automated measures by far excel in terms of practicality. However, Normalized Levenshtein Distance scores are not possible when comparing languages like English and Japanese where orthography is not shared.

Fewer cross-linguistic similarity measures have been based on P similarity alone, although P information has been shown to be sufficient to create cross-linguistic activation (Duyck, 2005). With Dutch-English bilinguals Duyck found facilitation of responses when using L2 pseudohomophone masked primes (e.g., *roap*, for *rope*) in an L1 lexical decision task. This effect was also observed in L2-L1 masked priming. This work extends the findings in the monolingual literature on pseudohomophone priming, which shows that a pseudohomophone prime such as *byke* facilitates naming of the visually presented target *bike* (e.g., Perfetti & Bell, 1991). Of course, one issue with such studies is that P and O similarity are confounded because *byke* and *bike* overlap in both P and O. Therefore, O controls are needed, such as *beke,* to control for any O priming effect and to confirm that P activation is the crucial factor driving the priming facilitation (as in Perfetti & Bell, 1991; Duyck, 2005). In Duyck's (2005) study and in many others, pseudohomophones, homophones, cognates and noncognates are selected by the experimenter based on their knowledge of the language(s), and do not use measures of P similarity. In a few studies, when determining the degree of cross-linguistic P similarity for a large number of items, participants' subjective ratings have been used (Dijkstra et al., 2010; Dijkstra et al., 1999); in these studies participants are asked to focus on the sounds of words and not their spelling and to rate them on a scale of 1-7 (1=identical, 7=completely different). It can be argued that subjective ratings are more reliable than objective measures of P similarity because it is difficult to operationalize objective measures that take into account all of the unique phonetic information of individual words.

In some studies using same script languages such as English-German and Dutch-English, a single similarity rating was collected for the degree of spelling and sound similarity, effectively combining P and O similarity measures (Tokowicz et al., 2002; De Groot & Nas, 1991; and also by Friel & Kennison, 2001). Tokowicz et al. (2002) had 16 bilinguals rate Dutch-English translation pairs for formal similarity on a

7-point scale (1=low similarity and 7=high similarity). For many words the ratings clustered at the formally ‘very different’ end of the scale (between 1 and 2), indicating that there were many noncognates in the item set. Crucially, for other words the ratings were spread across the remainder of the scale (between 3 and 7. Thus, for cognates there is a degree of variability in perceived formal similarity. These studies highlight the continuous nature of formal (O and P) similarity as perceived by bilinguals as well as providing a useful set of measures for further experiments investigating bilingual word processing. For languages that differ in script, such as Japanese and English, O similarity measures are not applicable, leaving P measures as the only way to determine cross-linguistic formal similarity. This is advantageous because P similarity is not confounded with O. Crucially, for Japanese-English translation pairs no previous studies have published measures of cross-linguistic P similarity. Therefore, the present study will seek to provide the first publicly available measures of P similarity for items in both of these languages.

Japanese-English cognates: Phonology

The purpose of this section is to highlight formal similarities and differences across the Japanese and English languages, and provides the basis for understanding the construct of P similarity across the two languages. This information is likely to be used by bilinguals, albeit in a subjective manner, when assessing the formal (P) similarity of Japanese-English translation equivalents. Crucially, this perceived similarity may influence bilingual language processing.

In general, when words are borrowed, P conversion, or *rephonalization,* occurs so that borrowed words conform to the P constraints of the host language. In English to Japanese rephonalization, the process can be divided into two distinguishable processes: converting English syllable structure to Japanese moraic structure and converting English vowels and consonants to Japanese vowels and consonants.

Syllabic conversion

The first process regards the phonotactic constraints imposed by the Japanese moraic structure. This system requires that all consonants other than /n/ are followed by a vowel. Thus, many consonant clusters found in English are not permissible in Japanese. As part of rephonalization, these consonant clusters are converted to moraic units consisting of a consonant plus a vowel (this process is referred to as 'vowel epenthesis'; Kubozuno, 2006). For example, *trust* becomes トラスト */torasuto/* in Japanese. In this example the single syllable word in English becomes a four-mora word in Japanese. Because most words in English have a more complex syllable structure than CVCV, few can be rephonalized without adding extra vowels, although a word like *banana,* (into バナナ, *ba-na-na)* is a notable exception. Table 2.1 below illustrates some of the insertion rules for forming Japanese loanwords from English words (also see, Kubozuno, 2002; cf. Kubozuno, 2006).

Table 2.1: Vowel insertion rules for converting English words into Japanese loanwords (adapted from Quakenbush, Fukuda, and Kobayashi, 1993).

		English to Japanese vowel insertion rules	**Examples**
1	/o/ insertion	/t/, /d/ at the end of a closed syllable -> /to/, /do/	バット /batto/ bat ガイド /gaido/ guide
2	/i/ insertion	/tʃ/, /dʒ/ (at the end of a closed syllable) -> /tʃi/, /dʒi/	マッチ /macchi/ match[1] オレンジ /orenji/ orange
3	/i/ insertion	/ʃ/, (/k/) (at the end of a closed syllable) -> / i/, (/ki/)	ブラシ /burashi/ brush

[1] In this thesis, the phonetic transcriptions following Japanese words are indicated using / /. These transcriptions follow simple conversion of Japanese phonemes to *roomaji* symbols (i.e., the roman alphabet as used in English). All *roomaji* transcriptions can be converted into more precise International Phonetic Alphabet using the information provided in this chapter. Thus, double-vowels are transcribed into *roomaji* by using two vowels (e.g., *aa*) instead of the vowel and colon (e.g., *a:*).

			ケーキ /keeki/ cake
4	/o/ insertion	/dl, dr, dn, dw/ (in a consonant cluster) -> /dol, dor, don dow/	キャンドル /kyandoru/ candle ドリーム /doriimu/ dream

This process of segmenting English words when rephonalizing them into Japanese loanwords is important for understanding how L1 native Japanese speakers may process L2 English words. Kubozuno (1995) showed that English and Japanese speakers decompose English words differently as a result of L1 segmentation patterns. Using auditorily presented stimuli, Kubozuno (1995) showed that English speakers preferred to segment *pen* into *p-en*, (86% of the time) while Japanese speakers segmented the same word into *pe-n* (79% of the time). McQueen, Otake, & Cutler (2001) showed that how well Japanese speakers perceive words depends on the phonotactic restrictions of the first language. In a monolingual word-spotting experiment, response latencies were measured when participants identified words (e.g., /uni/) within words (e.g., /gyabuni/) and the response latencies were recorded. Words that did not align with the Japanese segmentation pattern (i.e. defied the phonotactic restrictions) were more difficult to identify (e.g., /uni/ in /gyabuni/, which is constituted by three mora: /gya/, /bu/ and /ni/). This study shows how segmentation processes influence language processing in the first language; another question is whether these L1 processing strategies also influence L2 processing. In a bilingual study, Taft (2002) showed that Japanese speakers showed a preference for L1 processing strategies when comprehending English words. In a visual lexical decision task he presented polysyllabic words that were divided into either a max onset condition or max coda condition and units were presented with two spaces in the middle (e.g., *ra dio* or *rad io*). Both long vowels (e.g., *r<u>a</u>dio*) and short vowels (e.g., *b<u>a</u>lance*) were tested as separate stimulus groups. It was hypothesised that Japanese speakers would process words in the former condition (e.g., *ra dio*) more quickly than the latter (e.g., *rad io*) as measured by response latencies because the max onset condition is more similar to Japanese words. The results indicated that bilinguals preferred the max onset condition for both long and short vowels. Thus, Japanese learners may utilise L1 P processing strategies when processing L2 (English) words; specifically, Japanese speakers may process visually presented words preferentially as CV-CV as opposed to CVC –VC. From the studies discussed here, it is clear that L1 processing strategies can influence L2 processing, and that where L1 and L2 segmentation patterns differ (as in the case of syllable- and mora-timed languages), bilinguals may process words more quickly depending on the cross-linguistic overlap of phonology.

Phoneme conversion

The second process, converting English vowels and consonants to Japanese vowels and consonants, is dependent on the cross-linguistic overlap of phonemes in the two languages. In this section, vowels shall be discussed first followed by consonants.

Japanese has five vowel sounds (/a/, /e/, /i/, /o/, /u/), all of which can be lengthened by doubling up the vowel (/a:/, /e:/, /i:/, /o:/, /u:/). In order to approximate English vowels, such as /i:/, Japanese rephonalization utilizes long vowels. Thus, for English word *sheet,* which includes /i:/, the Japanese equivalent is シート/shiito/. Vowel lengthening is common in both loanwords and native Japanese words.

English has 20 vowels, which include both single vowels and dipthongs. Thus, the rephonalization process requires reducing the variation in vowel sounds in English down to those that exist in Japanese, resulting in considerable differences in P form of cognates across the two languages. Table 2.2 shows the vowel substitutions substitutions that occur when importing words. The English schwa is generally rephonalized into one of the nearest deemed equivalent vowels found in Japanese (e.g., singer, /singə / and シンガー /shingaa/).

Table 2.2: Vowel substitutions from English words to Japanese loanwords (from Quakenbush, et al., 1993)

JP	a	i/i:	ɯ	o/a	a	ai	ai	aɯ	oi
EN	æ	ɪ	ʊ	ɔ	ʌ	aɪ	ai	aʊ	ɔɪ

JP	ɛi	o/oɯ	a/ɛ/o/i	a:	ɯ:	ɛ:	o:
EN	eɪ	ou	ə	æ:	u:	e:	ɔ:/ou

Interestingly, certain dialects of Japanese have vowel devoicing, which will effect the perceived similarity with English. When certain vowels are devoiced, it makes the Japanese P converge on the English P. High vowel (/i/ and /u/) devoicing is common in Tokyo and other dialects (Tsujimura, 2007) when they occur between voiceless consonants (/k/, /t/, /p/, /s/, /sh/, /ch/, /ɸ/, /dz/). Thus, くさい/kusai/ 'bad smell' becomes /ksai/. Also, high vowels are devoiced when they are the coda of a word and preceded by a voiceless consonant e.g., ガス/gasu/ 'gas' becomes /gas/. As this last example illustrates, vowel devoicing can result in Japanese-English cognates that have greater P similarity.

Consonants

Japanese has fourteen consonants (/k/, /g/, /s/, /t/, /h/, /r/, /b/, /p/, /d/, /m/, /n/, /w/, /y/, /z/) that appear in syllable-onset position, and which are *always* followed by a vowel (e.g. /ka/, /ke/, /ki/, /ko/, /ku/; /sa/, /se/, /shi/, /so/, /su/), or a glide [j] then a vowel (e.g., /kya/, /kyo/, /kyu/; /sha/, /sho/, /shu/. However, the phonotactic restrictions in Japanese mean that only some CV (consonant-vowel) units are modified by the addition of the glide (e.g., /kye/* and /kyi/* are not permitted). Each of these combinations is considered to be a phoneme and is referred to as a *mora*, which make up the basic phonemic unit in Japanese.[2] There is also one free-standing consonantal phoneme, [ŋ]. A total of one hundred and four individual mora make up the phonemic inventory of Japanese. In contrast

[2] The consonants /k/, /s/, and so on are not phonemes in Japanese as they never occur without a vowel. Instead, in Japanese, /ka/, /sa/, and so on, as well as /kya/, /sha/ and so on, are phonemes, or alternatively, morae.

to many languages such as English, the number of discrete, permissible phonemic units in Japanese is highly restricted. As discussed above for vowels, this restriction guides the rephonalization process and consequently influences the degree of cross-linguistic P similarity of loanwords.

Table 2.3 shows the cross-linguistic overlap of consonants in English and Japanese. As illustrated, there are five English consonants that do not exist in Japanese (/f/, /v/, /θ/, / ð /, /ʒ/, /l/) and are thus converted to the nearest phonetic equivalent (/ɸ/, /b/ /v/, /s/, /z/, /ʤ/, /r/, respectively). Other consonants are not exactly the same across languages, though are largely equivalent. The voiceless stops (/p/, /k/, /t/) are less heavily aspirated at word onset in Japanese than in English words that feature them at the onset of a word (e.g., *pan, tan, can;* Tsujimura, 2007, p.11).

Table 2.3: Shared and substituted phonemes in English and Japanese (cf. Igarashi, 2007). Phonemes in squared brackets [ ] are typical substitutions where shared phonemes do not exist

Japanese	English	Japanese	English
p	p	ʃ	ʃ
k	k	[ʤ]	ʒ
b	b	ʧ	ʧ
t	t	ʤ	ʤ
d	d	ts	[ts]
g	g	h	h
ɸ	[ɸ]	M	m
[ɸ]	f	n	n
[b]	v	ŋ	ŋ
[s]	θ	[r]	l
[z]	ð	r	r
s	s	w	w
z	z	j	j

The voiceless labial-dental fricative in English /f/ does not exist in the Japanese standard syllabary and the closest sound is the bilabial fricative / ɸ / found in Japanese as ふ or フ. English /f/ sounds in loanwords are approximated using / ɸ / in combination with vowel sounds, creating a previously unused additional set of *katakana* phonemes ファ, フェ, フィ, フォ (/fa/, /fe/, /fi/, /fo/). Because these phonemes are not used in other native Japanese words, they have a noticeable foreignness to them. The fact that certain phonemes only occur, or predominantly occur in loanwords, may have implications for the degree of cross-linguistic activation. Because /h/ occurs in both native Japanese words (e.g., /haku/ 'white') and (e.g., /happii/ 'happy'), there is no P information indicating that the word is actually borrowed. In contrast, upon encountering ファ, フェ, フィ or フォ in spoken form, it is clear that the word is borrowed because these phonemes in Japanese are used exclusively in loanwords (e.g., ファイト/faito/ 'fight'). Other *katakana* phonemes that have this distinguishing quality include ヴァ, ヴェ, ヴィ, ヴォ, ヴ, (/va/, /ve/, /vi/, /vo/, /vu/).[3]

One contrast of particular interest is the English phonemes /l/ and /r/, which are both equivalents of Japanese /r/. The English 'dark L', the allophone of /l/ found in *fa<u>ll</u> /fa:ɫ/*, does not exist in Japanese and the closet approximate is る /ru/. The 'L' allophone in *<u>l</u>ittle* /l/, which is a liquid tap, is approximated by Japanese /r/. However, the English /r/ phoneme is also approximated by the same Japanese /r/. It has been suggested that Japanese /r/, which is an apico-alveolar tap (Vance, 1987), is more similar to flapped 't' and 'd' in American English (*ibid.*). It is well known that Japanese learners of English struggle with distinguishing in perception and in production the /l/ and /r/ phonemes in English. Ota, Hartsuiker, and Haywood (2009) showed that during L2 phonological coding, Japanese-English bilinguals activate both /l/ and /r/ English phonemes on presentation of a word that contains only one of the two. During a decision task in which two words were presented and participants decided whether they were related or not (i.e., S decision), the authors included stimuli that were functionally-homophonous for

[3] Note that in the Table 2.3 above, /v/ in English is appropriated by /b/ in Japanese, which is typical in the rephonalization of loanwords. The more recently added /v/+vowel phonemes in Japanese are less often used, but could in theory replace the /b/+vowel phoneme in words such as バット'vat' (i.e., ヴァット).

Japanese-English bilinguals e.g., *rock/lock, rate/late, raw/law* and *river/liver*. The authors found that when presented with one of these words response latencies were delayed relative to controls. This finding is interpreted as simultaneous activation of both possible words (i.e., *rock* and *lock*), which creates a momentary delay in decisions. Importantly, in this study participants were also tested on their ability to discriminate between these sounds, revealing that the results of the decision task were not due to perceptual difficulties. Rather the delays were caused at the phonological coding level. The implications of these findings are that care should be taken when investigating cross-linguistic processing to ensure that stimuli that are potentially homophonous are accounted for in tasks that require semantic access. For example, in an auditory lexical decision task that includes words such as *lock* or *rock*, the processing of these words may be influenced by their homophonous nature in the L1. Presentation of such words in lexical decision may result in simultaneous activation of multiple lexical representations (*lock* activates both *lock* and *rock*) with the possible result that lexical decisions are affected.

Long consonants are common in loanwords and are formed by the addition of the geminate obstruent (/Q/, which is indicated in Japanese written form as a small /tsu/, ッ) following a vowel and preceding the consonant that is lengthened. Long consonants are often indicated in English spelling by doubled consonants as in ‘pp’ in *slipper*. This spelling constricts the reading to /slipə/, and not *sliper** /slaipə/. In order to rephonalize the English word *slipper*, a small ッ is placed following the vowel in リ/ri/ and preceding the consonant beginning パ/pa/ (i.e., スリッパ/surippa/); without the obstruent the Japanese loanword would be /suripa/, which would sound much less like the English equivalent. However, long consonants are also common in native Japanese making them poor indicators of language of origin (i.e., loanword or native word; e.g., 行った/itta/-*went*).

In Japanese, the nasal /ŋ/ changes depending on the place of articulation of the following phoneme. Examples of this phenomenon, result in assimilation of /n/ to /m/ and the allophone /ŋ/. The sound /n/

becomes /m/ when followed by a bilabial consonant e.g., /binbo/ becomes /bimbo/. When followed by a velar consonant /k/ or /g/, /n/ becomes /ŋ/ as in 三級、サンキュー/sangkyuu/.

A relatively small number of loanwords end up as truncated loanwords,[4] that is, they are shortened from their original form; this applies to both individual and compound loanwords. These words are often borrowed whole into Japanese only to be perceived as too long, and subsequently abbreviated. In fact, this is typical of not only loanwords but also of native Japanese words (e.g., /kokuritsukokugokenkyuujo/, 'the national institute for Japanese language research', is more usually referred to as /kokken/). The length of words is a reflection of typical sound-meaning forms in the Japanese language: Japanese words are typically between two and four mora in length (Tsujimura, 2007). Examples of loanword truncation include リモコン/rimocon/, 'remote control' and デパート /depaato/ 'department store'.

Two additional features of phonology that may impact phonological similarity across languages are differences in rhythm and accent. In terms of rhythm, Japanese is said to be a mora-timed language, in contrast to syllable-timed languages (e.g., Spanish) and stress-timed languages (e.g., English; Kubozono, 2006). While some phonetic studies have found that Japanese mora are not completely isochronous, that is, the boundaries between mora are not strictly defined in spoken production, there is considerable evidence to support the view that mora are fundamentally the basic phonemic units in the Japanese language (see Kubozuno, 2006, for an argument in favour of the mora-based account of Japanese spoken production, and Warner and Arai, 2001, for a review of opposing evidence). In terms of accent, languages fall into categories determined by stress (e.g., English), tone (e.g., Chinese) or pitch (e.g., Japanese). A pitch-accent language like Japanese has an accent on one mora in each word; the pitch is high preceding this accent and falls thereafter. For example, 空 /sora/ (HL), 川 /kawa/ (LH), 形 /katachi/ (LHH). Accent in Japanese is usually determined by the number of mora, with the accent falling on the antepenultimate (i.e., third from last) mora (McCawley, 1968; cf. Kubozuno, 2006). However, as shown in the examples /sora/ and /kawa/, both of which have two mora, pitch may differ on a case-by-case basis rather than being rule-governed. In terms of language processing, in any case, it is more likely that individual word accent is acquired in a piecemeal as opposed to a rule-governed manner. Pitch is an important aspect of Japanese phonological processing because it helps speakers to understand the meaning of homophones, of which there are many. Yamada (1983) found that 35% of a Japanese dictionary was made up of homophones, which are distinguished by different orthographic forms (i.e., different *kanji*) and also often by their pitch placement. Pitch is relevant to cognate processing as high pitch in Japanese and stress placement in English may either be the same or different for any particular cognate. When stress and pitch are similarly placed in particular cognates across languages it may influence the perceived phonological similarity of the words. An example is *hamburger* and ハンバーガー/hanbaagaa/ where stress falls on the initial syllable in English but pitch is high on the penultimate mora in Japanese. Such differences not only influence comprehension and production of an L2 but may influence perceived phonological similarity.

The variation between Japanese and English P is rather complex and requires consideration of conversion of English to a CV-CV structure and also conversion of many phonemes. Where the two languages have equivalent phonemes across languages, as mentioned above, even these sounds may not be perceived as *identical,* due differences in articulation. Thus, the similarity between English and Japanese cognates in terms of P is dependent on a number of factors. The question then becomes whether such overlap can be effectively (and efficiently) operationalized objectively. In other words how does one quantify slight differences in aspiration between the two languages, vowel devoicing, replacing one phoneme for another or changing syllable structure? The cost of developing a computer application that can measure P overlap effectively by accounting for all of the cross-linguistic variations may outweigh its utility. Alternatively, collecting bilinguals' subjective ratings of P similarity, would be comparatively simple to do, and given that the P features make up bilinguals' mental P inventories (depending on L2 proficiency and other factors such as AoA), the resulting measures of overlap may not be so different.

Japanese-English cognates: Orthography

Japanese and English do not share a script (except for *roomaji*, which is covered in this section) and therefore have no cross-linguistic orthographic similarity. However, it is important to understand the Japanese orthographic scripts and their usage because certain types of words, including cognates, are written in particular scripts. This means that orthography can demarcate particular types of words, isolating them from other types of words. In this section, the Japanese orthographic system is reviewed in order to contextualise cognates in the Japanese written language. Issues directly related to cognates are discussed in the latter part of this section.

The Japanese language may be one of the most orthographically demanding modern languages as it has four scripts in everyday use: *kanji*, *hiragana, katakana,* and *roomaji* (Table 2.4).

Table 2.4: An example of the four Japanese scripts; all words are pronounced /toukyou/ and refer to the capital city of Japan.

Kanji 東京	*Hiragana* とうきょう
Katakana トウキョウ	*Roomaji* Tokyo[5]

Kanji are logographic characters, either of Chinese or Japanese origin, and can be used singularly (as in 東/higashi/ 'east') or in combination (as in 東京/toukyou/ *Tokyo,* lit. 'eastern capital'). A single *kanji* character, which is a morphemic unit, is often composed of sub-morphemic units

[5] *Tokyo* is the internationalised spelling using roman characters; in more accurate *roomaji* transcription *Tookyoo* or Toukyou (depending on the transliteration system used) would be considered the best approximation.

called *radicals*. These radicals can be semantic or phonemic, and provide cues about the characters meaning and sound, respectively (see Miwa, Libben, & Baayen, 2012, for a study of how semantic radicals influence word recognition in Japanese). *Hiragana* is a shallow orthographic script that is used for particles, verb-endings and other syntactic as well as lexical functions. *Katakana* is a second syllabary, which is comparable to *hiragana* in that it is a shallow orthography. However, this script serves primarily as a means for transcribing foreign loanwords (primarily Japanese-English cognates); note how *katakana* and *hiragana*, which are phonemically identical, are differentiated in O style: *Katakana* uses straight lines with hard corners, while *hiragana* uses curved lines and soft corners. The syllabaries, *hiragana* and *katakana*, are known collectively as *kana* (or the *kana* scripts). The *kana* syllabaries are made up of 46 characters that are phonemically equivalent, in other words, they represent the same phonemes and mora. Both of these scripts are almost completely consistent in their grapheme-phoneme mappings, and as such Japanese is often referred to as a shallow orthography.[6] *Hiragana* and *katakana* are used to indicate the pronunciation of *kanji* because logographs by their nature do not provide consistent grapheme-to-phoneme mappings. A further 25 additional *katakana* characters are made by adding one of two different clitics to a selection of the original 46 characters (e.g., ハ、バ、パ、*ha, ba, pa*). These additional 25 characters are also featured in the *kana* syllabaries. Finally, 33 symbol-sets made up of two *kana* characters, a full size character and a reduced size character (a glide, either ュ、ョ、ャ、*yu, yo,* or *ya; e.g.,* ヒュ、ヒョ、ヒャ、*hyu, hyo, hya*) complete the syllabary. Many of these compound-phonemes are almost exclusively written in *katakana* because *katakana* is used to transcribe loanwords, which often include phonemes not found in the Japanese native phonological lexicon; that is, phonemes

6 While Japanese spelling-sound corresponances are almost completely consistent, two kana characters can be read in two different ways due to archaic usage: は in hiragana and ハ in katakana are realized as both /ha/ and /wa/, with the former phonemic realization when used in a content word and the latter when used as a particle; へ (which is the same in both kana syllabaries) is realized as both /he/ and /e/, in the same instances as described for は.

that have been introduced to approximate the foreign phonemes are usually written in *katakana*, an important fact that differentiates the two *kana* scripts. Finally, *roomaji* is a fourth script utilising 22 of the 26 Roman alphabet characters and is used to transcribe Japanese words into an internationally recognizable script. This script is the most recent addition to the O series of scripts. It is debatable whether *roomaji* is an authentic 'Japanese' script, because it is rarely used in Japanese texts, except for defining words of foreign origin. Nonetheless, because of technological applications, such as computer and mobile device input keyboards, *roomaji* is regularly used as the initial input script, and as such it can be argued that it is a supplementary part of the Japanese writing system. The full syllabary, containing *hiragana*, *katakana* and *roomaji*, is provided in Appendix 2.1 (cf. Kess and Miyamoto, 1999).

Although it is typical to see all of the three main scripts in a single Japanese sentence; for example (バスで病院へ行きました /basu de byouin he ikimashita/ '(I) went to the hospital by bus'), where the first two characters are *katakana*, the third, sixth and seventh-tenth characters are *hiragana* and the fourth, fifth and seventh characters are *kanji*, there is variation in the script distributions within the Japanese language. Typically, *kanji* is most frequently used, followed by *hiragana* and finally *katakana*, in terms of token character distribution. Table 2.5 shows the proportional distributions of Japanese script types across three text genres: newspaper articles, magazine articles and TV commercials. The proportions of script-type occurrence show that *kanji* is the most common script across in all three genres, followed by *hiragana, katakana* and finally *roomaji.* Notice that the proportion of *katakana* words varies across genres, with more occurrences in magazines (15%) and TV commercials (17.35%), compared to newspapers (5.73%). This prevalence of *katakana* in TV advertising and magazines can be explained through its stylistic uses, which are discussed later. In terms of word *types*, as opposed to *tokens* used in Igarashi's (2007) study, *katakana* usage may exceed *hiragana*, which is primarily used for particles and the affixes that make up much of Japanese verbal conjugations. This is due to the ever-increasing numbers of loanwords being introduced into the language, compared to a smaller, more stable set of *hiragana* words. Indeed, the use of foreign loanwords appears to be increasing steadily: one study of a weekly magazine from 1906 to 1976 reported a rise from 0.4% to 2.3% in the proportion of loanwords in the Japanese language (Igarashi, 2007; Igarashi's own study of a weekly magazine in 2005 put the proportion at 5.73%; *ibid*, 2007).

Table 2.5: Percentage of words in each script in three genres sampled by Igarashi (2007)

Script	**Magazines**	**Newspapers**	**TV commercials**
Katakana	15.00%	5.73%	17.35%
Kanji	58.38%	72.23%	51.34%
Hiragana	22.97%	18.24%	20.31%
Roomaji (inc. numerals)	3.65%	3.18%	10.80%

The *katakana* script, which is most relevant for the present thesis, has a variety of uses that can be categorized in terms of frequency distribution. Table 2.6 below displays the proportions of *katakana* words found in the above genres once categorized as either foreign loanwords, Sino-Japanese words, mixed words, onomatopoeia, proper nouns and Japanese native words (cf. Igarashi, 2007). The use of *katakana* for foreign loanwords by far dominates its use in the Japanese language; in printed media, such as newspapers and magazines, over 90% of *katakana* usage is attributed to foreign loanwords, while in TV the proportion is 80%. The larger percentage of native Japanese words that are found in TV commercials in *katakana* form is most likely due to the use of the *katakana* script for attracting attention due to its bold lines, not dissimilar to the use of upper-case script in English. It should be noted that while words can be incorporated into the Japanese language from any potential source, the vast majority (around 90%) of loanwords are borrowed from English (Shinnouchi, 2000).

Table 2.6: Percentage of *katakana* word usage in three genres sampled by Igarashi (2007)

Word-type	**Magazines**	**Newspapers**	**TV commercials**
Loanwords	91.06%	95.99%	80.74%

Sino-Japanese words	0.96%	0.34%	2.96%
Mixed words	0.08%	0%	2.96%
Onomatopoeia (*kana*)	1.68%	0%	2.22%
Proper nouns	0.64%	0.67%	0%
Japanese native words	5.57%	3.02%	11.11%

To summarize, *katakana* is the least frequently used script of the three primary Japanese scripts, in terms of word token frequency of occurrence, and the great majority of *katakana* usage is for writing foreign loanwords, mainly from English, though it is not solely used for this purpose. *Katakana* was originally developed as a reading aid for Chinese characters used in primarily religious scriptures. Japanese monks used *katakana* to transcribe the pronunciation of Chinese characters, making them readable for Japanese speakers. Consistent with its introduction into the language, *katakana* is still used to transcribe foreign words for Japanese readers, for example in foreign language phrasebooks (e.g., ハウ マッチ イズ イット? /hau macchi izu itto/ 'how much is it?'). However, as shown by the script distributions previously, the primary use of the *katakana* script is for writing loanwords.

An additional note should be made regarding mixed-script words, which consist of a loanword and a native Japanese word or sino-Japanese word, such as カンきり /kankiri/ 'can opener' and アイロン台 /airondai/ 'ironing board', respectively. Also, but more rarely, these words occur with the *roomaji* script, as in ファイナルOFF /fainaruofuu/ 'final reduction'. These compound words are illustrative of *wasei-eigo* (literally 'made in Japan English') coined compounds. Across three different studies conducted by the NLRI (1974; 1964; 1956) using different genres (newspapers, magazines, high school textbooks, respectively), the proportion of mixed-script words was 4.8%, 1.9% and 0.7%, respectively (cf. Igarashi, p.49), showing that mixed-script words are rare compared to same-script words.

An important concept for understanding the Japanese writing system is word-script frequency and refers to the frequency that a word is usually used in a particular script. As discussed previously, *kanji* words can be written in either of the *kana* scripts, while any word can be transcribed using *roomaji*. This situation gives rise to a number of scripts being used for many words, for a variety of reasons and depending on the discourse context. Table 2.7 below shows the word-script frequencies for three words. As the example illustrates each word varies in terms of word-script frequency, yet the most common script can be easily identified.

Table 2.7: The word-script frequencies of three words with transcriptions in four Japanese scripts when applicable; raw word frequency in brackets taken from Amano and Kondo (2000).

English Meaning	Origin	*Kanji*	*Hiragana*	*Katakana*	*Roomaji*
glasses (spectacles)	Sino-Japanese	眼鏡 (1314)	めがね (253)	メガネ (667)	*megane* (0)
opportunity	Japanese	切っ掛け (2)	きっかけ (23463)	キッカケ (0)	*kikkake* (0)
spoon	English	N / A	すぷーん (0)	スプーン (420)	*supuun* (0)

There are a number of reasons why word-script frequencies differ for words. One reason is concerned with readability: for low frequency *kanji*, a *kana* transcription is often provided above the characters so that Japanese readers can pronounce the *kanji* (as in the *hiragana* script shown in Figure 2.1). Alternatively, low frequency words that can be written in *kanji* may instead be written in *kana* scripts, particularly if the intended audience is presumed not to know (or not needing to know) the *kanji* reading. On the other hand, high frequency words that are typically written in *kanji* are almost always written in *kanji*. A second reason is that scripts have a stylistic role, particularly in advertising and the media, where they may evoke particular connotations; for example *kanji* is often seen to be more scientific, whereas *hiragana* is softer (Inoue, 1995; cf. Igarashi, 2007). Also, the bold lines of *katakana* may be more eye-catching, hence their increased frequency in advertising. This situation has implications for psycholinguistic studies as the frequency of use in a particular script will impact on processing of the visually presented words. For example, a word such as *megane* (glasses) is most often seen in *katakana* and *kanji,* but much less in *hiragana.* Therefore, the speed of processing of the item in each script should be a function of its frequency in that script, and there is some evidence that this is the case (e.g., Besner & Hildebrandt, 1987). Two illustrative examples of multiple-script use are provided in Figures 2.1 and 2.2, in which the cognate *sauce*-ソース /soosu/, is written in *kanji, katakana* and *hiragana*, all on the same bottle and *new*-ニュー/nyuu/ is used for comic effect in a product advertisement.

The present introduction to Japanese language was included to provide the necessary background to understand how Japanese-English cognates fit into the Japanese language. This background is necessary for the following section, in which these cognates are described in much greater detail.

Figure 2.1 (Left): A bottle of sauce in a restaurant; the word *sauce* is written in three different scripts as indicated. Note that it is extremely rare for cognates to be represented in *kanji* in Japanese, and the first example appears to be a type of borrowing commonly seen in the Chinese language (i.e, imported words are assigned *kanji* that are phonologically similar to the loanword, though the original meaning of the character bears no similarity to that of the loanword).
Figure 2.2 (Right): An advertisement for a new café latte product. Three scripts are visible and bilingual wordplay is used for comic effect: *It's* is taken from English and ニュー/nyuu/ can be read as *new* in English or as a transcription of 乳 /nyuu/ 'milk'.

The differences in P described above often create inconsistencies in transliteration from English to Japanese, which is turn may affect processing of cognates. For example, Masuyama and Nakagawa (2005) found six variations of the spelling in *katakana* of *spaghetti* in a newspaper corpus (スパゲッティ, スパゲッティー, スパゲッテイ, スパゲティ, スパゲティー, スパゲテイ). The authors then inputted each as a search term into a search engine, finding examples of all six spellings, albeit some of them being extremely infrequent (104,000 (34.6%); 25,400 (8.5%); 1,570 (0.5%); 131,000 (43.6%); 37,700 (12.5%); 886 (0.3%); Masuyama & Nakagawa, 2005). This inconsistency causes problems for general reading and writing literacy in Japan, as well as computer-related disciplines and procedures, such as machine translation and information retrieval. This is related to the issue of word-script frequency discussed previously, that is, the subjective frequency of a word will differ for each of the written forms available. If multiple *katakana* spellings of words exist for Japanese-English cognates, then this may have implications for the processability of these words relative to cognates that have only one spelling.

Another somewhat unfortunate consequences of language borrowing on the massive and largely unregulated scale are *doublets*, words that have been borrowed twice, each time in a slightly different form, and denoting a different sense of the word from which it originally derived. For example, *glass* (as in *a glass window*) is written as ガラス /garasu/, whereas *glass* (as in *wine glass*) is written as グラス /gurasu/. In this example, the difference in form stems from the fact that consonant clusters such as *gla* cannot exist in Japanese, meaning the /*g*/ is converted into one of two syllables: *gu* or *ga.* Fortunately doublets (and triplets, which also exist) are few in number, but nonetheless they serve as a warning about the complexities of Japanese-English cognates. Also, as discussed above, words that have multiple representations need to be treated with care, as each form will vary in subjective familiarity and thus may impact on the relative strength of connections between the L1 and L2 words.

At this stage, it seems appropriate to mention the impact of the Japanese P system upon the transcription of loanwords into *roomaji*, or roman characters. As noted earlier, only 22 out of 26 characters of the English alphabet are usually used in the Japanese *roomaji* script due to these phonological differences between the two languages (*h, q, x, v* are not used in *roomaji*; note that *l/r* are both used interchangeably in *roomaji* with no difference in sound in Japanese; *v* is usually written as *b*, as /v/ is usually rephonalized as /b/). Furthermore, insertion of vowels breaks up consonant clusters and transforms them into Japanese moraic units, meaning that *roomaji* transcriptions vary greatly in terms of similarity with English cognates. This O similarity can be measured objectively in a similar fashion to same script languages such as Dutch-English, if *roomaji* spellings are used for the Japanese loanwords. Levenshtein Distance, the measure of similarity used by Schepens et al. (2011) could be used as a measure of O similarity. Such measurements will be indicative of the O similarity of Japanese-English cognates in their *roomaji*-English forms, respectively. This similarity measure, which reflects the English-Japanese rephonalization process, is likely to be highly correlated with P similarity measures, however, meaning that it may be of little utility if P measures are already available. However, because *roomaji* is not a completely legitimate Japanese script (as it is so rarely used outside of advertising, media and foreign language learning), a measure of O similarity using *roomaji* may be less theoretically sound. One possibility is that by using *roomaji*-English word pairs an O measure of similarity could be calculated efficiently that would serve as a substitute for P similarity ratings. If this was the case then the practical value of such a measure is self-evident, even if using *roomaji* as a metric for P is problematic.

Japanese-English cognates: Syntax

Finally, a brief mention should be given about the derivation of grammatical classes of loanwords borrowed from English. Japanese cognates are treated similarly to native words in terms of their syntax, in other words, how they are lexicalised as verbs, adjectives and adverbs.

Loanword verbs in Japanese derive from blending the loanword and the general verb *to do* in Japanese する *suru* (such as ハイキングする, /haikingusuru/, 'to hike'; ドライブする /doraibusuru/ 'to drive'). Less commonly, and only in informal contexts, some loanwords are affixed by simply adding る/ru/ to the end, a procedure reserved usually for native Japanese verbs (e.g., エコル or エコる /ecoru/, 'to be environmentally friendly'. Adjectival loanwords are also grammaticalized for compatibility into the Japanese language. The affix な /na/ is added to a wide range of borrowed adjectives, which again vary widely in frequency and familiarity (for example リッチな /richina/ 'rich'; ゴージャスな /goojasuna/, 'gorgeous'). Similarly, in Japanese by adding the particle に /ni/, adjectives can become adverbs. This procedure of adverbialization also applies to loanwords (for example スムーズに, /sumuuzuni/, 'smoothly'.

Semantic similarity

In this thesis, S similarity is defined as the degree to which two words from different languages share the same *meanings*, or *senses*. Although some senses may appear unrelated (as in the different senses of *bank* in English) and others are more clearly related (as in two senses of *television* that refer to the device itself and the medium), different terminology is not applied to define this apparent difference in relatedness. The terms *meanings* and *senses* are thus used synonymously. This is because the degree of relatedness varies across a continuum and thus utilising binary terms such as related or unrelated seems unintuitive. Moreover, research has shown that the different senses of words (both related and unrelated) are represented similarly, that is, as separate senses of words (Klein & Murphy, 2002). Klein and Murphy (2002) found no difference between words with related senses (polysemous words) or unrelated senses (homonyms), which suggests that there is no viable distinction in terms of the representational organization of senses that are related or unrelated (but see Rodd, Gaskell, & Marslen-Wilson, 2002 for differential influences of these word types in processing in lexical decision). Previous research has also treated related and unrelated senses equally in terms of their representation in the lexicon (Hino, Lupker, & Pexman, 2002).

It has been postulated before that cognates generally share the same conceptual features across languages (e.g., Kroll & Stewart, 1994) and that words which share form across languages (i.e. cognates) are more likely to share meaning (Van Hell & De Groot, 1998). In other words, the English-Dutch cognates *beer* and *bier* refer to the same general concept, with cultural differences potentially shaping the finer details of these concepts. The finer details are related to the issue of conceptual similarity (Pavlenko, 1999), which for the sake of brevity will not be discussed here. Although cognates by definition share both P and/or O and S features, it is also the case that cognates can share some senses while not sharing others. In French, the word *addition* has two meanings 'to add things' and 'bill'. Only the former sense is shared with the English cognate, while the latter is not. As this example illustrates, cognates can vary in the degree of S overlap across languages with some senses being shared and others being only associated with one of the cognates. Therefore, the S similarity of cognates may be no different from any other noncognate translations, which also share senses across languages in some cases but do not in others. (For example, *work* and *travail* both refer to similar senses in French and English but also have senses that are unique to each language). To investigate this issue, Tokowicz et al. (2002) conducted a rating survey of S similarity, using a 7-point scale, to assess the degree of S overlap of word pairs from Dutch and English. The task involved deciding how similar translation equivalents are in terms of their shared meanings. If items have senses that are shared across languages then they are rated as more similar, while if they have senses that differ across languages, then this will result in lower S similarity ratings. Tokowicz et al. showed that while S similarity ratings varied for translation equivalents (including both cognates and noncognates), they typically clustered at the 'very similar' end of the scale (i.e., between 6 and 7). Thus, cognate and noncognate translations in Dutch and English did not diverge significantly in terms of S similarity.

Another way of looking at S overlap is to consider the number of translations that a word has in the other language. For example, *television* has only one primary translation in Japanese (テレビ/terebi/). However, *run* has multiple translations in Japanese depending on the sense of the word that is being translated. It is possible to assess the number of translations by using translation tasks, in which participants provide a translation for items in another language. The degree of S overlap can be assessed by the likelihood of one item being translated as another. If two items share a single sense then they should always be translated into the same word; if two words have multiple senses that are shared across languages then they also should be translated into each other; on the other hand, if items share some senses but not others, then they are more likely to be translated into a variety of word forms in the other language (depending on the number of unshared senses, and whether these are known to the raters). In addition to the similarity-rating task, Tokowicz et al. (2002) performed a word translation task in which 24 Dutch-English bilinguals wrote the primary translation for 1003 Dutch and English words. This method is referred to as the first translation method (Schönpflug, 1997; cf. Tokowicz et al., 2002; see Hino et al., 2002 for discussion about the advantages and disadvantages of this method). The number of primary translations of words accounted for a significant amount of the variance (r^2=-.4, p<.05) of S similarity ratings when translating from both Dutch to English and from English to Dutch. Specifically, there was a negative correlation between the two measures, such that items for which more translations were given were rated as less S similar. It also suggests that both S similarity measures and number of translation measures were tapping into similar cross-linguistic lexical-semantic resources. Unfortunately, Tokowicz et al. (2002) did not report whether there was a larger number of translations given for either cognates or noncognates. However, they found that the ratings and the first translation method measures were highly correlated, making it reasonable to assume that both cognates and noncognates elicited the same number of translations. In sum, both S similarity ratings and translation tasks appear to be useful methods of assessing cross-linguistic S overlap.

The number of senses that words have has also been found to influence bilingual processing (e.g., Hino et al., 2002; Tokowicz & Kroll, 2007) and from the discussion presented above the number of senses is clearly important when considering cross-linguistic S overlap. However, measuring the number of senses that words have in each language may not be the most appropriate way to measure bilinguals' perceived S overlap of words. This is because the number of senses that words have, according to monolingual sources such as WordNet (Princeton University, 1990) or published monolingual (or bilingual) dictionaries, may not be equivalent to the S knowledge that bilinguals have of those words. A particular issue is that published 'expert' sources such as dictionaries vary greatly in the categorization of senses (Gernsbacher, 1984), and databases such as WordNet tend to overestimate the number of discrete senses that words have. For example, *banana* has two senses according to WordNet: one for the species and one for the fruit. Therefore, when gathering information about cross-linguistic S overlap it seems more appropriate to ask bilinguals to rate similarity (or translate items) in order to obtain a measure that is representative if their S knowledge in both languages.

Semantic similarity of cognates has also been shown to differ depending on other semantic characteristics, such as concreteness (Tokowicz et al., 2002). The degree of concreteness has been shown to be an important predictor of lexical processing in various tasks (e.g., Tokowicz & Kroll, 2007)[7]. Tokowicz et al. (2002) also investigated whether concreteness predicted S similarity and found that that more concrete words were rated as significantly higher in S similarity across languages. This is unsurprising as concrete words tend to have both

[7] Imageability, which refers to the extent to which a word evokes a mental image, has been shown to correlate highly with concreteness (e.g., De Groot & Poot, 1997). For this reason, previous research has often treated concreteness and imageability as measures of the same underlying concept (e.g., Samson & Pillon, 2004). Therefore, concreteness and imageability will be treated as synonymous for the purposes of the present research

fewer senses and fewer translations across languages (Schönpflug, 1997). Consequently, when examining cross-linguistic S overlap it is important to consider the concreteness of the items.

Japanese-English cognates: Semantics

Japanese-English cognates are all loanwords, as opposed to being etymologically related. An important question is whether S features of cognates differ either partially or wholly across the languages.

Japanese loanwords are typically introduced to fill lexical gaps in terms of inventions (e.g., ラジオ/rajio/ 'radio'), technology (e.g., ソフト /sofuto/ 'software') and new social phenomena (e.g., ホリデー/holidee/ 'holiday'). Therefore, they usually share at least one S sense with their English cognate (this has been discussed in more detail above). Words can also share P and/or O but have different meanings across languages, which are referred to as false friends. Igarashi (2007) notes a number of false friends in Japanese, for example, 'stove' in Japanese (ストーブ /sutoobu/) refers to a room-heater, and not to the kitchen appliance as in English. Such false friends are referred to as *wasei-eigo* in Japanese (literally 'Made-in-Japan English'). A main source of false friends in Japanese are the numerous novel compounds made up of English words, but which form compounds not found in English. The S content is either partially or wholly transferred from English for each individual word, but the meaning of the compound is often not deducible from the sum of the parts, especially when they are out of context. 'Pure' false-friends are, however, very rare in Japanese.

A problematic issue with loanwords is the widespread tendency to borrow one sense of a word into the adopting language. This phenomenon is referred to as *semantic narrowing* (Shibatani, 1990). For example, the high frequency word *stop* in English exists as a loanword in Japanese, yet it has very limited utility in comparison to its English counterpart. In Japanese, ストップ/sutoppu/ is usually used as an imperative command, such as when directing a driver into a parking space or commanding the cessation of an activity. In addition, it is found in compounds such as ストップウォッチ/sutoppuuochi/ 'stopwatch'. It is not used in its most frequent English usage as part of phrasal verbs or in verb-noun collocations such as *stop smoking*. This partial-equivalence extends to other high frequency words such as *drink* and *go*. It is also usually the case that where English words have more than one distinct meaning (e.g., *bat*), only one of the meanings will be borrowed into Japanese.

Sometimes Japanese loanwords are not only semantically narrow in comparison to the English equivalent, but also the borrowed sense may be modified or different in its nuance to the English word. For example, the word *gorgeous* may be used to signify beauty for a wide range of people and objects in English; on the other hand, in Japanese ゴージャス/goojasu/ is used to refer to a particular type of person, usually female, who is strikingly attractive but also gaudy and flaunting. The overlap of meaning is thus partial, and the English word *gorgeous* has positive connotations while ゴージャス/goojasu/ has both positive and negative connotations. It may also be argued that the *concepts* associated with these words differ across speakers of languages as discussed by Pavlenko (1999).

The reason why some loanwords are often semantically narrowed and have limited use Japanese is because native words are primarily used to perform most of the functions of the English cognate, whereas the Japanese cognate forms are in many cases secondary, additional words that provide a particular use or nuance in Japanese. As such, borrowing is often more to do with 're-branding' words for particular uses. This phenomenon generally has to do with the Japanese population's desire to incorporate western ideas and products into daily life, and the media's desire to re-brand old products: loanwords can provide 'old wine in new bottles' (Honna, 2006, p.104); they serve to modernize a concept or to make a distinction between existing Japanese concepts and new foreign ones (e.g., ウォター/uotaa/). Rebuck (2002) notes that loanwords can convey a variety of 'special effects' such as conveying positive stereotypes, sophistication and cosmopolitan appeal; images of trendy and modern; changing images of and services (ビューティ サロン /byuutei saron/ vs. 美容室 /biyoushitsu/ ‘beauty salon’). Loanwords are also used as euphemisms where the Japanese word may seem too direct (e.g., /harowaaku/ lit. hello work [‘Job Centre’]). They are especially apt for introducing new social concepts (e.g., /sekuhara/ ‘sexual harassment’; Rebuck, 2002).

It is important to note that cognates are not necessarily semantically equivalent across languages, and the degree of S similarity is dependent on the number of borrowed senses and the degree to which these senses are actually similar in both languages. It is thus unlikely that a simple ‘same-different’ approach to measuring cross-linguistic S similarity will be sufficient; instead, a continuous measure that more precisely gauges the degree of S similarity will be of more utility. Crucially, this variation in S similarity can be accounted for by collecting S similarity ratings and number of translations measures from bilinguals (as in Tokowicz et al., 2002). When meaning differs greatly across languages, cognate word pairs will be rated as less S similar; in contrast, when they overlap considerably, they will receive higher S similarity ratings. If they are simply used in Japanese to create special effects or highly specific nuances, this should be reflected in the S similarity ratings of bilinguals.

Summary

Unlike many languages that have cognates, Japanese and English cognates do not share O, meaning that the only formal similarity is due to P overlap. However, the previous description of how P differs in English and Japanese should make clear that while there are similarities in P, there are equally as many, and if not more, differences. Japanese is mora-timed, as opposed to syllable-timed, meaning that loanwords are rephonalized to fit the native moraic structure of words, resulting in considerable differences in P. Moreover, Japanese does not have all of the English phonemes, particularly vowel sounds, meaning that these are converted into a limited number of approximate equivalents. These conversion processes lead to Japanese-English cognates with greatly varying degrees of P similarity, a fact that is critical when considering the role of P similarity in cross-linguistic activation in bilingual processing.

Japanese-English cognates share not only P but also S features. An important aspect of S similarity for cognates relates to the issue of S narrowing, which is commonplace for borrowed words. Japanese-English cognates thus share varying degrees of S similarity, which is also likely to be important for determining cross-linguistic activation in bilingual processing. Finally, O, which is not shared, and syntactical features, which do not differ especially for Japanese borrowed words and Japanese native words, are not central to cognate processing and thus are not considered further in the present research. The present discussion has thus provided the necessary linguistic and methodological background for understanding cross-linguistic similarity and its impact upon bilingual processing in Japanese-English participants. In the following chapter, a more thorough discussion of psycholinguistic aspects of cognate processing is provided in terms of models of bilingual processing.

Chapter 3: Bilingual models of language processing

Outline

The purpose of this chapter is not to provide an overview of previous research that has investigated cognate processing (see Costa, 2005, and Dijkstra, 2007 for a review of the literature) but to provide a birds-eye view of models of bilingual processing that have been developed to explain how cross-linguistic similarity influences the bilingual's processing system. The main focus is thus on current models of bilingual representation and processing, specifically in terms of cognate processing.

A great number of models exist to explain bilingual representation and processing, but only a selection of the most relevant is included here. The present research seeks to investigate processing of cognates in both word production and recognition, therefore both production and recognition models are reviewed. In this section I discuss the following models: the Revised Hierarchical Model (Kroll & Stewart, 1994), an Interactive Activation model of picture naming (Costa et al., 2005), the Inhibitory Control Model (Green, 1998), the Revised Bilingual Interactive Activation Model (Dijkstra & Van Heuven, 2002), the Distributed Conceptual Feature Model (Van Hell & De Groot, 1998; De Groot & Kroll, 1997), and Multilink (Dijkstra & Rekké, 2010).

For each model an overview of the model is provided considering the following questions: Is it conceptual or implemented? What was it designed to account for? What type of tasks is it applicable to? Following the overview, a brief discussion of how the model accounts for effects of formal and semantic cross-linguistic similarity is provided. Finally, I discuss how the model explains differences in processing due to language proficiency effects.

Bilingual models of language processing

1. The Revised Hierarchical Model (RHM)

The RHM is a conceptual model (Figure 3.1) and has no implemented form. It consists of three parts: a lexicon for L1 words, a smaller lexicon for L2, and a conceptual store. Arrows linking lexicons and concepts are *conceptual links,* and arrows between lexicons indicate *lexical links*. Unbroken arrows indicate strong connections while broken arrows indicate weak connections. These arrows also indicate uni- or bi-directional connections, which dictate the flow of activation between the parts.

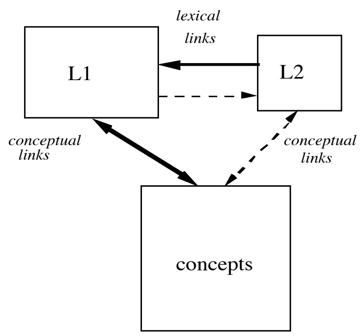

Figure 3.1: The Revised Hierarchical Model of bilingual processing (from Kroll and Stewart, 1994)

The RHM (Kroll & Stewart, 1994) has been used to explain the effects of visual translation, picture naming, lexical decision, vocabulary learning and free recall (Brysbaert, Verreyt, & Duyck, 2010). However, the RHM was initially devised to explain asymmetrical effects of bilingual translation, in other words, why bilinguals translate words faster into their L1 than into their L2. Moreover, Kroll et al. (2010) argue that translation is similar in its process to picture naming (p.374; Kroll & Stewart, 1994; Potter et al., 1984), as it relies on activation of conceptual features, followed by retrieval of a lexical representation and phonological form, and finally articulation. Thus, the RHM is argued to be primarily a model for bilingual production, as opposed to word recognition. However, translation also involves word recognition: a presented word must be recognized before it is translated. The initial

stage in translating thus requires word recognition and this is followed by retrieval of the translation, lexical and phonological form and then the articulation. Thus,
the RHM must also incorporate mechanisms of word recognition in order to explain the process of translation. The comparison between picture naming and translation is less clear, as the former task does not require word recognition while the latter does. Nevertheless, in the following, the RHM is discussed primarily in relation to picture naming and translation tasks.

The original RHM assumed there was a shared conceptual store but separate lexicons. Recent evidence, such as bottom up cross-linguistic similarity effects in language processing (in both L1 and L2; Dijkstra & Van Heuven, 1999), suggests that all words are stored in a shared lexicon. However, as Kroll et al. (2010) proposed more recently, while evidence suggests that lexicons may be shared, the effects observed do not necessarily prove a shared lexicon; there could be two separate lexicons that are 'functionally separate but with parallel access and sublexical activation that creates resonance among shared lexical features' (p.374; also see Schwartz, Kroll, & Diaz, 2007). The mechanisms for sublexical activation are, however, not specified precisely in the RHM's two lexicons.

A major contribution of the RHM is that it has been able to explain the changes in proficiency that occur during language acquisition. This is due (in part) to the changing strength of connections between L2 lexical representations and concepts. While lower proficiency learners may have weaker links formed between L2 words and conceptual features, the opposite is assumed to be true for higher proficiency bilinguals (and also for L1 lexical representations and concepts). Importantly, this implies that conceptual activation is necessary for the process of translation (Van Hell & De Groot, 1998, p.205), though the degree of activation of conceptual information may well differ according to the stage of language development.

The use of lexical links in the model draws upon previous models of word-association (Potter et al., 1984), which proposed that L2 learning was achieved by mapping L2 lexical representations to those of the existing L1. Because L1 words are already connected to the concepts, it allows L2 words to activate meaning indirectly via the L1. The evidence for these lexical links was that L2-L1 translation is faster than that for L1-L2 (Kroll & Stewart, 1994). Because L2 lexical representations are strongly linked to L1 lexical representations but not vice-versa, L2 words more quickly activate L1 words.

Cross-linguistic similarity

The RHM is extremely simple in its design and does not visualize any SOP features within the lexicons and conceptual store. Thus, there is little specification of how similarity is represented within a language, such as *cat* and *chat* (P+O+S-) in English, or between languages, such as the noncognates *cat* and 猫 /neko/ (P-O-S+) or cognates *television* and テレビ /terebi/ (P+O-S+) in English and Japanese.

Initially cognates were thought to have a single shared lexical representation as well as a shared conceptual representation (Kroll & Stewart, 1994). Thus, during a translation task, cognates were presumed to activate single, shared lexical and conceptual representations. This would explain speeded responses to cognates in the L2 with both high and low L2 proficiency bilinguals. Hence, cognates were afforded a 'special status' that differed from noncognate translation equivalents (see also Sanchez-Casas, & Garcia-Albea, 2005, for an argument for a special morphological status for cognates).

There are a number of problems with this explanation, however, and a number of questions are raised by it. If cognates have a single, shared lexical representation, is it in the L1 or L2 lexicon? Cognates may share complete O form but rarely share P form (e.g., *metro* in Dutch-English). Does this mean that only an O representation is shared but separate lexical P representations exist for the cognate and these are stored in separate lexicons? Do non-identical cognates (e.g., *kat-cat* in Dutch-English) have separate O representations (and P representations) similar to noncognates? The role of sublexical O and P information within the lexicons is difficult to realise. The simplicity of the RHM means it is very difficult to see how formal cross-linguistic overlap is represented.

Moreover, the degree to which translations overlap in terms of their meanings in their respective languages (semantic overlap) is also underspecified in the RHM. As described in detail in other parts of this thesis (Chapters 2, 4, 5, and 7), translations often have different degrees of overlap (e.g., *call*-コール/kooru/ refer to one shared sense but *call* is associated with many senses that *kooru* is not; on the other hand, *television*-テレビ/terebi/ have one primary sense, which is shared across languages). The different degree of S overlap is not well articulated in the basic RHM model. A related issue raised by Brysbaert and Duyck (2010) is that translations do not always have one-to-one mappings (as discussed in depth in this thesis), which means that the intra-lexical links would be only one of a network of lexical connections between translations (but see Kroll & De Groot, 1997). For example in English and Japanese, *call* can be translated as 呼ぶ/yobu/，コールする/koorusuru/，電話する/denwasuru/, amongst others, meaning that all of these translations would have intra-lexical links for the L1 and L2 words, but at the same time, each Japanese word would have links to other English translations (e.g., 電話する/denwasuru/ can be translated as (*to*) *telephone*, (*to*) *phone* as well as (*to*) *call*). This complex network of translations across languages is problematic for the lexical links hypothesis of the RHM, which instead oversimplifies the relationship between translations. A more likely reality is that links between concepts in memory (or co-activation), as observed in semantic priming, create spreading activation to related words in both languages. Therefore, translations are co-activated via semantic links to concepts, rather than being directly linked by the intra-lexical links.

Proficiency

The RHM makes predictions about the influence of proficiency in bilingual production tasks. The links between lexical representations and conceptual information are thought to be stronger for L1 words than L2 words, when bilinguals are late learners or of non-native level proficiency. Therefore, in picture naming, activation of semantically relevant lexical representations proceeds faster for the L1 than for the L2, because of the stronger links between L1 word forms and concepts. In contrast, links between L2 lexical representations and conceptual information are weaker meaning that activation of L2 word forms is slower than for L1 word forms. Thus, asymmetry in performance is accounted for by assuming stronger and weaker links to conceptual information.

However, it is not *only* the strength of the lexical-conceptual connections that determine the disadvantage for L2 picture naming. When naming pictures in the L2, conceptual information feeds activation through to both lexicons, more so to the L1, leading to higher activation of L1 words and lower activation of the L2. This activation of L1 is presumed to cause interference resulting in the delay in naming in the L2 compared to the L1. Thus, production is slower and less accurate than comprehension in the L2 (as in slow L2 picture naming and L1-L2 translation) because as Kroll et al. (2010) suggest, it is a 'consequence of competition for lexical selection that potentially imposes increased processing demands for reducing activity of candidates in the non-target language' (p.375). This explanation is in line with Green's (1998) IC model, which states that L2 production is slow and error-prone because it is 'more difficult to overcome the tendency to produce the more dominant L1 word' (2010, p.378). Also, the intra-lexical links could be a source of additional competition: as L2 words are strongly linked to L1 words, activation of L2 lexical representations would also lead to strong additional activation of the L1 translation equivalent. If it is competition between the L1 and L2 (i.e., difficulty in inhibiting L1) that determines slower performance for L2 production, this would be exacerbated by intra-lexical links.[8]

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[8] Alternatively, speeded responses in the L1 could be due to subjective frequency (of use) mechanisms that dictate the speed of production (i.e., access to L2 lexical and phonological forms, and subsequent articulation); because L1 is produced much more than L2, it will be faster and more accurate. In Kroll et al., (2010), there is not one mention of subjective frequency, though this is a very plausible explanation.

To recap, the difference between L1 and L2 picture naming performance can be explained by the different strength of connections in *three* ways: firstly, activation of L1 lexical representations from concepts is faster than those of L2 ones; secondly, the greater activation of L1 compared to L2 lexical representations creates competition that needs to be resolved in order to allow correct selection of the L2 representations; and thirdly, the intra-lexical links further boost the activation of L1 creating additional difficulty in overcoming L1 activation.

For translation, a similar complicated explanation holds: while concept-lexicon links would suggest slower activation of conceptual features from L2 input, the inhibition mechanism and the intra-lexical links predict faster production of L1 (i.e., faster L2-L1). The word-association option in L2-L1 bypasses the need for slower conceptual activation via the L2 and thus L1 responses are speeded relative to L2. An alternative explanation for faster L2-L1 translation is that quite simply producing words in the first language is faster than producing words in the second language, due to the frequency of use of both languages. This explanation is taken up again in regard to the Multilink model towards the end of this chapter.

Another issue tackled by the RHM is the difference between bilinguals' performance in production and comprehension tasks, with the former being less successful than the latter. Kroll and De Groot (1997, p.410) suggest 'it may be possible for less fluent bilinguals to direct conceptual access on the basis of a limited L2 but, at the same time, not be able to use conceptual information to retrieve L2 words'. In other words, whereas conceptual information can be accessed in comprehension (for low proficiency L2 learners), the same information is *not* available for production. This explains why learners may be able to do L2-L1 translation and word recognition tasks, but not L1-L2 translation and L2 picture naming tasks. However, the RHM is a model for *production* and not comprehension. As there is no specification of differences in connections between concepts and lexical representations for production (i.e., phonological forms) and comprehension (i.e., lexical forms) it is difficult to propose any concrete solution to these issues.

The RHM model predicts a relationship between proficiency and cross- linguistic effects, such as cognate effects. Specifically, unbalanced bilinguals should experience greater cross-linguistic interference when processing L2 words because of the strong intra-lexical connections between these and L1 translations and the weaker connections between L2 words and concepts. Less competition is expected when processing in the L1 because of weaker intra-lexical connections in the direction of the L1 to L2, and also because of the stronger connections between L1 words and concepts. Kroll et al., (2010) argue that the RHM was originally devised to account for this lexical level transfer from L1 to L2. The links between cognates are stronger than the links between noncognates, due to the similarity in form.[9] Therefore, the intra-lexical links also account for cross-linguistic formal similarity effects, with stronger intra-lexical links for words that have a greater degree of formal overlap (either P or O). The intra-lexical links are, however, suggested to be primarily utilized during early L2 learning and become obsolete for balanced bilinguals, who have strong lexical-conceptual links for both languages. Importantly, cognates are processed and acquired more easily than noncognates at any stage in language learning, thus the advantage for cognates for balanced bilinguals is difficult to explain only by considering the intra-lexical links.

The implications of intra-lexical links between translation equivalents are problematic for a number of other reasons highlighted by Brysbaert and Duyck (2010). Namely, intra-lexical links should mean that L2-L1 priming is observed, though this is rarely the case and never when O is not shared (also see Wang & Forster, 2010). Moreover, the links would be problematic for interactive activation models of word recognition such as the BIA+ (see Brysbaert and Duyck, 2010 for more details). The necessity of the links for translation has also been questioned by Dijkstra and colleagues, who simulated translation processes using a recently developed IA model, Multilink (see section 6 of this chapter).

[9] Note that this is a revision from the original RHM (Kroll & Stewart, 1994) in which cognates were believed to share representations.

2. Costa, Santesteban and Cano's (2005) model for picture naming

Costa et al.'s (2005) model for picture naming is also discussed in Chapter 4 in relation to the picture naming study conducted in the thesis. Therefore, only a brief overview is provided here. The model is an Interactive Activation model that was developed to account for bilingual picture naming performance, including facilitation for cognate concepts. As far as I know, this model has not been implemented and thus is currently only a conceptual model. The basic architecture can be seen in Figure 3.2: there are semantic, lexical and phonemic levels. The picture stimulus (either 'lamp' or 'table') activates conceptual features that are related to lexical items (the semantic nodes). This activation spreads uninhibited to lexical representations in both languages. Following activation of lexical representations, activation spreads to the related phonemes that make up the sublexical components required to articulate the word.

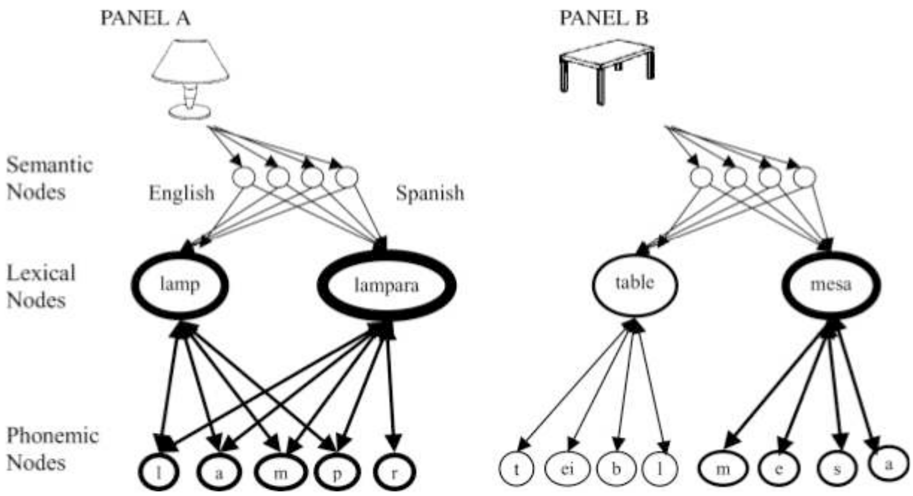

Figure 3.2: A schematic representation of picture naming in Spanish by Spanish-English bilinguals; cognates are represented in panel A and noncognates in panel B; the thickness of the lines and circles depicts the level of activation (from Costa et al., 2000).

Cross-linguistic similarity

Importantly, the links between the phonemic and lexical nodes are bi-directional meaning that activation spreads to and from the phonemic nodes with the result that words that overlap more in phonology (such as cognates) create greater flow of activation back to the lexical nodes. This results in faster naming for cognate items in bilingual production. Similarly, words that have a greater number of phonological neighbours (both within and across languages) would have greater activation because the activated phonemic nodes that correspond to the appropriate lexical representation feedback activation to other lexical representations that also share those phonemes. After a number of iterations (or cycles) the level of activation of the shared phonemes would have increased considerably, with the result that the target lexical item would be activated most and lexical selection can be achieved. The implication of this is that cognate facilitation and neighbourhood effects have the same origin (i.e., are determined by the same mechanism).

Proficiency

As illustrated in the figure, greater activation occurs for the Spanish lexical item because the bilinguals in the example are Spanish (L1)-English (L2). This mechanism is dependent on the resting level of activation of the languages, which in turn is dependent on subjective frequency of use of the two languages. Thus, proficiency is accounted for in the model by the mechanism of subjective frequency, which applies to all nodes in the model.

Costa et al. (2005) cite considerable evidence in favour of activation between lexical and sublexical levels, especially from naming performance of aphasic individuals (p.100). This is also compatible with other IA models such as the BIA+ described later. Note that unlike the RHM, the model does not contain intra-lexical links. Instead, activation from conceptual features as well as feedback from activated phonological nodes is sufficient to explain the influence of shared formal and semantic similarity. Costa et al.'s model has an additional benefit of specifying the nodes at each of the levels.

One difference between this model and other bilingual IA models (e.g., BIA+) is that there is no language node to specify which language the lexical representations belong to, although this could potentially be present at the lexical level. While unrestricted cross-linguistic activation can occur to create within-language neighborhood and cross-language cognate effects, language selection may be language-specific or non-specific. The selection mechanism would kick in after lexical nodes are activated: in a language-specific account the selection mechanism would only use activation from the response language in the selection of phonemes; this explanation is in line with Green's (1998) Inhibitory Control model discussed in the next section. On the other hand, in a language non-specific account activation from all activated lexical nodes could spread to P nodes and compete for selection at the sublexical level.

Finally, the model does not include a task/decision system as featured in other IA models (i.e., BIA+), which means that it is only really applicable to picture naming. The addition of such a system would allow the model to explain the cognitive processes that underpin a wider range of production tasks such as translation.

3. Inhibitory Control Model (IC)

The inhibitory control (IC) model, formulated by Green (1998), is a conceptual (i.e., non-implemented) model of bilingual language processing designed to account for how bilinguals perform tasks, such as translation, with minimal difficulty. Green likens the standard translation task to the Stroop task, which is one of the most well known experimental tasks of cognitive control. The primary purpose of the IC model is to explain how bilinguals produce words in one language and prevent mistakenly producing words in the other.

The fundamental parts of the IC model architecture are a *conceptualiser,* a *supervisory attentional system* (the SAS; derived from the work of Shallice and Burgess, 1996), *language task schemas,* and the *bilingual lexico-semantic system* (Figure 3.3). The SAS is responsible for constructing and monitoring schemas to achieve task goals. A language task schema regulates activation within the lexico- semantic system by inhibiting *language tags* (not visually represented) within that system; each language has its own language tag. The language tags in turn inhibit *lemmas* within the lexico-semantic system. Through this process, *top-*

down inhibition of languages occurs according to the task schema. Thus, when the task is to translate a visually presented L1 word to L2, the task schema for L1-L2 translation inhibits the L1 (via language tags and then lemmas in that language) at the output stage. This allows for production if the L2 word without mistakenly outputting the L1 word.

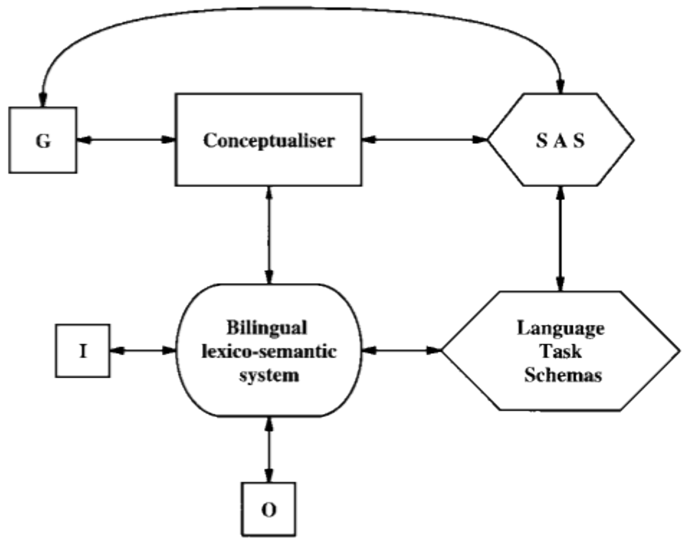

Figure 3.3: The IC Model; I and O refer to Input and Output, respectively, while G refers to Goal, which is the intention to achieve a communicative goal through language (from Green, 1998)

The architecture itself is revealing of the model's explanatory objectives. The SAS and language task schema components represent executive, top-down control systems that inhibit lexical representations (lemmas). Note there are no sublexical levels for O and P, nor is there any detailed description of SOP representations or how they interact with one another; they are simply encapsulated within the bilingual lexico-semantic system. In addition, there is no bottom-up inhibition resulting directly from the input (as proposed by IA models of word recognition, such as the BIA+); all inhibition is top-down and via task schemas. The model seeks to explain bilinguals' ability to perform tasks, such as translation, but does not specify the architecture and processing mechanisms at the SOP levels.

In the 1998 paper, Green has little to say about cross-linguistic effects as found in cognate processing, because the SOP information is underspecified in the IC model. As noted by Costa et al. (2005), if one language is inhibited then it should not be able to affect the retrieval of P information and thus no cognate effect should be observed in picture naming (p.101). Further, there is little discussion of proficiency and how language experience modulates language processing. However, it is possible to see how proficiency effects could be accounted for in the model. Thus, while there are considerable weaknesses with the IC model, it is able to account for bilingual performance in a number of tasks: translation, Stroop and language switching.

4. The Revised Bilingual Interactive Activation Model (BIA+)

The original Bilingual Interactive Activation model (BIA; Van Heuven, Dijkstra, & Grainger, 1998) shared the basic architecture and parameter settings of the monolingual IA models (McClelland & Rumelhart, 1981). Though the BIA was capable of simulating the available bilingual data, it had a number of limitations (e.g., lack of specificity of sublexical and lexical O and P representations, issues with the language nodes and under-specification of the role of task demands during word recognition: Dijkstra & Van Heuven, 2002). The BIA+ addressed the limitations of the BIA, and crucially accounted for non-selective effects of SOP codes (e.g., Dijkstra et al., 1999).

The BIA+ is shown in Figure 3.4 below. Visual input is decoded and sublexical O representations (i.e., letters) become activated. Activation is transmitted through excitory connections to lexical O representations (i.e., whole word representations), which in turn activate S representations. Sublexical and lexical phonological representations can become activated at any time during this process and the bi-directional connections between levels (sublexical, lexical and semantic) and between SOP codes means activation spreads uninhibited through the system. Importantly, the BIA+ assumes non-selective access to an integrated lexicon, meaning that at each level in the system both languages can become activated.

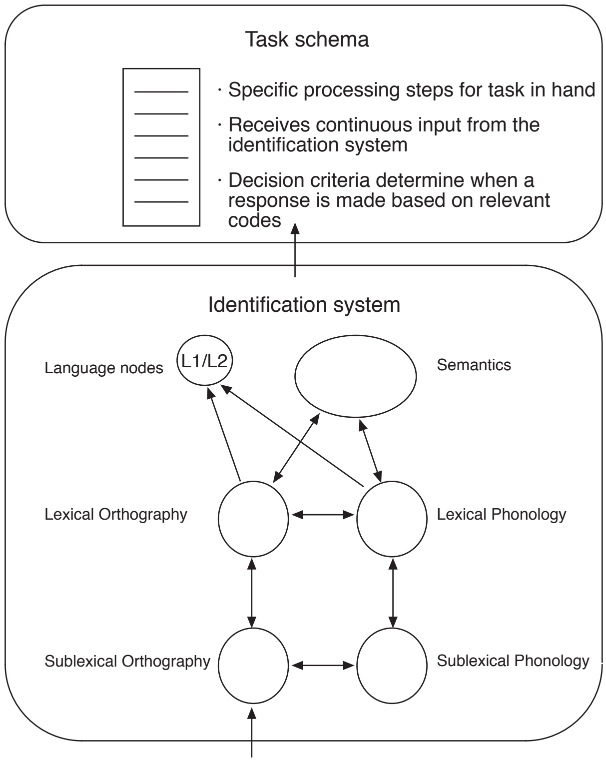

Figure 3.4: Schematic representation of the BIA+ (from Dijkstra and Van Heuven, 2002)

The level of activation of competing codes depends on the subjective frequency of the codes.[10] Thus, the more a word (lexical representation), or bigram or syllable (sublexical representation) is encountered in language the faster it will become activated. In other words, increased subjective frequency increases the resting level of activation of the word (or bigram or syllable), meaning it will be more quickly activated by input or feedback from other levels in the system.[11] The dependence on subjective frequency as the driving mechanism

[10] Subjective frequency is defined as the frequency that a particular person encounters a word; this differs from objective frequency, which is simply the frequency that a word occurs in a particular corpus of texts.

[11] Green's (2002) commentary on the BIA+ raises the issue of whether the model only relies on subjective frequency as a purely cumulative determiner of activation levels or whether recency effects (i.e., words encountered more recently will be activated more quickly) also play a role in the system. Recency, like AoA, is a concept that may modulate subjective frequency effects and is quite likely to be highly integrated with our measures and understanding of language proficiency.

(amongst other factors) for activation levels has a number of important consequences for bilingual processing. Most importantly is the temporal delay assumption, which states that L2 P and S codes will be delayed relative to those L1 codes due to their lower subjective frequency. Even though L2 codes may be activated during word recognition, the activation of L2 codes will typically be too slow to create any observable effect in processing. On the other hand, L1 codes will be activated more quickly, as their subjective frequency is higher, meaning that L1 effects are more clearly observable in bilingual tasks.

The temporal delay assumption leads to two predictions: firstly, cross-linguistic effects will be larger from L1 to L2, because L1 codes are more frequently encountered in the input; and secondly, it is possible that phonological and semantic effects are not observable when responses are fast and task demands allow responses based on O alone (Dijkstra et al., 1999).

The addition of the task/decision system to the BIA+ was a significant advance from the initial model. The task schema is like an algorithm of what the task
requires (e.g., in lexical decision the participant sees the word, decides if it is an English word or not, and presses the appropriate button), and bears a resemblance to what was articulated by Green (1998). Importantly, composition of the stimulus list (Grainger & Jacobs, 1996) may affect real-time tuning of decision criteria. Also, performance can be adapted once decision criteria improve (as in the practice part of experiment tasks).

The language nodes in the BIA+ differ from the BIA in that they only influence processing at the word identification level (i.e., bottom-up linguistic effects), while the task system controls top-down, non-linguistic context effects. When working in a single language, the language node for that language will have increased activation, reflecting global lexical activity. This bottom-up effect is apparently insufficient to block cross-linguistic activation, however, as homophones and cognates are typically responded to differently to noncognate and non- homophone controls. This is also the case when languages do not share script.

Thus, script is not a strong enough cue to inhibit activation of the other language.

In the BIA and IC models, global contextual information (such as expectations

based on the language of the experimenter or the context of an experiment) can influence the initial stages of word identification by inhibiting one language. This is similar to the relative activation of languages depending on the language 'mode' discussed by Grosjean (1997). In the BIA+, such effects would only influence the top- down mechanisms (i.e., the task decision criteria), but not the bottom-up identification mechanisms, meaning that cross-linguistic effects cannot be removed completely. Thus, task criteria can influence bilinguals' responses, but cannot create top-down inhibition of one language (contra original BIA and IC models).

Cross-linguistic similarity

Within the word identification system, similarity to the input determines activation of sublexical and lexical representations, not language membership . Hence, the BIA+ assumes non-selective access of words regardless of language membership with increasing overlap of SOP. Thus, "the degree of code activation of the non-target reading also depends on the *degree* of cross-linguistic code overlap" (p.183, italics added for emphasis). Within-language factors are also important, such as frequency and orthographic neighbourhood size, which influence activation, but the focus here is on the influence of cross-linguistic similarity.

When orthography is shared, homographs and some cognates have complete O overlap, which raises the question of whether they have a single, shared O representation or one for each language. Many cognates have partial O overlap, and for these separate lexical representations are presumed to exist. In languages that differ in script, separate O representations exist for cognates, and homographs do not

exist. Because languages differ in at least some elements of their phonology and/or
phonotactics, it is presumed that cognates and homophones will not be completely identical and thus do not have shared P representations. However, the degree of P similarity at both the sublexical and lexical levels will determine the degree of cross- linguistic activation and the speed of access for languages that differ in script. The BIA+ does not propose a special status or shared lexical representations, but instead proposes that cognate facilitation comes about as a result of shared sublexical P and/or O representations. Much like Costa et al.'s (2005) interactive activation model of picture naming, in the BIA+, shared features at both the S node and P node levels can account for cross-linguistic facilitation effects for cognates that differ in O. However, the P and S units in the BIA+ are not implemented, and this is an important requirement of the next generation of IA models for word recognition (Friesen & Jared, 2010).

Importantly, when O differs across bilinguals' languages, O information may inhibit the non-target language. Further, language specific bigrams lead to a tuning of the recognition system towards that language and away from the other language for which the bigram is not shared. This tuning occurs at the bottom-up level with input from one language activating sublexical and lexical O representations of that language only (while P and S cross-linguistic activation may continue to occur, albeit at later stages in processing). The BIA+ proposes therefore that no (or very little) O cross-linguistic activation occurs for languages that differ in script.

Proficiency

IA models can account for proficiency in terms of the strength of connections between lexical representations and concepts (in both L1 and L2). The increased speed of activation is derived from frequency-based input, which generally places L1 lexical and sublexical representations at a higher resting level than those for the L2. Because the relative frequency of L1 is much higher than L2, it is rare to see L2 effects in bilingual tasks with L1-dominant participants (e.g. Jiang, 1999). However, increasing L2 proficiency (which is determined by increased use of the language) should result in faster connections for L2 lexical and sublexical representations culminating in a gradual increase of cross-linguistic activation in both languages.

A recent critique by Dimitropoulou et al. (2011) argues that the RHM and BIA+ both predict that as L2 proficiency increases cross-linguistic effects in L1 tasks should gradually arise. However, this usually turns out not to be the case. In their research the authors show that three groups of bilinguals (low, intermediate and high proficiencies) do not show gradually increasing cross-linguistic effects in masked priming with lexical decision in the L1, but instead that native-level proficiency is required for these effects to emerge. This suggests some additional element in the mechanism is modulating cross-linguistic effects, namely AoA. In other words, proficiency alone does not affect the degree of cross-linguistic effects in the L1, but early acquisition is required for these effects to emerge. This may be similar in principal to Ellis and Lambon-Ralph's (2000) connectionist model which proposes stronger representations for words learned earlier than those learned later: such early learned words, and also those that have a high subjective frequency (regardless of AoA), may be the most likely to receive and produce cross-linguistic effects.

5. Distributed Conceptual Feature Model

The Distributed Conceptual Feature Model (DCFM) as articulated in Van Hell and De Groot (1998) is a conceptual (i.e., non-implemented) model of bilingual semantic representation. The model was developed to account for the processing advantage for cognates, as well as the influence of concreteness and grammatical class. A key assumption of the model is that concreteness, cognateness and grammatical class determine the degree to which concepts are shared.

Cross-linguistic similarity

The DCFM considers concreteness to be a key feature in determining cross-linguistic semantic overlap. Concrete and abstract words tend to be associated differently across languages. That is, concrete words are more likely to be associated with a single translation in another language, whereas abstract words are more likely to be associated with a greater number of translations. This has subsequently been shown in other research (Tokowicz et al., 2002; this thesis). Van Hell and De Groot (1998) explained this finding in terms of both localist and distributed models of semantic representation. In terms of a localist model, differences between concrete and abstract words were taken as evidence for a single store for concrete translations and separate stores for abstract translation pairs. Thus, concrete translations should be produced more quickly because they are stored together, while the opposite is true for abstract translations because they are stored separately. In terms of the distributed model, concrete translation equivalents share more conceptual features than abstract translations.[12] This leads to faster translating of concrete words compared to abstract words due to greater cross-linguistic semantic activation of the former compared to the latter. The architecture of the localist and distributed models are represented in Figures 3.5 and 3.6 below.

[12] Grammatical class (nouns vs. verbs) was also shown to be a predictor of the number of word associations provided by bilinguals. Verbs had more word associations and were more likely to elicit multiple translations than nouns. However, this is most likely due to the high collinearity between noun-verb status and concreteness-abstractness. Nouns regularly have either concrete or abstract meanings, while verbs tend to convey actions and states, making them more likely to be abstract (i.e., less tangible and imageable). As discussed above, abstract words have more translations than concrete words. Therefore, verbs are likely to have more translations than nouns because they are more likely to be abstract than concrete.

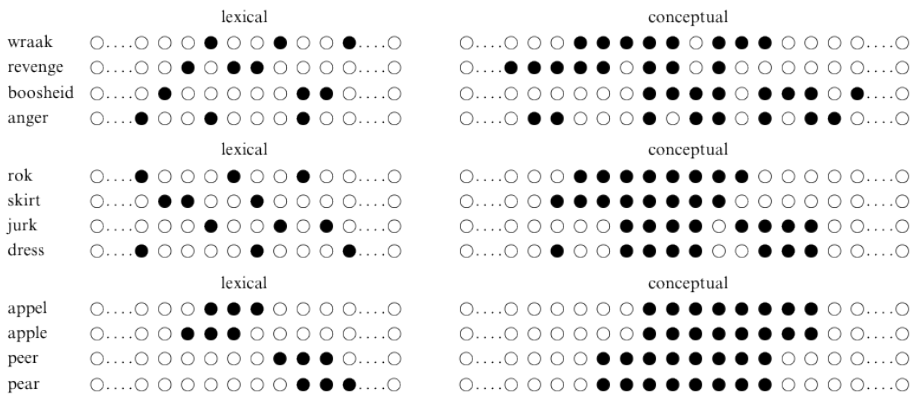

Figure 3.5: Distributed representations are shown for abstract noncognate translations (upper), concrete noncognate representations (middle) and concrete cognate representations (lower; from Van Hell and De Groot, 1998)

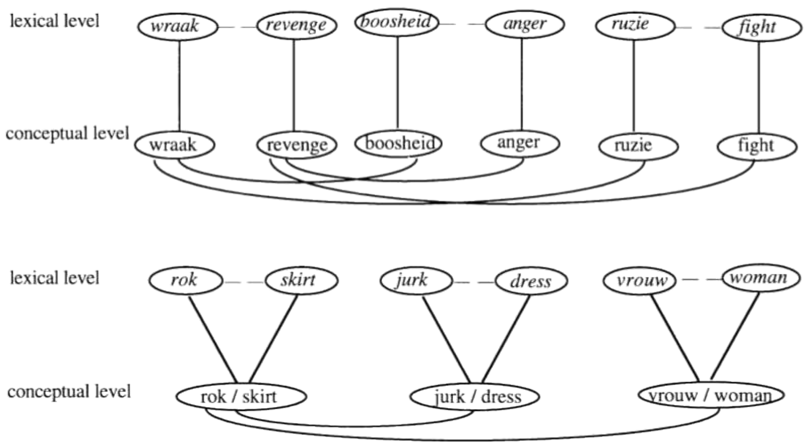

Figure 3.6: Local representations of abstract noncognate translations (upper) and concrete noncognate translations (lower; from Van Hell and De Groot, 1998)

A critical issue with the DCFM is that it assumes that cognates have complete conceptual (S) overlap (similar to the RHM of Kroll and Stewart, 1994), due to formal similarity across languages (Van Hell & De Groot, 1998, p.194). Formal similarity (OP) between words influences responses in bilingual tasks in a variety of ways, as well as being influential in processing in monolingual tasks (i.e., neighborhood effects). In a cross-linguistic word association task, a particular 'associate' might be produced because it has a great deal of formal overlap with the target. Thus, a cognate prime might elicit its cognate translation due to their formal similarity, whereas a noncognate target may elicit a translation equivalent or another word that is simply semantically associated (which is actually what the task is asking participants to do). The fact that cognates and noncognates elicit different patterns of responses might not be due to differences of S overlap, but instead the degree of OP overlap. Crucially, recent work (Tokowicz et al., 2002; this thesis) has shown that cognates and noncognates appear to be indistinguishable on the basis of the shared semantic/conceptual features. Tokowicz et al. (2002) demonstrated this using mean cross-linguistic semantic similarity ratings with Dutch-English bilinguals; this thesis confirms the finding with different script bilinguals, Japanese-English bilinguals (Chapter 4).

Additionally, the *degree* of formal similarity, that is P and O similarity, is not adequately accounted for in the DCFM. Consequently, it is unclear how cognates that overlap completely or only partially in form could influence conceptual representations. In their reasoning, cognates are more likely to share conceptual features, but does this apply to all cognates irrespective of formal similarity? The answer to this question is unclear because formal features are not discussed adequately. The more general issue of formal overlap and how it influences processing could be resolved, for the localist model at least, by implementing sublexical O/P nodes, as in the BIA+. The distributed model illustrates overlap at the lexical level (Figure 3.5), with individual nodes relating to sub-lexical features. However, because the DCFM is not implemented it is not possible to test theories relating to formal overlap, either in the localist or distributed versions of the model.

According to Van Hell and De Groot (1998) a word association task reflects
conceptual processing. Importantly, in a bilingual version of the task, 'a large amount of translations (or "same" responses) is considered evidence for a common conceptual store. In contrast a large amount of different responses is taken to indicate a language- specific storage of word meanings in bilingual memory' (p.195). Thus, when participants consistently produce translations in the between-language association task (e.g., *apple* is always translated as *appel* and vice-versa), this is presumed to provide evidence of a single concept for those words.

Importantly, because two words are primarily given as translations for each other does not necessarily indicate that they share a conceptual (S) representation. If we take the example of アップル /appuru/ 'apple' in Japanese, it is likely to elicit the English word *apple* in a translation or word association task. However, /appuru/ is used primarily in compounds such as アップルパイ/appurupai/ - 'apple pie', and the native Japanese word リンゴ/ringo/ is used to name the fruit. Thus, while アップル /appuru/-apple may meet the psycholinguistic definition of cognate, it is unlikely that they share (or completely share) a semantic representation. Since many Japanese- English cognates are subject to a similar sort of semantic narrowing, the amount of S overlap will vary, which makes assuming that cognates share a conceptual (S) representation problematic. Studying more distant language pairs, such as Japanese-English, should provide us with a greater understanding of S representation of cognates. What seems most important is for research to systematically manipulate or control POS similarity in bilingual studies to understand how degree of overlap influences representation and processing.

The discussion of localist vs. distributed representations is interesting and highlights the main distinction in these types of computational models in terms of semantic representation. Localist representations would need to include multiple separate senses (semantic representations) for single lexical representations, which, given the complexity of dividing word meanings into senses, seems problematic. Distributed representations seem more in line with cognitive representation of knowledge structures. Most importantly for this thesis, distributed conceptual features would provide the simplest method of visualizing and understanding how translations overlap in meaning; that is, how they vary in their semantic similarity. Needless to say, this is a complex issue and must be returned to in the Discussion section of this thesis.

Proficiency

Proficiency is not discussed in Van Hell and De Groot (1998) in relation to the DCFM and as so cannot be discussed in any detail here.

5.1 Other distributed conceptual feature models for semantics

The Sense Model (Finkbeiner et al., 2004) is another model that seeks to explain the organization of semantic representations in the bilingual lexicon. The model was intended to explain effects of asymmetrical priming observed in lexical decision and the symmetrical effects observed in semantic categorization. It was developed on the basis of the DCFM with a number of unique additions, specifically conceptual features are distributed but bundled together in to senses, and the total activation of these senses is what determines (asymmetrical) bilingual priming effects. In addition, the Sense Model assumes that the activation of senses drives cross-linguistic activation leading to priming. Thus, there is no difference in the strength of connections between L1 and L2 conceptual representations and lexical representations. Chapter 7 empirically explores the predictions of the Sense Model, and therefore it is discussed in greater detail there.

6. Multilink

Multilink is perhaps the most recent bilingual IA model and was developed by Dijkstra and Rekké (2010; and see Lormans, 2012). It was developed to address a number of limitations of the BIA+ and RHM models. Because the BIA+ is ‘a narrow model of word recognition’ (Kroll et al., 2010), and has not been applied to tasks that involve language production (i.e., translation), a primary objective of Multilink is to implement a model of both bilingual comprehension and production. A second aim is to implement a model that can account more precisely for changes in language proficiency (i.e., developmental processes), similar to what the RHM does. The Multilink model therefore attempts to provide a localist-connectionist, implemented alternative to the non-implemented, theoretical RHM, which has until now dominated discussion of bilinguals' translation processes and language acquisition. While the RHM has stimulated considerable research in the field of bilingual processing, on the surface it appears not to have changed since its inception. This is due to its simple design and 'verbal' nature, which leaves it both difficult to falsify and simple to modify (Dijkstra & Rekké, 2010). In contrast, implemented computational models that can simulate experimental data provide a more concrete framework for understanding the complex nature of bilingual processing (*ibid*, 2010; Brysbaert & Duyck, 2010).

Figure 3.7 shows the general architecture of Multilink, which is identical to the BIA+ described previously, except for the absence of the sublexical O and P level and the addition of translation to the task system. The absence of the sublexical level appears to be a practical constraint as opposed to a theoretical statement of its non-necessity; this issue is discussed in relation to cross-linguistic similarity below. The addition of translation to the task system is one of the main innovations of Multilink, which allows it to model language production as well as recognition.

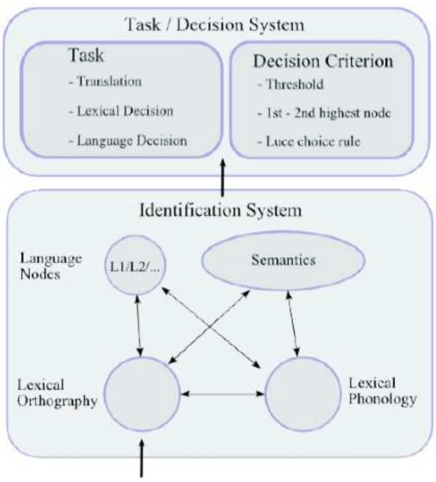

Figure 3.7: The architecture of Multilink (from Lormans, 2012)

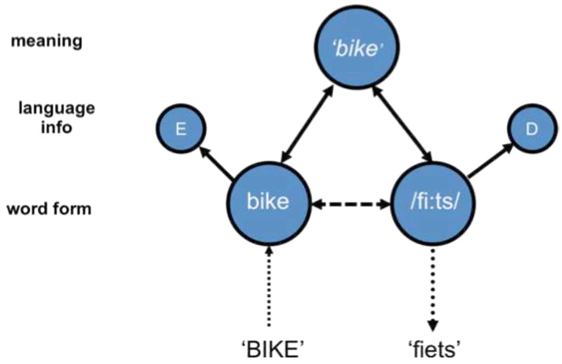

Figure 3.8: The conceptual framework for translation assumed by Multilink (from Dijkstra and Rekké, 2010)

Figure 3.8 illustrates the conceptual framework for translation. Dijkstra and Rekké view translation as a process that 'includes aspects of word recognition, meaning retrieval and word production' (p.14). This contrasts with the RHM's assumption that translation does not necessarily involve word recognition, and as such, the RHM is suggested to be primarily a model for production (Kroll et al., 2010). Moreover, because Dijkstra and Rekké assume translation always involves meaning retrieval (conceptual access), this also contrasts with the word-association route of the RHM, which is believed to be carried out without direct access to meaning when translating from L2 to L1. This word association method of translation is assumed to occur primarily in low proficiency bilinguals (Kroll & Stewart, 1994), via the intra-lexical links formed during L2 development. Importantly, Multilink can test the contested intra-lexical links featured in the RHM, as it has weighted links between words that can be set to zero meaning that no intra-lexical activation occurs via the direct links (see Lormans, 2012).

Cross-linguistic similarity

Multilink does not include sublexical P and O units, therefore cross-linguistic P and O similarity effects occur at the lexical level. Importantly, because Multilink specifies that activation is non-selective, activation spreads both within and across languages, meaning formal similarity effects are language-independent. Similar to the BIA+, Multilink specifies lateral inhibitory O links between O neighbours; thus, BIKE will inhibit BILE, BAKE, CAKE, and so on. Normalized Levenshtein Distance (NLD; see Schepens et al., 2012) is used as a measure of O similarity for lexical representations. NLD accounts for word length effects because the number of position-specific differences in characters between the two items is divided by the length of the word (number of characters). Cross-linguistic activation of cognates has been simulated by Multilink (Dijkstra & Rekké, 2010) and demonstrates that activation occurs as a result of cross-linguistic O similarity (in Dutch-English words) and also S activation. S activation occurs due to feedback between O representations and S representations.

Simulating a translation task with Multilink, Lormans (2012) found strong facilitatory effects for identical cognates. In this case, the input activates O similar representations in the target language but also in the non-target language; O identical cognates are both activated to the same degree, and more than other O similar cognates, and activation is sent to the related S representations. As S representations exist for each language, both are activated by the cognate and send activation to the associated P lexical representations in each language. The question becomes how the model selects the item from the correct language for the task. In the BIA+, bottom-up activation of language specific features drives activation within-language and reduces the threshold of activation for target language representations. Multilink uses a similar mechanism, but at the lexical level, given that sublexical features are not featured in the model at present. Additionally, the language nodes in both models represent 'global activation' in each language, but cannot inhibit the 'other' language. Furthermore, the task/decision system can provide top-down modulation over language activation, but again, cannot completely inhibit either language.

The simulations by Lormans (2012) replicated O and S priming effects: orthographically and semantically related primes speeded responses to targets relative to control words. Crucially, for O priming, greater cognate effects were found for identical cognates, compared to non- identical cognates and noncognates. However, non-identical cognates at two levels of O similarity (Levenshtein Distance of 1 or 2) did not differ greatly, suggesting a minor role for subtle O differences between non-identical cognates. Thus, cross-linguistic O similarity at the lexical level can be accounted for by Multilink in translation priming with Dutch-English bilinguals. The observed S priming is discussed briefly in the following sections that deal with S representations.

Currently, P similarity is implemented only in the production component of the model (i.e., on the output side). In translation, lexical-phonological representations are activated by semantic representations, as in the concept mediation route of the RHM. Non-target P representations can be activated in a number of ways. Firstly, they are activated via spreading activation from S representations. For example, the input BIKE activates the concept ‘bike’, which activates ‘helmet’, ‘road’, and so on; the P representations of these S neighbors thus also become activated. Secondly, non-target P representations can be activated through spreading activation due to O similarity of words to the input. For example, if the input is BIKE, then BAKE, BILE, and so on, will be activated; in turn, the S representations, as well as the P representations for these words (i.e., /baɪk/, /beɪk/, /bail/) will also be activated. Thirdly, although P and O lexical links have not been implemented in Multilink as yet, O lexical representations should also be able to activate P representations directly, i.e., without going through S representations. Finally, P similarity effects should also occur independently from O similarity effects. In other words, P representations should spread activation to P lexical neighbours depending on the degree of P similarity. For example, /baɪk/ should activate /haɪk/, /maɪk/ and so on, to the degree that these words overlap in terms of P. At present there is no measure of P similarity that is utilized in Multilink. Importantly for languages that differ in script, such as Japanese-English, P similarity is the critical factor in determining cross- linguistic formal similarity effects. Thus for the model to be applicable to different- script bilinguals, P similarity requires theoretical consideration as well as implementation.

As mentioned previously, Multilink does not specify sublexical representations and mappings between sublexical P and O representations because of problems in position-specific encoding of letters (p.15). One of the major advantages of the BIA+ is in its ability to explain (and reproduce) cross-linguistic similarity effects due to sublexical P and O representations. Thus, a future aim of Multilink should be to incorporate the sublexical level of the identification system. Semantic representations, as with the BIA+, are under-specified in Multilink. In the model, S representations are holistic units (localized, single representations). Each lexical representation activates one or more of these S units, depending on the number of distinct senses that it has (a word like *bank,* presumably activates two or more distinct S units). A discussion of the complex nature of S similarity (number of shared senses across languages) and conceptual similarity (degree of conceptual overlap of individual senses) is 'avoided'.

S representations are currently language-independent in Multilink. That is, pairs like *tomato* and *tomaat*, as well as *bike* and *fiets* (i.e., cognates as well as noncognates) have shared semantic representations in the lexicon. This is a temporary and practical solution to allow an implementation of associations: Multilink includes connections between S representations based on their degree of association with other words. The semantic associations between words are currently derived from monolingual English word association databases. In the future, the S representations could be made partially language-specific. For example, *tomato* would be associated with *vine*, *sauce, soup*, and so on, while *tomaat* would be associated with analogous but potentially also different Dutch equivalents. Thus, Lormans (2012) was able to demonstrate S priming effects within languages using Multilink. However, it is not clear how cognates, noncognates, and simply S related words are connected across languages. Importantly, the degree of S overlap between cognates, noncognates, and S related words needs to be instantiated in the model. While S association databases might be useful for developing within- language lexicons, they are less useful at illustrating cross-language associations. On the surface, the use of separate language association databases suggests an orientation towards separate conceptual stores. However, this is more a practical issue, because no cross-language semantic association databases exist, and creating one will be fraught with issues.

Proficiency

The BIA+ assumed that L2 proficiency was reflected in the speed of access to lexical representations, which is determined by subjective frequency of words. Low proficiency L2 learners have had fewer encounters with words than higher proficiency bilinguals, thus lower proficiency means lower subjective frequency. Multilink simulates the effects of different stages of L2 proficiency in translation by adjusting the subjective frequency of L2 representations. This in theory could be achieved with the BIA+ for word recognition.

Initial simulations showed that asymmetrical translation direction effects can arise as a result of proficiency (Lormans, 2012). When using the actual occurrences per million frequencies of the L1 and L2 words (with no adjustments for proficiency), translating was equally fast in both directions (as in Christoffels et al., 2006). However, when subjective frequencies for input (O) and output (P) representations were set by hand for translation equivalents to mimic the unbalanced bilingual's proficiency (i.e., the subjective frequency of the L2 was reduced), the cost of having a lower output frequency was greater than having a lower input frequency (p.24). Thus producing L2 was slower than producing L1, replicating the observed asymmetry of faster L2-L1 translating and slower L1-L2 translating. Importantly, the asymmetry was reduced for cognates (p.25) because of facilitation by cross-linguistic O similarity.

In sum, Multilink in its present state seems very promising in that it can account for O similarity, word frequency and word length effects, as well as the influence of bilingual proficiency in both word recognition and production. Further, the model can simulate results for bilingual lexical decision, translation and language decision, meaning it can potentially account for bilingual performance across a range of tasks. Presumably, in the absence of O similarity (in the case of languages that differ in script), P similarity can be used to mimic cognate effects and other cross-linguistic effects if a measure, such as similarity ratings from bilinguals, was available for P. The S representations are good in that they spread activation to related representations and to both O and P representations. However, S units are localized and cannot deal with effects of S similarity across languages. Implementing developed semantic representations will be a challenge for this model (as well as any model wishing to reflect the complexities of semantic representations and their interconnections). While task effects are potentially accounted for in the model, more simulations are necessary. In particular, Kroll and Stewart (1994) have argued that translation is like picture naming, and so Multilink's ability to account for picture naming stimuli will be another challenge.

Summary

In this chapter the principal models pertaining to aspects of bilingual lexical representation and processing were reviewed. No single model is adequate for explaining the influence of cross-linguistic similarity and language proficiency across both production and recognition tasks. However, some models may prove more useful than others.

Of all the models, the IA models (Costa et al.'s picture naming model, the BIA+ and Multilink) may come closest to explaining the effects of O/P similarity across languages. These models can also simulate effects of word length, frequency, and within-language similarity. However, the BIA+ has only been used for simulations using O similarity, not P similarity. For the present research, as the focus is different-script languages, P rather than O similarity is the important component of formal similarity. Multilink does not have sublexical O and P units, nor has it implemented P units on the comprehension side of the model. Thus, cross-linguistic similarity facilitation is primarily due to the O similarity.

The RHM does not specify mechanisms to account for word length, frequency, or within-language formal similarity, nor does it specify in detail how P and O overlap account for variation in processing. The IC model does not detail cross-linguistic similarity, which is presumably contained in its ‘bilingual lexico-semantic system’.

In the research in this thesis, the role of between-language S similarity is important. The DCFM (and the Sense Model) provides the most detail about the influence of S. While the view that cognates share more meaning than noncognates is problematic, the predictions for conceptual feature overlap as a function of concreteness is an important factor in determining S overlap of translations (both for cognates and noncognates). While Costa et al.’s model of picture naming appears to use semantic nodes that could vary across languages, leading to a different level of overlap, the model has not been implemented computationally. Semantics are also not implemented in the computational BIA+ or Multilink models. As localist-connectionist models it is unclear how the issue of shared conceptual features could be operationalized such that it represents cross- linguistic S overlap at a very fine-grained level of detail. Distributed S representations seem more intuitive, but it is unclear weather these could be implemented within the BIA+/Multilink S systems. Multilink simulates within-language S relatedness by using word association measures. The use of these measures for each of the bilingual’s languages may provide a partial solution to the issue of number of senses in each language; however, word associations between languages, as well as within languages, would ideally be utilized to predict spreading within- and between-language S activation in the bilingual lexicon. These issues are taken up further in the Discussion at the end of the thesis. Finally, the RHM an IC models do not represent S features specifically in the models. The RHM would have difficulty accounting for S similarity effects at the conceptual level in early stages of L2 development due to the intra-lexical links, which assume that L2 lexical items are initially mapped onto L1 lexis/semantics. Such links would be abundant among translations (both cognate and noncognate) and pose potential problems for computationally implemented models (Brysbaert & Duyck, 2010).

Only two of the models were developed specifically to account for how proficiency influences processing and representation: the RHM and Multilink. The former specifies different strength connections between conceptual and lexical stores, with the addition of intra-lexical links that are used primarily by L2 learners during early stages of learning. Multilink, similar to the BIA+, postulates subjective frequency as the main determiner of variation attributable to proficiency. While subjective frequency undoubtedly plays a major role, AoA, which has been shown to be important in bilingual lexical processing, must also be accounted for. It is not clear exactly how AoA modulates the strength of the connections in the RHM or the speed of processing in Multilink. Though Costa et al. do not discuss proficiency, being an IA model, it should be possible to incorporate subjective frequency as a means of modulating activation of representations in each language. The IC model, which uses top-down inhibition to control selection language selection, presumably uses relative cognitive control ability to account for performance at different proficiency levels.

Unfortunately, each model only accounts for bilingual processing in limited set of tasks, instead of capturing lexical production and comprehension across all tasks. Costa et al.'s model is restricted to picture naming, the BIA+ to word recognition (lexical decision, language decision, progressive de-masking) and Multilink to translation and word recognition tasks. The IC model was developed primarily to account for differences in ability to perform translation, similar to the RHM, though the latter has been applied to data from a huge variety of tasks (from those involving production, recognition and acquisition). The DCFM is based on translation tasks but only details conceptual and semantic representations, so cannot explain word recognition or production processes.

Three of the models reviewed were connectionist IA models: Costa et al.'s picture naming model, the BIA+ and Multilink. Only the latter two of these have been implemented as actual computational models. Implementation is a useful way to investigate theory further by testing data in simulations, and simulations have been useful in revealing possible mechanisms for cross-linguistic similarity, proficiency and task differences. Future modeling work may benefit from implementing measures of cross-linguistic P and S similarity to investigate how languages interact at these levels, as well as the O level. This will be essential when modeling languages that differ in script, such as Japanese-English.

Rationale for present research

Most of the research on bilinguals, particularly that looking at cross-linguistic similarity, has focused on languages that share script (e.g., Dutch-English). Fewer studies have investigated cross-linguistic similarity effects with different script bilinguals. Because different script languages do not share O, they provide a unique opportunity to test the importance of P similarity in processing, without being confounded by sharing both P and O similarity being confounded. Similarly, only a handful of studies have investigated bilingual processing with Japanese-English bilinguals (Finkbeiner et al., 2004; Hoshino et al., 2010; Hoshino & Kroll, 2008; Miwa, 2013; Taft, 2002), and fewer have looked at cognate processing (Hoshino & Kroll, 2008; Miwa, 2013; Taft, 2002).

Japanese-English cognates vary greatly in terms of P similarity due to the process of rephonalization of loanwords from English. This provides an opportunity to test the role of gradient differences in the similarity of P across languages. If P similarity is shown to be important and that its influence is continuous as opposed to binary in nature, this will support models of bilingual processing that postulate greater cross-linguistic activation based on the degree of similarity (e.g., BIA+). Japanese- English cognates are interesting because they are all loanwords and are not historically related. Particular features of loanwords such as semantic narrowing may mean that these loanwords provide the perfect basis for testing theories about the role of S similarity. In other words, because many loanwords share only a subset of the English words' meanings, while others may share the majority, they may provide useful stimuli for testing the influence of S similarity in bilingual processing.

Semantic similarity has generally been under-researched in comparison with P and O similarity. Though S similarity varies greatly, research has typically assumed that translation equivalents generally share meanings across languages, and discrepancies in terms of senses and meanings has received little attention. Moreover, models of bilingual processing rarely have much to say about shared S features, and none of the IA models reviewed here deal sufficiently with cross-linguistic S similarity. Thus, the present study will provide considerable evidence about the importance of S similarity in bilingual processing and thus make a case for greater development and implementation of S features in bilingual models.

Finally, because of the great number of Japanese-English cognates and bilinguals[13] who speak those languages, the importance of research findings for informing theories of language learning should not be understated. The findings may inform research in applied linguistics and thus potentially improve teaching methods and materials.

[13] English education is compulsory in most junior high, high schools and sixth form colleges meaning that in 2010, for example, most of 3,558,166 students at junior high and 3,368,693 at high schools studied English as a second language. In addition, of the 2,887,414 students who attended university (not including vocational schools or short-term universities) in the same year, most would have taken English courses as a compulsory part of their tertiary education. As English has been De-facto compulsory in these schools, colleges and universities since the end of the Second World War, one could estimate that the majority of Japan's current population (128 million in 2010) has studied English to some extent, and the most recent generations have had around 6-8 years of English Education by the time they leave high schools. [All statistics are from the Ministry of Internal Affairs and Communications Website, 2013].

Chapter 4: Cross-linguistic similarity norms for Japanese-English translation equivalents

Abstract

Formal and semantic overlap across languages plays an important role in bilingual language processing systems. In the present study, Japanese (first language; L1)- English (second language; L2) bilinguals rated 193 Japanese-English word pairs, including cognates and noncognates, in terms of phonological and semantic similarity. We show that the degree of cross-linguistic overlap varies, such that words can be more or less ‘cognate’ in terms of their phonological and semantic overlap. Bilinguals also translated these words in both directions (L1-L2, L2-L1) providing a measure of translation equivalency. Notably, we reveal for the first time that Japanese-English cognates are ‘special’ in the sense that they are usually translated using one English term (e.g., コール/kooru/ ‘call’ is always translated as *call*), while the English word is translated into a greater variety of Japanese words. This difference in translation equivalency likely extends to other non-etymologically related, different script languages where cognates are all loanwords (e.g., Korean-English). Norming data were also collected for L1 Age-of-Acquisition, L1 concreteness and L2 familiarity, as such information is currently unavailable for the item set. Additional information on L1/L2 word frequency, L1/L2 number of senses, L1/L2 word length and number of syllables is also provided. Finally, correlations and characteristics of cognate and noncognate items are detailed to provide a complete overview of lexical and semantic characteristics of the stimuli. This creates a comprehensive bilingual data set for different-script languages and should be of use in bilingual word recognition and spoken language research.

Introduction

Words within a language can have formal (phonological (P) and orthographic (0)) and/or semantic (S) overlap (e.g., *bat/bat* (+P, +0, -S), *tear/tear* (-P, +0, -S), *break/brake* (+P, -0, -S), *couch/sofa* (-P, -0, +S)). Importantly, research has shown that such overlap can increase activation and speed processing or create competition and slow processing (Balota, Cortese, Sergeant-Marshall, Spieler, & Yap, 2004; Jared, McRae, & Seidenberg, 1990; McClelland & Rumelhart, 1981). The English word *ball* and the Japanese word ボール /booru/ overlap a great deal in S and P, although there is no O overlap as the two languages are written in different scripts. Such overlap, or what we will refer to in the current research as cross-linguistic similarity, plays an important role in bilingual language processing (Chapter 5; Dijkstra et al., 2010).

In the literature on bilingual word processing, words that share both form and meaning are usually referred to as *cognates* (Dijkstra, 2007). This is because until recently most of the research has investigated the processing of European languages (e.g., Catalan, Dutch, English, French, German, Italian, and Spanish). Thus, when words had form and meaning overlap (e.g., English *night*, French *nuit*, German *Nacht*) this was in fact due to the modern words having a common historical root (e.g., Latin *nocte*); therefore, they were cognates. In the case of the Japanese word ボール /*booru*/ 'ball', it is more appropriately called a loanword/borrowing. However, it is not the historical origin of such words in a language, but instead their cross-linguistic similarity that influences their processing. Thus, for the purposes of this paper we will refer to any cross-linguistic word pairs that share form and meaning as cognates. While Japanese-English cognates can be easily identified by simply considering the overlap of form and meaning across languages, a much more precise definition of 'cognateness' can be determined by the use of bilingual measures of perceived similarity. This is discussed further in the following sections.

Cognates have been central to psycholinguistic research into bilingual language processing.[14] An important question about bilingual language processing was whether bilinguals could selectively activate a single language or whether both of their languages were activated non-selectively. In other words, when processing one language, is it possible to turn the other language 'off'? Cognates provided an ideal way to investigate this question, as they had a great deal of formal and S overlap. When bilinguals perform a task such as lexical decision, in which all words are presented in one language, cross-linguistic overlap should only influence processing if language activation was non-selective. That is, if both languages are activated during single language processing, cognates should facilitate processing. Alternatively, if only a single language is activated during language processing, shared cross-linguistic SOP features of cognates should not influence processing relative to words that have no SOP overlap.

A considerable amount of research has shown that bilingual word recognition is fundamentally non-selective in nature (e.g., Dijkstra & Van Heuven, 2002; Van Heuven, Dijkstra, & Grainger, 1998; see Dijkstra, 2007 for a review). When using a second language, cognates have been shown to speed bilinguals' responses relative to matched noncognate controls in a wide variety of tasks, such as word naming (Schwartz et al., 2007), word translation (Christoffels et al., 2006) and lexical decision (Dijkstra et al., 1999). Moreover, similar findings have been presented for languages that differ in script (e.g., Lexical decision with Hebrew-English*,* Gollan et al., 1997; picture naming with Japanese-English*,* Hoshino & Kroll, 2008; masked priming lexical decision with Japanese-English, Nakayama, Sears, Hino, & Lupker, 2012; masked priming lexical decision and word naming with Korean-English*,* Kim & Davis, 2003). Typically, in such studies cognates and noncognates are matched on important characteristics such as frequency, length,

[14] Bilinguals are defined by their language proficiency in both languages. This definition is standard practice in psycholinguistics and diverges form the classic distinctions of compound and additive bilinguals made by scholars such as Weinreich (1953). Thus, for example, under this definition if a native speaker of Japanese also speaks English as a second language to some degree of proficiency they can be referred to as bilingual.

phonological onset and phonological neighborhood size (for naming) and orthographic neighborhood size (for lexical decision).

While cognates typically speed responses in L2 tasks such as lexical decision, picture naming and translation, Dijkstra et al. (1999, 2010) showed that in language decision tasks, where bilinguals had to decide whether targets were either Dutch or English, cognates were inhibited relative to noncognates. Thus, for tasks in which cross-linguistic similarity is disadvantageous, as in language decision, cognates can actually slow processing.

Even in sentence processing tasks, where semantic and syntactic constraints may be more likely to induce language selective processing, cognate facilitation has been observed relative to noncognates (e.g., Schwartz & Kroll, 2006; Van Hell & De Groot, 2008; Van Assche, Duyck, Hartsuiker, & Diependaele, 2009; Van Assche, Drieghe, Duyck, Welvaert, & Hartsuiker, 2011). While cognate effects are typically more prominent in the L2 than in the L1 for unbalanced bilinguals (i.e., bilinguals who are not equally proficient in both languages and typically more proficient in the L1) due to the boosted activation of the more dominant L1, L2 cognate effects have also been observed in the L1 (Duñabeitia et al., 2010; Van Assche et al., 2009). Thus, even when bilinguals are more dominant in an L1, it is still possible to observe cross-linguistic similarity effects in both L1 and L2 processing.

While much of the previous research into bilingual processing has defined cognates and noncognates as dichotomous, a growing number of studies have reported that bilinguals are sensitive to the degree of similarity above and beyond a simple binary distinction (e.g., Chapter 5; Dijkstra et al., 2010; Van Assche et al., 2009, 2011). Using mixed-effects modeling with multiple independent variables, these studies have revealed that continuous measures of cross-linguistic similarity are indeed predictive of bilinguals' responses in L2 tasks. Most relevant for the present study, Chapter 5 (this thesis) found that Japanese-English bilinguals responded to English words faster in lexical decision, depending on the degree of P similarity between the English and Japanese words. For example, while both *bus*-バス/basu/ and *radio*-ラジ

オ /rajio/ are cognates and were responded to more quickly than noncognate matched controls, *bus* was rated as being more phonologically similar to バス/basu/ than *radio* was to ラジオ,/rajio/ and *bus* was responded to significantly more quickly than *radio*. This study used mixed-effects modelling with multiple predictors including word length and word frequency. Because such predictors are correlated with each other and also P similarity, residualization was used to orthoganlize the predictors prior to model fitting. Collinearity was removed between all correlated variables and then the residuals of these predictors were used to predict RTs. The orthogonalized predictors showed that length, word frequency and P similarity accounted for significant, but independent, portions of the variance in RTs. These facilitatory effects of P similarity were observed in L2 English lexical decision and picture naming with Japanese-English bilinguals. In addition, S similarity was shown to be an important predictor of responses to cognates in picture naming, with more semantically similar cognates being responded to more quickly than less semantically similar cognates. In the English lexical decision experiment, S similarity had the reverse effect to that in picture naming: less semantically similar word pairs were responded to faster, due to such items having more senses which apparently boosted activation of the lexical representation leading to speeded responses relative to more semantically similar words (which tend to have fewer senses). These results highlight the importance of task effects in language processing but also underscore the importance of continuous measures of cross-linguistic similarity as crucial indicators of bilinguals' processing performance.

Despite the importance of cross-linguistic measures of word similarity in bilingual language processing research, to our knowledge only one previous study has collected bilingual measures and made them available to researchers. Tokowicz et al. (2002) conducted a large-scale study on 1,003 word pairs with Dutch-English bilinguals who rated translation equivalents for cross-linguistic O, P and S similarity. They also elicited translations to determine translation equivalency and to assess the number of translations that a word has. Bilinguals translated words in both directions (i.e., from L1 to L2, and L2 to L1), and this was used to determine whether a word has one or more translations in each language, as the number of translations a word has, has been shown to influence bilingual processing. The number of translations also can provide a metric of the amount of S overlap between words in two languages. If a word that has a number of senses in one language is translated into a single word in the other language, then both words are likely to be used in similar contexts in the two languages. Whereas if a word in one language has multiple senses that lead to different translations in the other language, then that word is likely to be translated into more than one word. Thus, the words will be used in a variety of contexts and likely have less complete S overlap.

For researchers interested in L2 and bilingual language processing, it is critical to have norms for cross-linguistic S similarity in order to control for the influences of the 'other' language during language processing tasks. Moreover, bilingual ratings may be more suitable measures of S overlap than dictionary measures of the number of meanings/senses in each language because dictionaries vary greatly in their methods of quantifying meanings/senses, and also reflect the total senses that *exist* in the language as opposed to those known by the average bilingual (see Gernsbacher, 1984, for a similar argument).

To our knowledge, there are currently no measures of cross-linguistic similarity available for languages other than Dutch-English. The present study thus provides cross-linguistic norming data for Japanese-English translations. Research into Japanese-English bilingual processing is particularly important, not only because there has been relatively little bilingual research with languages that differ in script (in comparison to research on same-script languages), but also because of the importance of English in Japanese society. Compulsory education and tertiary institutions place a strong emphasis on language education, and English is the most widely learnt second language in Japan. Also, the Japanese language has many thousands of loanwords borrowed from English, many of which are in regular and in general use; however, the majority are reserved for technical and academic uses. The proportion of loanwords in the 5th edition of the *Koujien* (1998), a comprehensive Japanese dictionary, was 10.2%, which equals around 23,000 word entries (Kawaguchi & Tsunoda, 2005; cited in Igarashi, 2007). Moreover, around 90% of loanwords are borrowed from English (Shinnouchi, 2000). Therefore, a better understanding of how Japanese-English bilinguals process these cognates is an important area for research.[15]

The primary goal of the present study was thus to provide a range of cross-linguistic similarity measures of Japanese-English translation equivalents. To this end, ratings were collected to assess P and S similarity. Also, participants were asked to translate words to provide an estimate of the number of translations and meanings that are known by the bilinguals. A second aim was to collect additional norming data that are critical for designing experiments that investigate bilingual processing, yet, which is not publicly available for all of the Japanese words in this study. Because most studies focus on high-frequency words (e.g., Yokokawa, 2009 investigated the top 3000 words in the BNC), there are few measures for many of the cognates that are ubiquitous in Japanese language but tend to be of lower frequency. Thus, information about perceived age of acquisition (AoA) and concreteness of L1 Japanese words was collected. Concreteness is particularly useful for researchers as it is typically highly correlated with grammatical class, such that verbs tend to refer to abstract events or actions while nouns often refer to concrete objects, as well as abstract entities. While grammatical class is problematic as a norming measure because many words can be read as verbs or nouns (e.g., *call, run, telephone*), concreteness can be used as a measure of the intrinsic S properties of the item which may include both the verbal and nominal uses of items. In addition, bilingual ratings of L2 (English) word familiarity were

[15] Some research has been conducted with English-Japanese bilinguals on the learning and use of cognates in Japanese (e.g., Prem, 1991; Tomita, 1991; see Kess & Miyamoto, for an overview), but it has not investigated cognate processing. Moreover, while one may assume that perceived cross-linguistic similarity may be comparable for both Japanese-English and English-Japanese bilinguals, no research has put this idea to the test (with any bilinguals), and thus the present dataset should be considered applicable only for Japanese-English bilinguals.

collected. To create a more complete set of information about Japanese-English cognates that could be useful to researchers, we also provide additional information in the current database: word length; number of English senses (WordNet); number of Japanese senses (Meikyo Japanese dictionary, 2008 edition); English word frequency (Balota et al., 2007); Japanese word frequency (Amano & Kondo, 2000). Finally, a set of descriptive statistics and a correlation analysis of the ratings and collected measures is presented.

Method

Participants

One hundred and sixty-six first and second year undergraduate university students participated in the present research. Participants were recruited from two Japanese universities: the University of Tokyo and Waseda University. All participants were enrolled in English language courses in one of the two institutions. All recruitment and participation procedures for studies reported in this paper were approved by the ethics committee at the School of English, University of Nottingham. All participants received course credit for taking part, and no participant took part in more than one study. All participants were native Japanese speakers who had studied English prior to their university education.[16] Details about the participants, as well as the number of participants in each study are shown in Table 4.1. Participants were asked to rate their own perceived English language proficiency in reading, writing, speaking and listening on a scale of 0-10 with 0 being no ability at all and 10 being native speaker level ability. The scores from each component for each participant were averaged to calculate an overall proficiency score.

Table 4.1: Number and mean age of participants, age they began learning English, time learning English, their proficiency in reading, writing, speaking, and listening, overall proficiency score

[16] In order to qualify for the rating studies, all participants confirmed that they considered themselves native Japanese speakers who had lived in Japan for the majority of their life and received their education in Japan. Thus, L1 proficiency data was not collected, as all participants were native speaker level.

	P and S rating (concrete items)	P and S rating (abstract items)	Number of translations task	English (L2) word familiarity rating	Concre-teness rating	Age-of-acquisi-tion rating
Number of participant-s	33	36	38	19	18	22
Age	20.4 (4.5)	20.2 (4.4)	18.8 (0.8)	18.4 (0.5)	20.6 (4.4)	19.1 (0.9)
Age began learning L2[a]	11-15 years	11-15 years	11-15 years	11-15 years	NA	NA
Time learning L2[b]	5-9 years	5-9 years	3-7 years	3-7 years	NA	NA
L2 reading proficiency	6.8 (1.1)	6.2 (1.6)	6.2 (1.2)	6.7 (1.5)	NA	NA
L2 writing proficiency	5.3 (1.3)	4.8 (1.6)	5.1 (1.5)	5.0 (1.6)	NA	NA
L2 speaking proficiency	4.2 (2.0)	3.8 (1.7)	4.1 (1.7)	4.4 (1.8)	NA	NA
L2 listening proficiency	5.4 (2.2)	4.7 (1.9)	4.6 (1.9)	5.4 (1.9)	NA	NA
Overall L2 proficiency[c]	5.4 (1.3)	4.9 (1.4)	5.0 (0.9)	5.4 (1.0)	NA	NA

Note: Standard deviations appear in parentheses; [a] *Age began learning* is derived from self-selected categories (*0, 1-5, 6-10, 11-16, 17-21, 21 years or above*) and the data provided above are the mode response for the participants; [b] *Time learning L2* is simply *Age* minus *Age began learning*; [c] Overall proficiency is the mean of reading, writing, speaking and listening proficiency measures.

Stimuli and apparatus

One hundred and ninety-three words were selected for the study. Our aim was to collect ratings for both concrete and abstract words in order to create a more representative stimulus set which can be used in a variety of tasks such as picture naming (which typically uses concrete nouns) and comprehension tasks (which may include both concrete and abstract words). Moreover, because bilingual studies often make use of cognates due to their unique characteristics of having both formal and S similarity, approximately half of the words in the database were cognates. Cognates were all loanwords in Japanese that the authors determined shared obvious P and S similarity with their English translations.[17] It was not

[17] Loanwords in Japanese are all written in a separate script, katakana, making it relatively easy to determine "cognate" status.

necessary to do more than this, as the ratings themselves will show how similar the words are across languages. The concrete cognate and noncognate items (*n*=94; cognate=48; noncognate=46) were selected from Nishimoto, Miyawaki, Ueda, Une and Takahashi's (2005) picture naming norming study. By selecting items from Nishimoto et al.'s study, which were taken from Snodgrass and Vanderwart's (1980) picture naming norms in English (also see Székely et al., 2004), the stimuli are suitable for research in both English and Japanese languages.[18] Because Japanese loanwords are often low frequency and to ensure that participants would know the items (i.e., that they are lexicalized in Japanese), all of the abstract cognate and noncognate words (*n*=104; cognate=50; noncognate=49) were selected from a high-frequency wordlist derived from a 330 million word Japanese web-corpus (Kilgariff, Rychly, Smrz, & Tugwell, 2004). For the cognates, two professional Japanese-English translators confirmed that the Japanese and English words were translation equivalents, although the translation was not always the most likely translation (e.g., the English word *call* has many possible translations, with the cognateコール/kooru/ being one of them).

For the similarity rating task, the items were randomized and compiled into lists for P and S ratings. An additional 20 non-translation filler pairs were added to the S ratings task to encourage use of the full scale for similarity ratings.[19] The full materials lists and ratings are provided in Appendix 4.1. The filler items were removed from the analysis and were not used in any of the other tasks reported here. Two groups of participants completed the rating studies, one for concrete items and another for abstract items.

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[18] Response latency data for picture naming with Japanese and English monolinguals is available from Nishimoto et al. (2005) and Székely et al. (2004), respectively.

[19] Because all item pairs are translation equivalents, they would be rated as similar to some degree across languages; in order to get participants to use the 'completely different' end of the scale, non-translation equivalents (e.g., *door*- 雨/ame/ "rain" in Japanese) were also included in the S rating task. Fillers were not necessary in the P similarity part of the study, as the use of both cognate and noncognate pairs ensures that the full scale will be utilised.

Procedure

All participants completed informed consent forms prior to beginning the experimental procedure. All surveys were administered using the online survey tool (www.surveymonkey.com). Fifteen participants were removed from the tasks due to due to incomplete responses or misunderstanding of the task. The total number of participants included in the tasks is shown in Table 4.1.

P and S similarity rating. Each item was rated on a 5-point scale ranging from (1='completely different' to 5='identical').[20] Instructions were provided in Japanese to ensure understanding of the task. A brief explanation and examples were provided at the beginning of each survey. Participants were asked to decide how similar the word pairs sounded based on their intuition and were encouraged to say the words aloud if necessary to help them decide. The examples provided for the P similarity task included band-バンド(/bando/), stress-ストレス (/sutoresu/), bird-鳥 (/tori/), which were rated as similar/very similar (4-5), somewhat similar/similar (3-4) and very different/different (1-2), respectively. For the S similarity-rating task, participants were asked to decide how similar in meaning the words in each pair were. The instructions asked participants to consider differences in senses shared and not shared between the languages, and also differences in use between the two languages. They were told not to use a dictionary, but to complete the task based on their intuition (i.e., their knowledge of the words). The examples provided were *triangle*-三角 *(/*sankaku/)*,* fan-扇子 *(/*sensu/*), clock*–壁 (/kabe/ "wall" in Japanese), which were rated as very similar (5), somewhat similar (3) and very different (1), respectively. Additional explanatory text was included to make clear the basis for the ratings of the examples: *triangle-* 三角 have one meaning that is almost identical in both languages, thus having considerable S similarity; *fan* has a range of meanings in English, while 扇子 in Japanese has only one

[20] A 5-point scale was used instead of the typical 7-point scale. In a pilot rating study, the participants stated that the former was preferable because it was difficult to discriminate between some of the levels on the 7-point scale (i.e., the difference between 5 and 6, or that for 2 and 3).

meaning that is similar to that of a (hand-held) *fan,* therefore they have some S similarity, but also differ in some senses; finally, *clock* and 壁 do not share word meanings, and therefore these words have no S similarity.

To ensure that all parts of the scale were used, 20 non-translation equivalents were included in the stimulus list (All non-translation equivalents were rated as '1', or 'completely different' in terms of S similarity). All Chinese characters that may have been unknown to the participants were transcribed in the hiragana phonetic script. Because of the large number of items that required ratings for both P and S similarity, and the likelihood of 'survey fatigue', each participant rated half of the words for each type of similarity, but no participant rated a pair of words for both types of similarity. Each individual item was rated for both P and S similarity by between 16 and 18 different participants.

Number of translations task. Because bi-directional translation data are desirable for bilingual research, two lists were created with half of the items being translated from the L2 to the L1, and the other half being translated from L1 to L2. These lists were counter-balanced across participants and items were presented in random order; each item was only translated once (i.e., either from L2 to L1, or from L1 to L2) by an individual participant. Participants were asked to think of the first translation that comes to mind for each item and to enter that word in the space provided. Instructions were in Japanese and examples were provided in both forward and backward translation tasks; these examples included both cognates and noncognates and were reversed for each language direction e.g., L1-L2: 鳥 (/tori/)-bird, ストレス (/sutoresu/)-stress; and L2-L1: bird-鳥, stress-ストレス.

Age-of-acquisition rating. Participants were asked to rate Japanese words on a scale of 1-7 indicating the age at which they had learnt the words in Japanese: the seven response categories included 1) *0-2 years,* 2) *3-4 years,* 3) *5-6 years,* 4) *7-8 years,* 5) *9-10 years,* 6) *11-12 years* and 7) *13 years or later.* Participants were asked to focus on when they acquired knowledge of the word itself rather than the written form, as this may vary depending on the script (i.e., kana or kanji). Instructions were in Japanese and an example provided for respondents was お母さん /okaasan/ ("*mother"*) whose meaning would be learned between the ages of 0-2 years, while its written form would typically be acquired between 3-6 years, with the kana form preceding the kanji form.

Concreteness rating. Participants were asked to rate Japanese word items on a scale of 1-7: response categories ranged from *very abstract* (1) to *very concrete* (7). Participants were asked to consider whether an item was easily pictured in their mind, making it concrete, or whether it was difficult to picture, in which case it is more abstract. No examples were provided with this task.

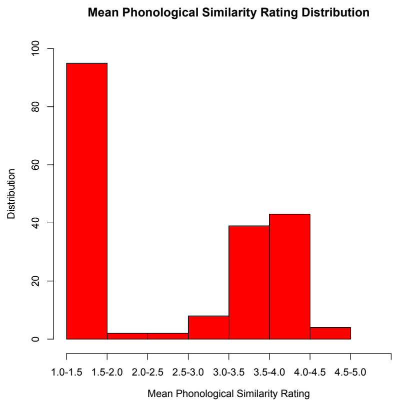
L2 familiarity rating. Participants were asked to rate English word items on a scale of 1-7: response categories ranged from *very unfamiliar* (1) to *very familiar* (7). Participants were asked to consider how often they use the words in speaking and writing and also in reading and listening. Instructions were in English and examples were provided (*signature* and *abolish* are not used every day, while *book* may well be). A clarification was made to consider the words only in English, not loanwords in Japanese (e.g., サッカー /sakkaa/, "*soccer").* Because participants were asked to focus on their use of the words, this familiarity survey is similar to a subjective frequency survey (e.g., Gernsbacher, 1984).

Results and Discussion

In this section we first describe the cross-linguistic measures (P and S similarity, number of translations), followed by the norming data (AoA, concreteness, L2 familiarity) and finally the additional data that we are including in the data set (L1/L2 frequency, L1/L2 number of senses, L1/L2 word length (number of characters/ number of syllables). The descriptive statistics of all cross-linguistic, norming and additional data are presented in Table 4.2. In what follows we make a distinction between cognate and noncognate items (based on both the script used (i.e., katakana for cognates and hiragana/kanji for noncognates) and the obvious P and S similarity between the words) for the purposes of illustrating the characteristics of the stimuli. However, the cross-linguistic similarity ratings provided in this research will allow for more precise measurements of 'cognateness' in future empirical Japanese-English bilingual studies.

P and S similarity: Respondents used all parts of the scale in both the P and S similarity rating tasks (Figure 4.1). Cognate items were clearly distinguishable from noncognates on the basis of P ratings (this difference was significant after a Bonferroni correction for multiple t-tests: t=47.85, df=170.49, p<.001). S similarity ratings were skewed to the right side of the scale indicating that items were mainly rated as being highly semantically similar across languages (Figure 4.2; note that non-translation fillers were removed from the analysis). The S ratings showed no difference between cognates and noncognates (t=1.01, df=183.92, p>.1). This was expected as the primary distinction between cognates and other translation equivalents is that cognates share both form and meaning, whereas noncognate translation equivalents share only meaning. This finding supports those of Tokowicz et al. (2002), who found a similar result for Dutch-English translations, and thus refutes the assumption made by Van Hell and De Groot (1998) that cognates are more likely to share meaning because they share formal features. The present study shows that for languages that differ in script, formal (P) similarity does not make it more likely that words will share a greater amount of S similarity across languages.[21]

[21] A reviewer suggested that the there was perhaps no difference in the S similarity ratings for cognates and noncognates because of the inclusion of abstract cognates, such as *work*-/waaku/. However, t-tests revealed no differences between abstract cognates and noncognates or concrete cognates and noncognates (p>.05), demonstrating that S similarity ratings were not different for items regardless of their cognate status or concreteness.



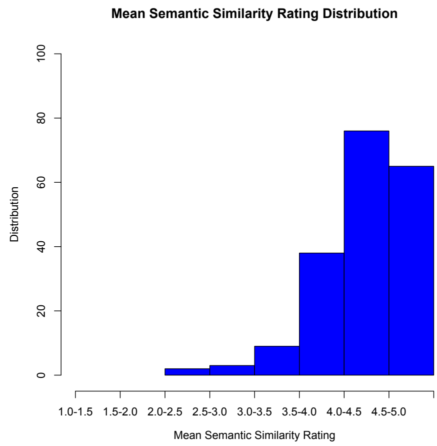


Figure 4.1 (Left): Distribution of mean P similarity ratings for all items. The x-axis shows the mean ratings on a 5-point scale, with 1 being completely different and 5 being identical. The y-axis shows the number of translation-pairs that fall into each mean rating band. Figure 4.2 (Right): Distribution of mean S similarity ratings for all items (non-translation filler items removed from S similarity task)

Table 4.2: Descriptive statistics (range, mean, standard deviation) of all ratings and additional standardization measures for all items; means (and standard deviation) for cognate and noncognate items; and significance value of *t*-test comparison for cognate and noncognate means

	Range	**Mean (SD)**	**Cognate mean (SD)**	**Noncognate mean (SD)**	***P*-value**
Mean P Similarity Ratings	1.0 - 4.3	2.3 (1.2)	3.5 (0.4)	1.1 (0.3)	<0.001*
Mean S Similarity Ratings	2.3 - 5.0	4.2 (0.5)	4.3 (0.4)	4.2 (0.5)	0.313
Number of Translations					
L1-L2 Translation	1.0 - 6.0	1.6 (1.0)	1.1 (0.3)	2.0 (1.3)	<0.001*
L2-L1 Translation	1.0 - 12.0	2.8 (2.1)	3.0 (2.1)	2.5 (2.0)	0.126
Number of Meanings					
L1-L2 Translation	1.0 - 3.0	1.2 (0.4)	1.1 (0.3)	1.2 (0.5)	0.012
L2-L1 Translation	1.0 - 4.0	1.4 (0.6)	1.5 (0.6)	1.3 (0.6)	0.126
Mean AoA Ratings	2.8 - 5.4	3.8 (0.6)	4.0 (0.5)	3.9 (0.6)	0.353
Mean Concreteness Ratings	1.9 - 6.1	4.5 (1.2)	4.4 (1.2)	4.5 (1.3)	0.514
Mean L2 Familiarity Ratings	2.0 - 5.4	3.8 (0.7)	4.1 (0.5)	3.6 (0.6)	<0.001*
Japanese Word Frequency (raw)	0.0 [22] - 156283	7012.6 (19013.6)	6706.7 (18768.0)	10421.2 (25027.3)	0.005
Log-transformed Japanese word frequency	0.0 – 12.0	7.3 (1.7)	7.3 (1.6)	7.7 (1.7)	<0.001*
English Word Frequency (per million)	1.1 – 861.4	70.3 (139.6)	80.0 (151.2)	60.6 (126.4)	0.335
Log-transformed English word frequency	0.1 – 6.8	3.2 (1.5)	3.2 (1.5)	3.1 (1.3)	0.431

[22] One item (シェアー/sheaa/-*share*) was not found in the Amano and Kondo (2000) corpus, hence there is a single zero frequency in the data set.

Japanese Number of Senses	1.0 – 15.0	2.1 (1.9)	1.9 (1.3)	2.4 (2.3)	0.084
English Number of Senses	1.0 - 45.0	8.0 (7.4)	8.6 (8.3)	7.2 (6.4)	0.128
Japanese Word Length (Mora)	2.0 - 6.0	3.3 (0.9)	3.5 (0.9)	3.1 (0.8)	<.0.001*
English Word Length	3.0 - 10	5.1 (1.3)	5.3 (1.4)	5.0 (1.3)	0.208
English Number of Syllables	1.0 – 4.0	1.5 (0.7)	1.6 (0.8)	1.5 (0.6)	0.261

Note: *indicates a significant difference after a Bonferroni correction for multiple *t*-tests where the significance threshold is set to $p<.003$.

Number of translations: Two professional Japanese-English translators determined the accuracy of translations in both directions (L1-L2, L2-L1). Correct translations were then coded for whether they were the expected translation (that provided by Nishimoto et al. (2005) for concrete items i.e., the picture naming stimuli, or the translation assigned in the initial item selection stage, e.g., *ball*-ボール), or an alternative translation. The number of distinct meanings provided as translations was also determined and added to the database. (We did not count verb uses of nouns, adjectival uses of nouns, and so on, as different meanings. Also, where meanings were not easily distinguishable, such as in the case of *find* and *locate* for 見つける /mitsukeru/ in Japanese, they were treated as the same meaning; thus, our number of meanings measure is somewhat conservative as only distinct meanings were coded as being different). Additional data for the translation task is included in a separate sheet in the database (see Supplemental Material).

Table 4.2 shows the descriptive statistics for the translation tasks in both directions. As expected, when translating from the L1 into the L2, there were more errors than when translating from the L2 into the L1 (11.5% vs. 8.4%).[23] Also, the mean number of translations and the mean number of meanings provided was smaller when translating into the L2 compared to translating into the L1 (mean translations: 1.6 vs. 2.8; mean meanings: 1.2 vs. 1.4). Interestingly, when comparing the number of translations of cognates compared to noncognates across the two tasks, one difference emerges: when cognates are translated from Japanese to English there is usually only one translation (M=1.1, SD=0.3), which is

[23] More information on error rates for translations of items in each direction are provided in the Supplemental Material for this article.

the English cognate (i.e., クラス /kurasu/ is translated as *class*); however, when translating the same cognates from English to Japanese there is a greater range of translations (M=3.0, SD=2.1), which may or may not include the Japanese cognate translation. Further, for concrete items, such as *television,* which have only one translation in Japanese, these are translated using the Japanese cognate form (テレビ/terebi/); however, more abstract words, such as *class* and other verbs, which can have multiple translations in Japanese, are translated using multiple Japanese words (e.g., クラス /kurasu/, 学級 /gakkyuu/, 等級 /toukyuu/). The difference between the mean number of translations for cognates and noncognates in the L1 to L2 direction was significant after a Bonferroni correction (p<.001), indicating that when bilinguals translate cognates into English, they use significantly fewer translations than when translating noncognates into English. Noncognates had more than one translation on average regardless of direction (L1-L2 M=2.0, SD=1.3, L2-L1 M=2.5, SD=1.8).

Age-of-acquisition (AoA): All parts of the scale were used, though few participants rated learning words in the earliest category (0-2 years). The mean AoA was 3.8, which is between the third and fourth categories (5-6 and 7-8 years; SD=0.6; Table 4.2). There was no difference in AoA ratings between cognate and noncognate items. To test the reliability of the ratings, they were compared to Nishimoto et al.'s (2005) Japanese AoA ratings for picture stimuli and to Kuperman, Stadthagen-Gonzalez and Brysbaert's (2012) AoA ratings for English words.[24] Correlations for the Japanese picture stimulus items were reasonable (r=.26, CI=0.04, 0.46) but stronger for the English word AoA ratings (r=.47, CI=0.35, 0.58). The weaker correlation between our AoA ratings and Nishimoto et al.'s (2005) ratings reflects the difference in task requirements. In Nishimoto et al. (2005), participants rated the AoA for the concepts depicted in the picture stimuli, whereas our measure

[24] Only the items that existed in both the present and the comparative data set could be subject to an analysis of rating comparabilty. Because Nishimoto et al.'s (2005) ratings focused on picture stimuli, only our concrete items occurred in both data sets. Kuperman et al.'s (2012) data set, however, was much larger and covers most of the concrete and abstract words in the present data set.

reflects the acquisition of word knowledge, which may be acquired later than conceptual knowledge. In sum, the AoA ratings appear most comparable to those collected from English native speakers by Kuperman et al. (2012). AoA for words thus appears to have some overlap across languages.

Concreteness: All parts of the scale were used showing that the stimuli included a variety of concrete and abstract words (*M*=4.5, *SD*=1.2). There was no difference in concreteness ratings between cognate and noncognate items. Correlations with concreteness and imageability ratings for those items that could be cross-referenced (*n*=76) taken from the MRC database (Coltheart, 1981) revealed strong correlations (*r*=.91, *CI*=0.86, 0.94, and *r*=.84, *CI*=0.76, 0.90, respectively), indicating that the present concreteness ratings collected with Japanese speakers are highly comparable to those collected with English speakers.

English (L2) familiarity: All parts of the scale were used. The result of a *t-test* for familiarity ratings for cognate and noncognate words showed a significant difference after a Bonferroni correction for multiple *t*-tests (*t*=6.67, *df*=188.9, *p*<0.001) with the mean cognate familiarity (*M*=4.1, *SD*=0.5) being considerably higher than the mean noncognate familiarity (*M*=3.6, *SD*=0.6). This shows that English words that are cognate with Japanese were rated as significantly more familiar than those that are noncognate (see Yokokawa, 2009, for a similar finding). To test the reliability of these ratings they were compared to Yokokawa's (2009) L2 familiarity ratings for visually presented English words collected from Japanese learners of English. The correlation was high (*r*=.77, *CI*=-0.25, 0.03) suggesting that the present ratings are a comparable and reliable resource.

Typically, norming data are collected from monolingual groups for use in monolingual studies. Such data can also be used as measures of one of a bilingual's languages. However, a bilingual's language processing system is not simply a combination of two monolingual systems (Grosjean, 1989). Research shows that a bilingual does not process language by accessing one lexicon exclusively depending on the language being used (Dijkstra, 2007). In contrast, non-selective access in language processing by bilinguals suggests that cross-linguistic activation influences performance a great deal in a wide variety of language tasks (*ibid,* 2007). Here we show that in an L2 rating task, a bilingual's first language (the non-target language) can modulate responses, demonstrating cross-linguistic influences in tasks that are not response-speed dependent (i.e., where RT is not the primary dependent variable). Thus, when researchers collect L2 norming data, such as familiarity, from bilinguals, they must consider the impact of cross-linguistic influences on such ratings.

Thus, the present L2 word familiarity measure incorporates bilingual participants' familiarity with both of their languages. While it is primarily a measure of L2 familiarity, this is clearly influenced by the L1 (as evidenced by the significantly higher familiarity ratings for cognate translations, which share form and meaning with the L1, compared to those for noncognates, which only share meaning). Therefore, it is likely that this measure will be particularly predictive of bilinguals' responses in word recognition tasks in the L2, at least for the particular sample population (i.e., mid-proficiency Japanese-English bilinguals). Because cross-linguistic influences tend to be more prominent in the weaker language (L2) than the dominant language (L1; Dijkstra & Van Heuven, 2002), the measure may be most predictive in L2 word recognition and or production tasks. Moreover, this bilingual measure of L2 familiarity should be more predictive of word recognition responses for Japanese-English bilinguals than a monolingual measure of English word familiarity.

Additional data for items

Japanese word frequency: Word frequency in Japanese was taken from the Amano and Kondo (2000) database, which consists of word frequencies from all issues of the *Asahi* Japanese newspaper between 1985-1998 (see Appendix 4.2). The corpus has a total type frequency of 341,771 morphemic units and a total token frequency of 287,792,797 morphemic units (cf. Tamaoka & Makioka, 2009). When Japanese words were used in more than one script (e.g., *camel*-ラクダ／駱駝 /rakuda/, the frequencies of the word in each script were totaled. When words had more than one reading (e.g., *head*-頭, where the Japanese as a stand-alone noun is read /atama/ and when used in a compound it is pronounced /gashira/ or /tou/), frequency of the stand alone noun only was used). Descriptive statistics for raw frequencies are provided in Table 4.2.[25] Log-transformed frequencies, which increase normality and reduce random variance are also provided.

Japanese word frequency was significantly lower after a Bonferroni correction for cognates than noncognates, using log-transformed frequencies (p<.001) but not for raw word frequencies (p<.005). Thus, although our cognates were selected from a high frequency wordlist of katakana loanwords in Japanese, they are still lower in frequency than the noncognates in the present sample. This may partially be due to the fact that cognates tend to have one borrowed meaning (i.e., few senses). This is especially true for borrowed verbs, adjectives and adverbs, as native words often exist and the borrowed word fills a narrow lexical gap. The implication of this is that it is difficult for researchers to match cognate and noncognate items in languages in which cognates are all borrowed words. Therefore, mixed-effects modeling, which can account for multiple continuous variables such as word frequency and number of senses as well as P and S similarity, might be most suitable for analyses with Japanese-English cognates.

English word frequency: Word frequency per million words in English was taken from the SUBTLEX corpus of film and television subtitles (Brysbaert & New, 2009) available from the Elexicon Project (Balota et al., 2007).[26] Log-transformed frequencies, which increase

[25] We could not provide occurrences per million as we only have the token count for morphemic units which overestimates the actual number of 'words' (which often have two or more morphemes) in the corpus.

[26] In addition to the frequencies from the subtitles corpus (SUBTLEX) for English and the newspaper corpus (Amano & Kondo, 2000) for Japanese, we provide an additional set of corpus frequencies taken from large web-corpora for each language. These two corpora were obtained from the Sketch Engine website (www.sketchengine.co.uk;

normality and reduce random variance (Baayen, 2008) are also provided (logSUBTLEX). There was no difference in English word frequency or log-transformed frequency for cognate and noncognate items.

Number of English senses: The total number of senses regardless of class (verb, noun, etc.) was taken from the online version of WordNet (Princeton University, 2010). There was no difference in the number of English word senses between cognate and noncognate items.

Number of Japanese senses: The total number of senses for Japanese words was taken from *MeikyoKokugoJiten* (Meikyo Japanese dictionary, 2008 edition). In four cases the Japanese loanword was not listed as a single entry (i.e., only as a compound entry) in the selected dictionary; therefore, the number of senses for these items was taken from a second dictionary *Koujien 6th Edition* (2008) in which the items were listed as single entries. Though non-significant, cognates tended to have fewer senses than noncognates (p<.09). Because cognates in Japanese are loanwords borrowed to fill a specific lexical gap, it is surprising that this difference is not significant.

An explanation of why this difference does not reach significance may be that dictionary categorization of senses differs widely. The difference in the number of senses between English and Japanese words is testament to this. In WordNet (the English source), the mean number of senses was 8 (*SD*=7.4) but in the Japanese dictionary source, the mean was 2.1 (*SD*=1.9). If equivalence in the categorization systems for senses in the two sources were assumed, this would indicate that English words typically (at least those selected in the present study) have four times

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Kilgariff et al., 2004); the English corpus (UkWaC) contains 1,318,612,719 words and the Japanese corpus (JpWac) contains 333,246,192 words. The advantage of using these corpora is that they are comparable in terms of their derivation: both are derived from the web, specifically from shopping and commercial websites, blogs and discussion forums. The log-transformed frequencies are included in Appendix 4.2. The UkWac corpus log-frequencies significantly correlate with the SUBTLEX corpus log-frequencies (r^2=0.76, p<001) and the JpWac log-frequencies correlated strongly with the log-frequencies from the Japanese newspaper corpus (r^2=0.71, p<001), while the two web-corpora also correlated (r^2=0.70, p<001) to a much higher degree than the English subtitles and Japanese newspaper corpora (r^2=0.34, p<001). Thus while within-language corpora correlations are strong for both languages, the web-corpora appear to better correlate across languages, indicating that they are utilising similar text resources as the basis for the frequencies. Thus, these may also prove to be valuable resources for studies of Japanese-English bilingual language processing. All log-transformed frequencies are provided in Appendix 4.2.

more meanings than Japanese words. However, it is well known that the level of sense disambiguation varies widely across dictionaries, and thus rather than assuming Japanese words tend to have fewer senses, we will assume the difference is due to the sources used and that different sources will provide different levels of sense disambiguation.

An important implication of this discussion is that the number of senses measures drawn from dictionaries is a less than satisfactory measure of word meanings. Moreover, these measures are unlikely to reflect the number of meanings that actually exist in the mind of language users (Gernsbacher, 1984). In terms of bilinguals' knowledge of word meanings the problem is more complex. One would need to assess word knowledge in both languages, and thus two measures of word meanings would be needed. Importantly, as discussed previously, a bilinguals' lexicon is not simply the combination of two monolingual lexicons (Grosjean, 1989). Thus, it may be that a measure of S similarity across languages, as provided in the present study, would be a better predictor of the influence of word meanings on bilingual processing. This is because S similarity takes into account the meanings in both languages and the degree of overlap of those meanings; moreover, because S similarity is derived from bilinguals' ratings it may more accurately predict actual word knowledge as opposed to maximal word knowledge as provided in dictionary sources.

Number of mora: Japanese word length was calculated as the total number of mora in each word. A mora is the basic phonemic unit in Japanese, roughly corresponding to a syllable. For example, 魚 /sakana/ 'fish' is written in *kanji* (Sino-Japanese characters) and contains three morae, which can be visualized by transcribing the word using the phonetic script, *hiragana*: さかな, /sa/, /ka/, /na/. On the other hand, カンガルー /kangaruu/ 'kangaroo', is written in *katakana*, which is used for writing loanwords, and contains five morae in Japanese (/ka/, /n/, /ga/, /ru/ and /u/) , even though the English word contains only three syllables. This exemplifies how the Japanese phonemic system determines the resulting phonetic constitution of the borrowed word, while also briefly illustrating the use of the three scripts of the Japanese language. The number of mora differed significantly for cognate and noncognate words after a Bonferroni correction (p<.001) with the former being longer on average. This is not surprising given that loanwords, which are rephonalized into Japanese from English, tend to be longer than native Japanese words, which typically contain 2-4 morae.

Word length: English word length was calculated as the total number of letters in each word. As expected, the word length did not differ for the English translations of cognates and noncognates.

Number of syllables: The number of syllables in English was calculated for each word. Similar to word length, the number of syllables did not differ for the English translations of cognates and noncognates.

Correlations between Ratings and Collected Measures

S similarity: A number of predictors were selected for a correlation analysis with the S similarity measure derived in this study: number of translations (in both directions), number of meanings translated (in both directions), concreteness, number of senses in Japanese and English, and P similarity (Table 4.3). Firstly, S similarity was strongly negatively correlated with the number of translations measures in the L1 to L2 direction (r=-.29, CI=-0.41 -0.16) and in the L2 to L1 direction (r=-.41, CI=0.52, -0.29). This shows that as the number of translations increases, S similarity decreases, which is similar to Tokowicz et al.'s (2002) finding for Dutch-English translations. Secondly, S similarity was negatively correlated with the number of meanings translated in the L1 to L2 direction (r=-.20, CI=-0.33, -0.06) and less so in the L2 to L1 direction (r=-.14, CI=-0.28, 0.00). Again, the negative correlation shows that words translated with more meanings were rated as less semantically similar across languages. The number of translations measures (L1-L2, L2-L1) were not strongly correlated (r=.13, CI=-0.01, 0.27); this was also the case for the number of meanings (r=-.09, CI=-0.23, 0.05). This reflects the fact that the degree of S knowledge varies across languages, with participants having a greater knowledge of S characteristics of words in the L1 relative to the L2. Thirdly, concreteness was highly correlated with S similarity *(r*=.40, *CI*=0.27, 0.51), such that the more concrete the words were rated, the more semantically similar across languages they are (this is similar to Tokowicz et al., 2002). Fourthly, S similarity was highly negatively correlated with the number of English senses (*r*=-.31, *CI*=-0.43, -0.18) and but much less so with the number of Japanese senses (*r*=-.10, *CI*=-0.24, 0.04). The discrepancy may well be due to the different degrees of sense disambiguation in the English and Japanese sources (WordNet vs. Meikyo Japanese Dictionary), the former tending to provide many senses while the latter tending to be more conservative. Nevertheless, the two measures of number of senses were strongly correlated (*r*=.37, *CI*=0.24, 0.49). Taken together the number of translations, meanings, senses and concreteness appear to be important S characteristics that determine cross-linguistic S similarity.

In addition, the role of P similarity was explored to determine whether there was any relationship between it and S similarity; however, the two similarity measures were not strongly correlated (*r*=.09, *CI*=-0.23, 0.05). This supports the finding of Tokowicz et al. (2002) who reported a similar finding for Dutch-English translations. Interestingly, P similarity was highly correlated with number of translations in the L1-L2 direction (*r*=-.43, *CI*=-0.54, -0.31) but much less so with the L2-L1 direction (*r*=.13, *CI*=-0.01, 0.27). This shows that more phonologically similar items (i.e., cognates) had fewer translations in the L2 than phonologically dissimilar items (i.e., noncognates); for example, コール /kooru/ ‘call’ is usually translated into English using the cognate translation only (i.e., *call*). Finally, P similarity was not correlated with the number of meanings in the L2 (*r*=.12, *CI*=-0.02, 0.26) or in the L1 (*r*=-.11, *CI*=-0.25, 0.03), which demonstrates that although fewer different translations were provided for cognates than noncognates in the L1-L2 direction, the number of meanings provided did not differ depending on cognateness or direction of translation.

The present study is the first to report this interesting difference in the number of translations for language pairs that do not share etymological origins but are instead loanwords. This characteristic of borrowed words is also likely to be observable in languages pairs such as Korean-English. Thus, when bilinguals translate Korean loanwords into English, they are likely to use a single translation, but this will not be the case when translating from English into Korean. To illustrate, the English word *style* can be translated into various Korean words: 스타일/sutail/, 모양 /moyang/, 품격 /pumkyek/, or 문체 /munche/. However, when translating the Korean loanword 스타일 /sutail/, Korean-English bilinguals will use only the English word *style*. Because the number of translations influences bilingual processing, this feature of loanwords in such languages is thus important for understanding bilingual processing mechanisms.[27]

Table 4.3:Intercorrelations among factors for S similarity

Factor	1	2	3	4	5	6	7	8	9
1. Semantic Similarity	-	-.29**	-.41**	-.20**	-.14	.40**	-.10	-.31**	-.09
2. Number of Translations from L1 to L2		-	.13	.01	.42**	-.31**	.10	.05	-.43**
3. Number of Translations from L2 to L1			-	.22**	.12	-.51**	.11	.37**	.13
4. Number of Meanings of Items Translated into L2				-	-.09	-.13	.10	.22**	.12
5. Number of Meanings of Items Translated into L1					-	-.11	.18*	.01	-.11
6. Concreteness						-	-.20**	-.37**	-.04
7. Number of Senses in Japanese							-	.37**	-.09
8. Number of Senses in English								-	.12
9. Phonological Similarity									-

* p<.05 **p<.01

[27] Korean-English cognates will perhaps be processed more similarly to Japanese-English cognates, as Korean and Japanese both utilise a phonetic syllabary to transcribe loanwords.

P similarity and cognates: In most research to date, words have been dichotomized as cognate or noncognate based on the degree of formal and S overlap. However, as we have shown here, words that are typically classed as cognate can vary in terms of their cross-linguistic P overlap. Because formal overlap across languages has been shown to influence processing bilingual tasks, both as a dichotomous 'cognate status' variable (Hoshino & Kroll, 2008; Taft, 2002) and as continuous measures of P and/or O overlap (Chapter 5; Dijkstra et al., 2010), it is crucial to investigate the role of overlap in bilingual processing.

As can be seen in Table 4.4, P similarity was highly correlated with cognate status (r=-.96, CI=-0.97, -0.95), showing that the two measures are predicting much of the same characteristic. The almost complete correlation between P similarity and cognate status demonstrates just how well P similarity can categorize items as either cognate or noncognate. Importantly, because bilinguals have been shown in this research to be sensitive to the degree of P similarity between translations across languages, as opposed to simply knowing that words are either cognate or noncognate, P similarity is a superior measure of bilinguals' actual word knowledge and thus should prove to be a more valid measure of bilingual performance in tasks that investigate cross-linguistic processes.

Also, while Japanese log word frequency was highly correlated with P similarity (r=-.24, CI=-0.37, -0.10) it was not correlated with English log word frequency (r=.06, CI= -0.08, 0.20). The same pattern is apparent for cognate status and the two log word frequency measures. This highlights the fact that in Japanese, cognates are typically of lower frequency than noncognates, even though we specifically selected half of the items from a high-frequency word list in Japanese.

Finally, while both the number of English syllables and English letters were not correlated with P similarity, the number of mora in Japanese was (r=.24, CI=-0.38, -0.11). This highlights the fact that Japanese cognates, which are loanwords from English, tend to have a greater number of mora than native Japanese words (i.e., noncognates).

Table 4.4: Intercorrelations among factors for P similarity

Factor	1	2	3	4	5	6	7
1. Phonological Similarity	-	.96**	-.24**	.06	.24**	-.05	-.02
2. Cognate Status		-	.25**	-.06	-.25**	-.09	-.08
3. Log-Transformed Japanese Word Frequency			-	.35**	-.24**	-.30**	-.11
4. Log-Transformed English Word Frequency				-	-.30**	-.42**	-.42**
5. Word Length (Japanese)					-	.45**	.39**
6. Word Length (English)						-	.78**
7. Number of Syllables (English)							-

* *p*<.05 ***p*<.01

Conclusions

The goal of this study was to provide cross-linguistic norming data for Japanese-English translation equivalents, which will be a useful resource for researchers of bilingual processing of Japanese and English languages. This is the first study to provide such rich resources for languages that differ in script. The data may be used for norming items for use in production tasks such as picture naming (see also Nishimoto et al., 2005; Székely et al., 2004), word naming and translation, and also comprehension tasks, such as lexical decision, sentence-context reading studies and studies using progressive de-masking techniques or the masked priming paradigm (e.g., Nakayama et al., 2012). In addition, we highlight a number of important features of cross-linguistic similarity for Japanese-English translations. Firstly, we showed that P similarity ratings are varied for translation equivalents and distinguish between cognates and noncognates as well as within the cognates category. Thus, P similarity is more likely to reflect the processing mechanisms of bilinguals than a dichotomous all or nothing categorization of similarity, even though cognate status and P similarity are very highly correlated predictors. Secondly, we showed that although S similarity ratings do not differ significantly for cognate and noncognate items (contra the assumptions of Van Hell and De Groot, 1998), the number of translations varies by direction. Specifically, when Japanese loanwords are translated into English, one translation is unanimously preferred. However, when English words that have loanword equivalents in Japanese are translated, bilinguals use not only the Japanese loanwords but other words as well. This interesting feature may well be present in other languages that borrow from English but do not share its etymological origins, such as Korean-English and Chinese-English. Such knowledge is crucial for selecting stimuli for experiments that test theories of bilingual processing and representation.

We also provided measures of standardization that are not freely available for all of the Japanese items in the present study (age-of-acquisition and concreteness) and bilingual norming data for English word familiarity. In the L2 familiarity study we observed language transfer effects that resulted in English cognates receiving higher familiarity ratings than noncognates, which is likely due to the effect of cross-linguistic similarity. This further stresses the important role of cross-linguistic similarity in offline, as well as online, tasks. Finally, additional information (frequency, number of senses, word length, number of syllables) was provided. Cognates tend to be lower in L1 frequency, longer in number of Japanese characters (mora) and have slightly fewer senses in the L1 as well, while these factors are no different for cognates and noncognates in the L2 (English).

To deal with these inherent differences between Japanese cognates and noncognates, bilingual research that uses cognates might benefit from the use of mixed-effects modeling as this method can account for multiple continuous variables, such as frequency, length and number of senses, as well as the researchers' particular variables of interest. All in all, the present data set provides the richest cross-linguistic lexical resource currently available for bilingual studies with different script languages.

Chapter 5: Cross-linguistic similarity and task demands in Japanese-English bilingual processing

Abstract

Even in languages that do not share script, bilinguals process cognates faster than matched noncognates in a range of tasks. The current research more fully explores what underpins the cognate 'advantage' in different script bilinguals (Japanese-English). To do this, instead of the more traditional binary cognate/noncognate distinction, the current study uses continuous measures of phonological and semantic overlap, L2 (second language) proficiency and lexical variables (e.g., frequency). An L2 picture naming (Experiment 1) revealed a significant interaction between phonological and semantic similarity and demonstrates that degree of overlap modulates naming times. In lexical decision (Experiment 2), increased phonological similarity (e.g., *bus* /basu/ vs. *radio* /rajio/) lead to faster response times. Interestingly, increased semantic similarity slowed response times in lexical decision. The studies also indicate how L2 proficiency and lexical variables modulate L2 word processing. These findings are explained in terms of current models of bilingual lexical processing.

Introduction

There is considerable evidence that cognates are processed more quickly than matched noncognates in a range of production (word naming: Schwartz et al., 2007; picture naming: Costa et al., 2000; Costa et al., 2005; word translation: Christoffels et al., 2006; De Groot et al., 1994; Kroll & Stewart, 1994; Sánchez-Casas et al., 1992) and comprehension tasks (lexical decision: De Groot & Nas, 1991; Dijkstra et al., 1999; masked priming: Dimitropoulou et al., 2011; Duñabeitia et al., 2010; Gollan, Forster, & Frost, 1997; Nakayama et al., 2012; Voga & Grainger, 2007); progressive de-masking: Dijkstra et al., 1999; sentence comprehension: Van Assche et al., 2009; Van Assche et al., 2011). Thus, the robustness of this cognate facilitation effect is attested across a wide range of tasks and with a number of first and second languages. The cognate advantage has been found even when languages do not share a script (e.g., Japanese-English, Korean-English, Hebrew-English, Greek-French).

Cognates share meaning (semantics; henceforth S) and form (phonological and/or orthographic; henceforth P and O) across languages. Their processing advantage could be underpinned by overlap in S, P, and/or O. The description of cognates in the psycholinguistic literature is usually based on the degree of overlap of O/P and S features across languages, instead of being described etymologically. Crucially, in the past the degree of O/P/S overlap has been used to select experimental materials, in other words, to decide whether a word was a cognate or not. More recently, a few bilingual studies have used continuous measures of similarity to explore how the amount of overlap influences processing of cognates and homographs (Dijkstra et al., 2010; Duyck et al., 2007; Van Assche et al., 2009; Van Assche et al., 2011). However, this work has been done in languages that share a script, which means that the contribution of O and P overlap is hard to disentangle.

The current research investigates how cross-linguistic similarity influences bilinguals' language processing in production and comprehension. The study provides the first evidence of how continuous measures of similarity can provide more comprehensive information about language co-activation in languages that differ in script and how this co-activation affects processing. In what follows we will first describe research on different script bilinguals, followed by a discussion of research using continuous variables of cross-linguistic overlap.

Different script bilinguals

Recent work has shown that even for bilinguals whose languages differ in script (e.g., Japanese-English, Korean-English, Hebrew-English, Greek-French), cognate facilitation effects can be observed (Gollan et al., 1997; Kim & Davis, 2003; Hoshino & Kroll, 2008; Taft, 2002; Voga & Grainger, 2007). In a lexical decision task with Hebrew-English script bilinguals, Gollan et al. (1997) found greater facilitation for cognates relative to noncognates when masked primes were in the L1 (first language) and targets in the L2 (second language). These effects were much weaker, however, when primes were in the L2 and targets were in the L1. Kim and Davis (2003) explored whether priming occurred in three tasks (lexical decision, semantic categorization and word naming) for Korean-English bilinguals. L1 Korean primes facilitated recognition of L2 English cognates in all tasks, whereas noncognates facilitated responses in only the former two tasks, and homophones facilitated responses in lexical decision and naming only. Thus shared P and S similarity (without O similarity) appears to provide processing advantages for cognates in a variety of priming tasks, at least when primes are in the L1.

In a lexical decision task conducted using a masked priming paradigm (Voga & Grainger, 2007), Greek-French bilinguals responded to L2 targets preceded by either related (translation) or unrelated (control) L1 primes. Voga and Grainger (2007) found a priming effect of cognate translation primes relative to noncognate primes, indicating that L2 P information was activated by the L1 prime. Crucially, they also found that cognate targets that had high P overlap with their translation primes were responded to more quickly than to cognate targets that had low P overlap with their translations, when compared to noncognates. This finding shows that the degree of P overlap impacts the amount of cross-linguistic activation in lexical decision with masked translation priming. However, in Greek and English, there is some overlap in O (e.g., the cognates 'kilo' and 'κιλό' have three graphemes that are very similar), which makes it difficult to completely disentangle the influence of P and O in their priming effect.

In a lexical decision task, Taft (2002) tested low proficiency Japanese-English bilinguals with two-syllable English words that were divided such that the coda or onset was maximized, (e.g., *ra dio* versus *rad io*). The items used in this study were either cognate or noncognate with English (i.e., they shared S and/or P features with English, but not O). Due to the influence of L1 Japanese, which typically has open syllables (*rad* cannot exist in Japanese, while *ra* can), participants responded more quickly to items such as *ra dio*, the maximal onset condition. Additionally, cognates were recognized significantly faster than noncognates (1118 ms versus 1186 ms), demonstrating the influence of P and S overlap from L1.

Finally, in a bilingual picture-naming task, Hoshino and Kroll (2008) showed that the cognate facilitation effect is present in both same script (Spanish-English) and different script (Japanese-English) bilinguals. As picture naming does not involve the presentation of written words, cognate facilitation should be a product of the activation of similar P information across the two languages. P activation appears to be sufficient to create cognate facilitation in production for both same script and different script bilinguals. Importantly for the current research, these findings indicate that both of the languages of a bilingual are activated, even when the script is not shared. Further, cognates create greater cross-linguistic activation than matched controls.

Degree of similarity

In all of the aforementioned studies other than Voga and Grainger (2007), experimental items were classified simply as cognate or noncognate (or homophone). However, the degree of similarity in both form and meaning varies greatly for translation equivalents; for example *bière, bier, beoir* in French, German, and Gaelic, respectively, can all be termed cognate with English *beer*. If overlap between words in two languages plays a role in cognate facilitation, it is important to assess the influence of the *degree* of overlap on facilitation. However, a weakness of many previous studies is that the methods used to determine 'cognateness' have often been unsatisfactory (Tokowicz et al., 2002).

A study by Tokowicz et al. (2002) demonstrated that raters are sensitive to the degree of formal similarity of Dutch-English translation pairs (in this case, sound-spelling cross-linguistic similarity). They showed that while many items were rated as having very little similarity (1-2 on a 7-point scale with 1 being 'completely different' and 7 being 'identical'), raters also used the remainder of the scale (3-7) to differentiate between word pairs having differing degrees of formal similarity. Though this measure combined both O and P information in rating formal similarity, bilinguals rating languages with different scripts should be able to differentiate degree of formal similarity based on P alone.

Cognates are distinguished from other translation equivalents on the basis of shared formal features. However, both cognates and noncognates share some degree of S similarity with translation equivalents. Tokowicz et al. (2002) also investigated cross-linguistic S similarity, hypothesizing that S similarity should be determined based on the number of shared senses and the similarity of these individual senses. They found that, while most word pairs (both cognate and noncognate) had high S similarity ratings, there was some variability across the items. They found that S similarity significantly correlated with the number of translations, context availability (the ease or difficulty of thinking of a context for a word), and concreteness measures: translation pairs that overall have fewer translations, that are more concrete and for which a context can easily be conceived are rated as more S similar. In sum, Tokowicz et al.'s (2002) study suggests that S similarity is a useful theoretical construct for understanding bilinguals' semantic representations and participants' ratings are useful for establishing S overlap. Ratings can thus be used to define cognates objectively by setting a suitable threshold of formal and semantic similarity.

For languages that share script, some recent studies have examined how the degree of overlap influences processing. In a series of experiments Duyck, et al. (2007) manipulated the O similarity of words in a L2 (English) lexical decision task with Dutch-English bilinguals. They used orthographically identical and non-identical cognates and compared decision responses to matched control items. Cognate facilitation was observed for both identical and non-identical cognates in comparison to controls. A second experiment used a contextualized task where subjects read a visually presented sentence followed by a lexical decision task on the final word (the critical item). They found cognate facilitation for both types of cognates, although the cognate effect decreased when the words were not orthographically identical. Crucially, in this study the division between identical and non-identical cognates was binary. However, if the amount of overlap between languages modulates processing, then a more subtle manipulation will be needed to detect this.

In a rating study, Dijkstra et al. (2010) had 24 Dutch-English bilinguals rate 360 words for O, P and S similarity. Unsurprisingly, they found that O and P ratings were highly correlated ($r = .94$, $p < .001$), meaning it is necessary to control for this correlation when assessing the individual influence of these characteristics. In a lexical decision task, they found that the ratings predicted responses times, such that that increased O similarity lead to faster responses to non-identical cognates, while P similarity had no influence. Moreover, for orthographically identical cognates there was increased facilitation when P similarity was greater, indicating that when O overlap is complete, P information becomes another source of information that is exploited. Another key finding of Dijkstra et al. (2010) was that the direction of effects of P similarity depended on the task conditions. In both L2 lexical decision and progressive demasking tasks, when English targets were P similar but S dissimilar (homophonous) to Dutch words, they were responded to more slowly than controls. The influence of L1 in the L2 task thus provided evidence for non-selective activation in bilinguals' processing of language, but importantly for the present study also provides evidence that P similar words can lead to inhibition of responses latencies under certain conditions.

The influence of cross-linguistic O overlap has also been shown for cognates when reading sentences in the first language (Van Assche et al., 2009). Using Van Orden's (1987) measure of O similarity for Dutch-English word pairs, Van Assche et al. (2009) showed that as O overlap increased, cognates were read more quickly and this effect did not differ depending on whether sentences were high or low constraint. In a more recent study, Van Assche et al. (2011) demonstrated significant effects of both an objective measure of O overlap and a combined measure of O and P overlap on lexical decision times to Dutch-English cognates presented in the L2 (English). Similarly, in sentence reading both early and late measures of fixation duration showed facilitatory effects of overlap, which was not greatly affected by sentence constraint (high vs. low). However, given the high correlation between the O and P similarity ratings for Dutch-English cognates, it is difficult to assess the singular contribution of P similarity on bilingual word recognition.

For languages that differ in script, P similarity becomes the only measure of formal similarity, and can distinguish cognates from noncognates as well as provide a metric for degree of overlap for cognates. For example, the Japanese loanwords *bus* (バス (/basu/) and *radio* (ラジオ/rajio/) can be classified as Japanese-English cognates because they share P and S features.[28] However, *bus* in Japanese (/basu/) intuitively sounds more similar to its English equivalent, while *radio* sounds more distinct from /rajio/. Differences in phonotactics and the phonetic inventories of the two languages, contribute to the degree of P overlap in these cognate/borrowed words. Based on previous studies with

[28] Japanese words such as テレビ/terebi/ are accurately referred to as loanwords as they are borrowed into the language from English; however, in psycholinguist terms overlap and not the origin of the words is what is important, and thus in the paper these are referred to as cognates.

same-script bilinguals (Dijkstra et al., 2010; Duyck et al., 2007; Van Assche et al., 2009; 2011), we expect that the degree of P overlap will modulate cognate facilitation in Japanese-English bilinguals. Because English and Japanese utilize different O scripts, no influence of O is expected. These predictions follow the theoretical assumptions of the revised Bilingual Interactive Activation Model (BIA+; Dijkstra & Van Heuven, 2002) for word recognition. In this model, O is presumed to be incapable of creating cross-linguistic effects in languages that differ in script. P cross-linguistic activation is predicted by the BIA+ in the absence of a shared O, and the degree of this cross-linguistic activation is dependent on the degree of P similarity of translations across languages. For language production, a similar prediction can be made based on models such as that proposed by Costa et al. (2000, 2005) for picture naming. While this model has been described in terms of same-script bilinguals (Spanish-Catalan and Spanish-English), it is potentially applicable to different-script bilinguals because picture naming does not necessitate O activation in order to produce a response. Thus, in line with this model and in the absence of O, P similarity should be the key determiner of cross-linguistic activation via formal features, such that increased P overlap leads to faster responses in picture naming. The focus of this research is thus how L1 P, not O, influences processing in the L2.

In addition, S similarity is an important variable when assessing degree of overlap for cognates, but also varies for translation pairs (Tokowicz et al., 2002). Thus, we may see further modulation of cognate processing based on the degree of S similarity. Specifically, increased S similarity may be expected to speed responses in tasks that constrain semantic activation to one particular sense, such as picture naming. In this task, picture stimuli activate conceptual features that feed forward activation to the appropriate lexical representations in both languages that are associated with the picture (i.e., the pictures' names). If the word has multiple senses (e.g., *bat* can refer to 'the creature' or 'the sporting equipment'), the alternative senses may be activated via feedback from lexical representations to conceptual features, and this activation may cause competition between the different conceptual features. If this is the case then activation of multiple senses may be expected to slow responses in picture naming. Because items with high S similarity ratings tend to have few senses across languages and these are more likely to be shared, such items should be named more quickly than item with low S similarity.

In contrast, in tasks that do not constrain the activation of particular senses, having multiple senses may actually be an advantage. In a lexical decision task, when the word *bat* is presented, activation of either the meaning 'creature' or 'sporting equipment' can lead to the correct "Yes" response. Unlike in picture naming, activation of multiple meanings should not cause competition as all should lead to the same response. In previous research, words with multiple senses are responded to more quickly in lexical decision relative to those with few senses (e.g., Hino et al., 2002); however, words that have multiple senses that are highly distinct (e.g., *bank* in English) have been shown to lead to slower responses due to competition between these different senses (Rodd et al., 2002). In sum, depending on the number of senses of the stimuli, how related the senses are and the type of task, responses may be facilitated or inhibited. A similar pattern of results may be expected for bilingual tasks. Specifically, in lexical decision we may see that responses to words with less S similarity (as long as the decreased S overlap is not due to distinct senses of words) will be speeded relative to words that have greater S similarity. In picture naming on the other hand, where semantic information is constrained, we may expect to see facilitation for items that have greater S similarity.

Such predictions are in line with current models of bilingual processing, such as the picture naming model proposed by Costa et al. (2000; 2005) and the BIA+ (Dijkstra & Van Heuven, 2002). Costa et al's model for picture naming (2000, 2005) assumes that multiple semantic nodes (conceptual nodes) become activated on recognition of the picture stimulus and that these nodes feed forward activation to lexical nodes. Thus, in picture naming, greater cross-linguistic S similarity would be advantageous. Increased shared conceptual features would lead to greater activation of both languages' lexical nodes. Conversely, if a target in one language had multiple senses, one of which was appropriate for the target while others were not, activation of the inappropriate senses via feedback from lexical to semantic nodes could potentially create inhibition in naming.

While Costa et al.'s (2000, 2005) model is specifically for picture naming, the BIA+ is specifically for word recognition and has a task/decision system that allows decision criteria to be modified depending on the task. The BIA+ would predict that in lexical decision, semantic activation is necessary to execute a correct response. This process does not require activation of a particular sense; rather any activated sense is sufficient to allow the correct response. When targets are presented that have multiple senses, the combined semantic activation of these senses deriving from lexical and sublexical activation during word recognition could actually speed responses relative to words that have a smaller number of senses. Thus, in lexical decision, when words have more senses in either or both languages (i.e., words with less S similarity), this should lead to facilitation.

The Present research

The aim of the present study is to investigate the role of P and S similarity in the processing of languages that differ in script, and to determine whether continuous measures of similarity can further illuminate cross-linguistic effects above and beyond binary cognate-noncognate classifications. To do this, we utilised mixed-effects modelling with multiple continuous measures and fitted a model for the data. To investigate the role of continuous measures of P and S similarity in both bilingual language production and recognition as well as the interaction between these two measures, we conducted two L2 tasks: picture-naming and lexical decision. Picture naming limits the types of words that can be explored (concrete), while lexical decision allows for the use of a range of words (concrete and abstract items, nouns and verbs). Thus, only a subset of the items in the lexical decision task is appropriate in the picture naming task. Because some of the items appear in both tasks, to avoid effects of repetition priming, two closely matched sets of bilinguals were tested in Experiments 1 and 2. In spite of these differences, the use of a production task and a lexical decision task allow us to explore how cross-linguistic measures might depend on different task demands. Namely, the role of P overlap and its potential interaction with S overlap may differ in production and comprehension tasks.

Although mixed-effects models do not necessitate matching items, as in typical factorial experiments testing cognates and noncognates, because we wish to maintain comparability with previous factorial studies, and simultaneously compare the effects of continuous similarity measures with binary measures of cognate status, we maintain the principle of item matching. Thus, while all items are initially distinguished by cognate status and matched accordingly, we can also add matched terms to the model to control for these effects more precisely.

Rating study: P and S similarity

A rating study was conducted for the items used in Experiments 1 (picture naming) and Experiment 2 (lexical decision). Japanese-English bilinguals rated word pairs (e.g., *television-テレビ* (*/terebi/*) or *ear*-耳 (*/mimi/*)) on a scale of 1 to 5 (1=completely different, 5=identical) for either P or S similarity. Because Japanese and English do not share a script, P similarity is crucial whereas O similarity should not play a role.[29] For the first set of 162 concrete items, 40 Japanese-English

[29] Japanese cognates and noncognates are typically, but not always written in different scripts. Cognates are usually written in katakana and noncognates are written in any of the three scripts, but with kanji and hiragana being more common than katakana. The difference between the Japanese scripts typically used for cognates and noncognates is unimportant because none of the L1 Japanese scripts is based on the Roman alphabet. Thus there are no differences in O overlap with English and the Japanese scripts. Moreover, both tasks are entirely in L2 English, limiting any potential cross-linguistic O influence. Even in Experiment 2 (lexical decision), which involves L2 O, differences in L1 script should not matter. Cross-linguistic activation of formal features should be at the level of P only. Importantly, if L1 O codes are activated, feedback should not differentially influence L2 O processing, because none of the scripts overlap with the L2 O code. According to the BIA+ (Dijkstra & Van Heuven, 2002) different script

bilinguals rated half of the items for P and the other half of the items for S similarity, meaning that each item was rated 20 times for both P and S similarity. For the second set of 120 abstract items, a different group of 39 Japanese-English bilinguals similarly rated half of the items for P and half for S similarity. Because S similarity is likely to be reasonably high for all translation equivalents, 20 non-translation equivalent word pairs were added as filler items, to encourage raters to utilise all parts of the scale for both P and S similarity ratings.[30] In both rating studies, cognates were rated as significantly more P similar than noncognates (concrete items: cognate *M*=3.4, *SD*=0.8; noncognate *M*=1.01, *SD*=0.02; *p<.001*; abstract items: cognate *M*=3.4, *SD*=0.6; noncognate *M*=1.1, *SD*=0.1; *p<.001*), while there was no difference for cognate and noncognates in terms of S similarity (concrete items: cognate *M*=4.5, *SD*=0.3; noncognate *M*=4.4, *SD*=0.4; *ns*; abstract items: cognate *M*=4.3, *SD*=0.4; noncognate *M*=4.1, *SD*=0.7; *ns*). Similar to Tokowicz et al. (2002) we found that raters used the whole scale for rating P similarity. S similarity ratings for experimental items clustered at the 'identical' end of the scale but there was some variation in S similarity. As expected, the non-translation equivalent filler items were clustered at the opposite ('completely different') end of the scale (*M*=1.2, *SD*=0.1). The mean ratings of P and S similarity for items are used as the cross-linguistic similarity measures in the following experiments.

Experiment 1: Picture naming in L2 English

To test the effect of cross-linguistic similarity in language production with bilinguals whose languages differ in script, we performed an L2 picture-naming task making use of words that differed in their degree of

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languages do not have any cross-linguistic activation at the level of O. Nonetheless, because Japanese scripts do differ for cognates and noncognates, it is not possible to completely rule out the effect of L1 script on L2 processing.

[30] Including non-translations may reduce the focus on nuanced differences between translations. However, there are two reasons why this is unlikely be the case: firstly, there were only 20 non-translations included meaning their overall frequency was minimal in the task; secondly, the distribution of responses for both S and P similarity show that ratings varied across the scale indicating that nuanced differences in meaning and also difference in form were taken into consideration by raters.

cross-linguistic P and S similarity. The present study extends previous research (Hoshino & Kroll, 2008), in which a cognate effect was found in L2 picture naming in different script bilinguals, by utilising continuous measures of similarity as well as by accounting directly for other factors (e.g., word length, frequency, and proficiency) in a mixed-effects model.

Method

Participants

Twenty participants (16 male; mean age=20y, ±3y) from the University of Tokyo were paid for their participation. All participants were native Japanese speakers and had similar proficiency in English (see Table 5.1 for participant characteristics). All participants performed satisfactorily in the task and thus data from all participants is used in the analyses. All participants completed informed consent forms prior to participating in the research described in this paper. The University of Nottingham, School of English ethics committee, approved all studies reported in this paper.

Table 5.1: Participants' characteristics in Experiments 1 and 2

	Experiment 1		**Experiment 1**	
Proficiency (self-rating from 0-10)	**L1**	**L2**	**L1**	**L2**
Reading	9.9 (0.5)	6.5 (1.3)	10 (0)	7.4 (1.2)
Writing	9.8 (0.7)	4.7 (1.7)	10 (0)	5.9 (1.7)
Speaking	10.0 (0.2)	3.8 (1.9)	10 (0)	4.4 (1.6)
Listening	10 (0)	5.5 (2.0)	10 (0)	6.2 (1.3)
Mean	9.9 (0.3)	5.1 (1.5)	10 (0)	6.0 (1.3)

Materials

Twenty-seven matched pairs of cognate and noncognate words were selected for the L2 English task (Appendix 5.1). The corresponding picture stimuli were from Székely et al. (2004). Cognate and noncognate items were matched on English word length, number of syllables, naming agreement (H statistic), mean naming latency, mean objective age of acquisition, mean conceptual familiarity, phonological neighbourhood size, phonological onset (fricative/non-fricative) and objective frequency.

The data for the first six variables were taken from Székely et al. (2004). To account for the familiarity of the cognate and noncognate pictures, conceptual familiarity measures were taken from Nishimoto et al., (2005) who asked native Japanese speakers to rate how familiar they were with the concept depicted in pictures from Székely et al. (2004). Data on phonological neighborhood size was gained from the Elexicon project (Balota et al., 2007). Finally, frequency measures were taken from the BNC (British National Corpus) including both the spoken and written components (BNC, 2007).[31] As Table 5.2 demonstrates, all of the cognate-noncognate pairs were matched as closely as possible on all of the variables, and there were no significant differences between cognates and noncognates on any of the variables, *p*'s>.1. In addition to the experimental items, thirty noncognate filler items were selected at random from the picture database (Székely et al., 2004) to reduce the overall frequency of cognates in the experiment. Twenty practice items (5 cognate, 15 noncognate) were also selected at random from the database. Pseudo-randomized lists were created to ensure that no two cognates and no words from the same semantic category or with the same phonological onset in English occurred in sequence.

Table 5.2: Stimuli characteristics for matched cognate and noncognate words in Experiment 1

Variable	**Cognate**	**Noncognate**	***P* value (t-test)**
Length	5.22	5.26	0.93
Number of syllables	1.63	1.48	0.47
Naming agreement	0.26	0.25	0.87
Word naming latencies (ms)	850.37	849.21	0.97
Age of acquisition (scale of 1-3)	1.81	2.04	0.41
L1 conceptual familiarity (scale of 1-7)	5.09	5.31	0.51
Phonological neighborhood size	10.6	10.5	0.97
Phonological onset (no onset fricative=0, onset fricative=1)	0.22	0.33	0.37
Frequency per million words (BNC)	4635.63	6564.33	0.33

[31] The frequencies are token frequencies taken from a total wordlist downloaded via Sketch Engine website (Kilgariff et al., 2004). Japanese word frequencies are also token frequencies, and when multiple readings are used (i.e., any combination of kanji, hiragana and katakana) the summed total of each reading's frequency is used.

Phonological similarity	3.47	1.08	< 0.01
Semantic similarity	4.39	4.43	0.98

Procedure

Participants were tested in a quiet room. Both the instructions given on-screen and by the experimenter were in English. A language background questionnaire was completed following the experiment to assess language proficiency. The experiment was constructed using DMDX (Forster & Forster, 2003). Participants were seated in front of a computer (Dell, English OS) connected to a headset. They sat around 40-50cm away from the screen with eyes level with the centre of the screen and were instructed to name the picture as quickly and accurately as possible in English. They were told to refrain from using hesitation words and say 'don't know' if they did not know the answer. Each trial began with a "+" fixation mark for 2000 ms followed by the picture stimuli at which point response timing began. Responses were detected using the headset's microphone at which point the picture was removed and the following trial initiated. If no response was detected during 10000 ms of presentation, the following trial began automatically.

Results and Discussion

Accurate responses were trimmed for outliers and errors. An accuracy analysis using a X^2 test of the number of errors for cognates (4.4% of total responses) and noncognates (6.0% of total responses) revealed no difference in terms of the number of accurate responses (X^2 = 0.005, df = 1, p= 0.94). This result may reflect the fact that items were equally familiar in both conditions. Correct responses that were less than 300ms or greater than 3000ms and outliers that were 2.5 standard deviations from the mean were removed from RT analyses (a further 6.9% of the total data). Items that had overall error rates of over 30% were removed along with their matched counterpart (8 items in total, half cognate and half noncognate). All false starts and 'don't know' responses were classed as errors and removed. Minor deviations from the target name were allowed if they were extensions *forefinger* (for *finger*) or truncated forms of the target item *phone* (for *telephone*).[32] This trimming of data resulted in a further 8.4% of the total data being removed bringing the complete percentage of data removed to 25.7%. The average response times and accuracy rates for both experiments are shown in Table 5.3 below. In picture naming, *t*-test comparisons revealed that neither accuracy or response latency were significantly different for cognates and noncognates ($p<.05$).

Table 5.3: Japanese-English bilinguals' mean response latencies and error rates for Experiments 1 and 2

	L2 picture naming			**L2 lexical decision**		
	Cognate	**Noncognate**	**Difference**	**Cognate**	**Noncognate**	**Difference**
Mean RT (SD)	1308 (524)	1362 (511)	54ms	706 (214)	727 (200)	21ms*
% Error	4.40%	6.00%	1.60%	5.60%	8.30%	2.7%*

Standard deviations are in parentheses; Asterisks indicate where paired t-test comparisons of cognates and noncognates were significant to $p<.05$.

To explore the contribution of the various factors, mixed-effects modelling (Baayen et al., 2008) was conducted with R version 2.11.1 (R Core Development Team, 2010). The following predictors were considered in the model: Mean P similarity; mean S similarity; mean self-rated L2 proficiency, which was calculated as a composite mean of four individually rated language skills (speaking, listening, reading and writing); English word frequency (BNC, 2007); and Japanese word frequency (Amano & Kondo, 2002). Additional predictors included word length, conceptual familiarity and English objective age of acquisition as these have been shown to be significant predictors of picture naming in other studies using similar stimuli (Székely et al., 2004; Nishimoto et al., 2005). Two task-related predictors were included: Trial number, which has been shown to account for variance in responses attributable to practice effects and task fatigue (Baayen et al. 2008), and previous RT, which is a measure that uses the previous trial's RT as a predictor for the current trial and has been successful at accounting for variance

[32] Accepting deviations may introduce additional "noise" into the data due to differences in frequency and word length of experimental targets compared to the control ones. However the number of deviations in the present experiment was very small (1.3% of the total data) and critically, when these deviations were removed from the analyses the pattern of findings remained the same.

attributable to task factors (*ibid,* 2008). Moreover, interactions between P/S similarity and L2 proficiency as well as L2 frequency were included. The response latencies and measures of English and Japanese word Frequency were log-transformed to increase normality and minimize random variance.

A correlation analysis was performed for all item predictors to ascertain which were significantly correlated. When two or more predictors were significantly correlated, this collinearity was removed by fitting a linear model in which one variable became the response and was predicted by the other correlated variables. For example, if word length was correlated with word frequency and P similarity then word length was used as the response variable in a model with word frequency and P similarity as predictors. Similar models were then made for the word frequency and P similarity as the response variables with all their correlated predictors (including previously residualized response variables, such as word length in the example). The residuals of these models were used as predictor variables in the final analyses. The resulting residuals were all significantly correlated with their related variables (r>.71; p<.01). By-subjects random slopes for predictors tied to items and by-items random slopes for predictors tied to subjects were also fitted.

A backward simplification procedure was automated using the package LMER Convenience Functions (Tremblay, 2012), such that all terms and interactions were in the initial model and non-significant interactions and individual terms were removed step-by-step. Interaction terms were always removed prior to individual terms, and each time a term was removed an ANOVA (Analysis of Variance) and log-likelihood ratio testing was performed to test whether this removal significantly affected the predictive capability of the model. If the removal was significant (p<.05) then the term was retained in the model. The coefficients of the fixed effects, their Higher posterior Density (HPD) intervals, p-values based on 10,000 Markov Chain Monte Carlo samples of the posterior samples of the parameters of the final models and the p-values obtained from t-tests are presented in the final model for response latencies in the L2 picture-naming (Table 5.4). The standard deviation, median and mean coefficients based on MCMC sampling, and HPD intervals for random effects of participants and items in the final model are shown in the lower portion of the Table 5.4.

Table 5.4: Final model for L2 picture naming with Japanese-English bilinguals

Fixed Effects	Estimate	MCMC mean	HPD95 lower	HPD95 upper	pMCMC	Pr(>|t|)
(Intercept)	7.165	7.163	7.097	7.242	0.001	0.000
Trial number	0.002	0.002	0.001	0.004	0.004	0.005
Log English word frequency	-0.001	-0.001	-0.031	0.031	0.948	0.943
Length	0.040	0.040	0.015	0.065	0.001	0.002
Conceptual familiarity	-0.084	-0.083	-0.116	-0.048	0.001	0.000
P similarity	-0.022	-0.022	-0.050	0.003	0.088	0.136
S similarity	-0.067	-0.065	-0.141	0.026	0.130	0.135
L2 proficiency	-0.075	-0.075	-0.123	-0.025	0.006	0.007
Log English word frequency: P similarity	-0.060	-0.059	-0.083	-0.036	0.001	0.000
P similarity: S similarity	-0.073	-0.075	-0.138	-0.019	0.024	0.029

Random Effects Groups		Std. Dev.	MCMC median	MCMC mean	HPD95 lower	HPD95 upper
Items	(intercept)	0.092	0.083	0.084	0.052	0.112
Participants	(intercept)	0.167	0.142	0.143	0.102	0.187
Residual		0.279	0.283	0.283	0.269	0.297

Mixed-effects modeling showed that naming latencies were not significantly predicted by P similarity ($p>.1$). Also, S similarity was not a significant effect in the final model ($p>.1$). However, P similarity interacted with S similarity ($p<.05$), revealing an advantage for items that were both more phonologically and semantically similar across languages. This appears to show that it is the combination of both P and S similarity that lead to the 'cognate effect' as opposed to the contribution of the individual predictors. Figure 5.1 shows this effect clearly: responses to items with high P similarity ratings (i.e., those in the two highest quartiles) and increased S similarity are faster, whereas those with lower P similarity ratings (i.e., those in the two lowest quartiles) are less so. There was a 156ms P similarity advantage for 'high S similarity' items (i.e., the difference between the highest and lowest RTs of this group), while there was only a 52ms P similarity advantage for the 'low S similarity' items. This indicates that how the combination of P and S similarity drive the cognate facilitation effect in picture naming.

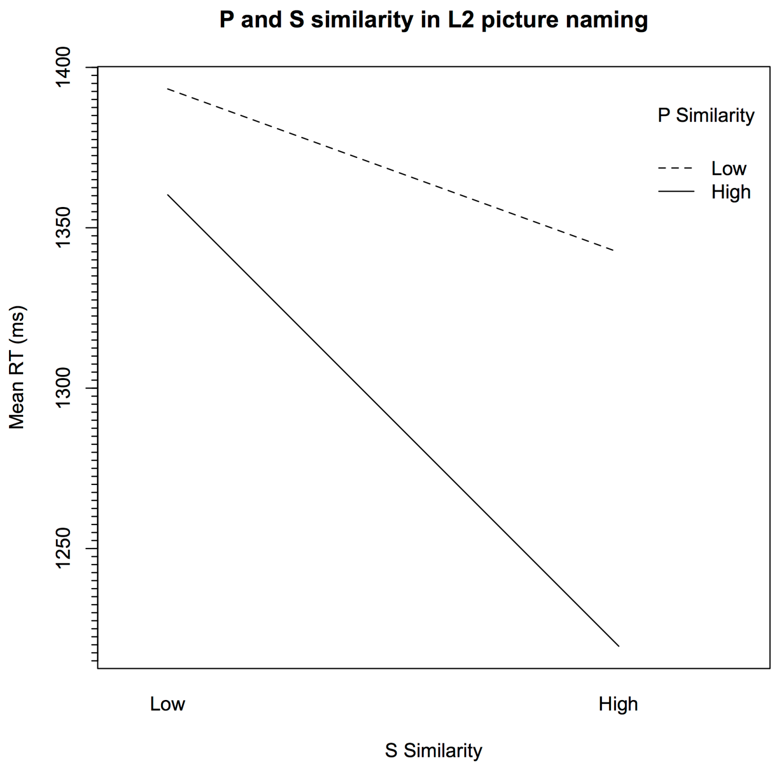

Figure 5.1: P and S similarity in L2 picture naming. For illustration purposes, S and P similarity ratings were divided into two equal groups along the median rating (Low, High).

Moreover, another highly significant interaction occurred between P similarity and log-transformed L2 word frequency (p<.001). Responses to words with the greatest P overlap (cognates) were faster the higher their frequency (effect size = 288ms). In contrast, items with the lowest P similarity (noncognates) appear to be slowed as a function of L2 frequency (effect size = 58ms; Figure 2). We return to this in the General Discussion.

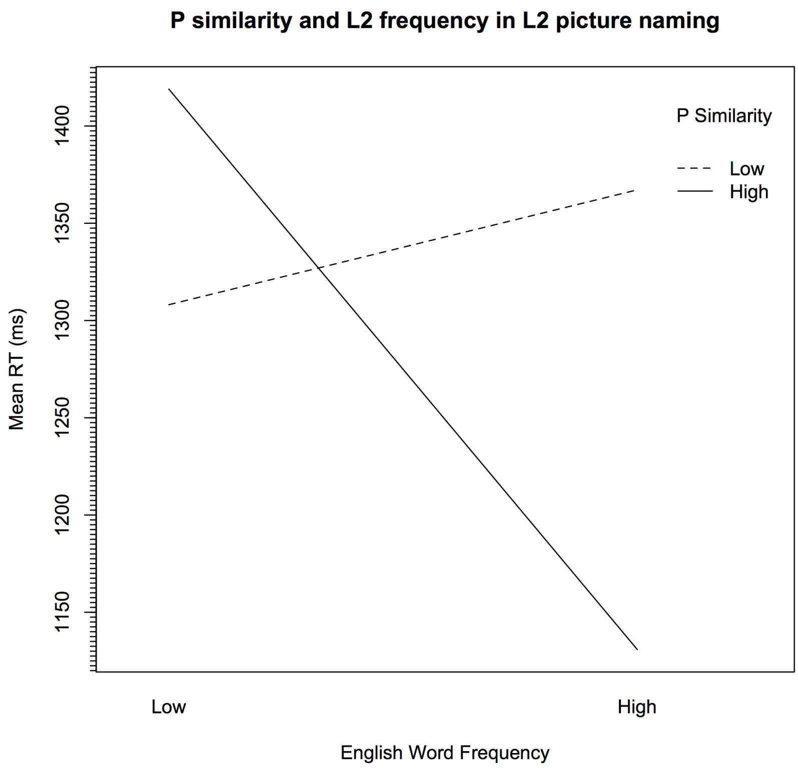

Figure 5.2: P similarity and L2 word frequency in L2 picture naming. For illustration purposes, P similarity ratings and log-transformed word frequency (taken from BNC, 2007) were divided into two equal groups along the median rating (Low, High).

L2 proficiency was highly significant (p<.01), showing higher L2 proficiency speeds picture naming. Conceptual familiarity was a significant predictor of picture naming RTs (p<.01), with greater familiarity resulting in faster RTs. Length was also significant (p<.01), with longer words taking more time for participants to vocalize. Trial was significant (p<.05) and revealed an overall slowing of RTs during the course of the experiment, likely attributable to task fatigue.[33] We performed adjustments by including by-subject and by-item random slopes for predictor variables tied to items and subjects but none of these significantly improved the model (p<.05).

Above we have suggested that due to the variability in P similarity that cognate status in and of itself is less useful as an indicator of cross-linguistic similarity. However, like previous research (e.g., Hoshino &

[33] Alternatively this may be attributed to increased competition at the lexical level: as the task progresses more words become activated which creates greater competition for selection.

Kroll, 2008), we can examine the binary cognate/noncognate status as a predictor of naming by classifying items as cognate or noncognate based on whether they are usually written in the katakana script (which is typically used for loanwords) or another script (i.e., kanji or hiragana, which are used for native and Sino-Japanese words). Thus, while the experiments reported in this paper do not involve presentation of words in Japanese, Japanese script information provides an unbiased way for differentiating loanwords/cognates from noncognates. Substituting P similarity with a binary cognate/noncognate classification, we found that cognate status was not a significant predictor in the final model (p>.1) but the interaction found between P and S similarity was replicated for cognate status and S similarity (p<.05). The absence of a strong cognate effect in the present experiment contrasts with the finding reported by Hoshino and Kroll (2008), who showed a significant effect of cognate status in a similar picture-naming task.

To investigate whether the cross-linguistic similarity measures were sensitive to variation in responses to cognates, another analysis was performed using only cognate latencies. Mixed-effects modeling for the cognates revealed that RTs were shorter for words that had been rated as more P similar, though this difference was only marginally significant (p>.07). The effect size for P similarity was larger when looking only at cognate items (estimate=-0.154, p<.08), than when looking at both cognate and noncognate items together (estimate=-0.022, p>.1). S similarity was highly predictive in the cognate-only model (p<.001), although it had not been significant in the full model (p>.1) with noncognates included. This indicates, as in the interaction in Figure 5.1, that S similarity had a greater effect when words were more P similar. The direction of this effect is negative, indicating that cognates with higher S similarity ratings were responded to more quickly than those with lower S similarity ratings.

To explain this finding the effect of S similarity it is necessary to consider the summed amount of activation that a lexical representation receives from conceptual activation via the picture stimulus. Considering a word such as *bat*, which has at least two distinct meanings, it is possible to assume that a picture stimulus of the animal *bat* would lead to activation of the lexical representation 'bat' and that little ambiguity exists as far as word selection is concerned. However, the fact that *bat* has multiple meanings may mean that alternative meanings are activated via feedback mechanisms from lexical to semantic representations. If this is the case, then multiple meanings may create a source of latent competition that influences word production. A related explanation that is applicable in the bilinguals' case may be that words with multiple meanings in one language are more likely to multiple translations in another language (e.g., Tokowicz et al., 2002). Thus, *bat* may activate バット/batto/ "object for hitting" and コウモリ/koumori/ "animal" in Japanese. If this is the case, then competition may arise from the activation of multiple L1 translations. When words are more S similar and thus have fewer translations, this is likely to lead to less competition and thus faster responses, even when there exists no ambiguity as to the concept that is to be produced. This effect may be amplified for cognates relative to noncognates because of the influence of P similarity in activating one translation. If the picture is consistent with the activated translation, then faster responses may be expected (i.e. in the case of *(baseball) bat* and バット). However, if the picture is inconsistent with the translation (i.e., in the case of *(baseball) bat* and コウモリ /koumori/), then slower response times may be observed.

In sum, the findings of the present experiment provide a richer view of lexical processing in bilingual picture naming than previous studies. Due to the continuous nature of cross-linguistic similarity measures and the sensitivity of mixed-effects modeling to this, we get a more detailed picture of how overlap influences the production of cognates. Importantly, P and S similarity were not significant by themselves, indicating that they did not contribute over and above other lexical and semantic characteristics such as word frequency, length, age-of-acquisition or conceptual familiarity. Further, the present study did not replicate Hoshino and Kroll (2008), who observed cognate facilitation in a very similar task. One reason for these discrepancies may be that overall RTs were slower in the present picture-naming task than in Hoshino and Kroll (2008), which allowed greater processing time thereby making the influences of cross-linguistic similarity more difficult to observe. Further, the Japanese-English participants in this research tended to be more proficient at reading than speaking (self-rated speaking *M*=4.2, *SD*=2.2; self-rated reading proficiency *M*=7.2, *SD*=1.2). Thus, it may be more likely to observe effects of cross-linguistic similarity in a comprehension task involving reading. In other words, because word recognition is faster than word production, the reduced time required between stimulus presentation and responses, as in a lexical decision task, may allow influences of cross-linguistic similarity to be clearly observed.

Experiment 2: Lexical decision in L2 English

In a picture-naming task the relationship between O and P overlap may be less important, as it primarily involves the activation of phonology. In a lexical decision task, both O and P are potentially important variables. However, previous research investigating the influence of degree of similarity on cross-language effects has made use of languages that share a script, making the role of O and P difficult to distinguish (e.g., *bière* and *beer* share both O and P). Because Japanese and English do not share orthography, they are ideal for exploring the contribution of meaning and form overlap, where form overlap is due to one variable, P, instead of two, O and P. Additionally, picture-naming limits the kinds of words that can be tested. Lexical decision task allows us to test whether P and S similarity measures were predictive of responses with a greater range of words (abstract and concrete). Finally, the use of different tasks will allow us to investigate whether the effects of cross-linguistic similarity are dependent on task demands.

Method

Participants

Twenty-three participants (19 male, mean age= 19.9y, *SD*=5.1y) from the University of Tokyo were paid for taking part in the study. All of the participants were native Japanese speakers and had a similar English proficiency (see Table 5.1 for participants' language experience). Participants' proficiencies were not matched across experiments and overall participants in Experiment 2 were higher proficiency. All participants performed satisfactorily in the task and thus data from all participants is used in the analyses. None of the participants had taken part in the rating studies or in Experiment 1.

Materials

Sixty cognates and 60 noncognates were selected and each group was made up of 30 concrete and 30 abstract words. Concreteness was established in a separate study where participants rated words on a 7-point scale (1=abstract, 7=concrete). Concrete words had a rating above 4.5 (*M*=5.59, *SD*=0.27) and abstract words had a rating below 4.5 (*M*=3.22, *SD*=0.63). Concrete items were selected from the same item pool as those in Experiment 1 (i.e., Székely et al., 2004), while abstract items were selected from a high-frequency wordlist derived from a 400 million Japanese web-corpus (Kilgariff et al., 2004) to ensure all participants knew them. The cognates and noncognates were matched on a number of English characteristics: word length, average response time and accuracy, orthographic neighbourhood size, part-of-speech, word frequency, and concreteness. The first five of these measures were taken from the Elexicon database (Balota et al., 2007); word frequencies were taken from the BNC (2007); and concreteness ratings were taken from the aforementioned rating study. As in Experiment 1, cognates and noncognates were matched as closely as possible with neither group being significantly different on any matched criterion (p's>.1; Table 5.5).

Table 5.5: Stimuli characteristics for cognate and noncognate matched groups

Variable	Cognate	Noncognate	*P* value (t-test)
Length	5.22	5.18	0.9
Number of syllables	1.55	1.55	1
Mean decision latencies (ms)	617.8	620	0.8
Mean decision accuracy	0.98	0.97	0.4
L1 concreteness (scale 1-7)	4.42	4.39	0.88
Orthographic neighborhood size	6.62	6.13	0.69
Number of senses: English	7.65	6.95	0.5
Number of senses: Japanese	1.83	2.27	0.2
Log frequency per million words (BNC)	7.72	7.57	0.6
Log frequency per million words (AK)	6.86	7.7	<0.01
Phonological similarity	3.42	1.11	<0.01
Semantic similarity	4.32	4.24	0.34
Part-of-Speech:			
Nouns	19	21	NA
Nouns/Verbs	30	22	NA
Verbs	0	2	NA
Adjectives	1	0	NA
Adj-Verb-Noun-Adverb	10	15	NA

In addition to the experimental items, 60 noncognate filler items were included to decrease the density of cognates in the experiment. One hundred and twenty nonwords were selected from the Elexicon database (Balota et al., 2007) and were matched with word items on length, orthographic neighbourhood size and average response accuracy. An additional 60 nonwords were selected to match the filler items on word length only. All nonwords were non-homophonic with Japanese words.

Procedure

Participants were tested in a quiet room. The language used in the on-screen instructions and in oral communication with the experimenter was English. Participants were seated in front of a computer (Dell, English OS) and responses were made via a keyboard press. The experiment was run using DMDX (Forster & Forster, 2003). Subjects sat around 40-50cm away from the screen with eyes level with the centre of the screen.

Participants were asked whether they were right or left handed (of the 23 volunteers tested, only one was left-handed); “Yes” responses were always made with preferred hand. Participants were told to make word/nonwords responses; they were urged to respond as quickly and accurately as possible. Response times and accuracy were recorded automatically via keyboard presses. Stimuli were presented in lower case (Arial, size 14). Participants began the experiment by pressing the spacebar. A “+” fixation was displayed in the middle of the screen for 800ms, followed by a black screen for 300ms. Finally, a word or nonword appeared and remained on the screen for 5000ms if no response was made. The next trial began immediately after a response was made or the trial timed out. Twenty practice trials preceded test trials and subjects were given feedback (i.e., “correct” or “incorrect” plus response time information) to encourage fast and accurate responses. No feedback was given during the experimental trials. Following the experiment, subjects completed a short survey detailing their language proficiency.

Results and Discussion

For both analyses filler items and nonwords were removed. A chi-square test for count data shows that there were significantly fewer errors for cognates (5.6%) than for noncognates (8.3%; $X^2 = 26.063$, df = 1, $p<.001$), which is in line with previous findings in the literature (e.g., Kim & Davis, 2003). For the latency analysis errors (6.9% of responses) and outliers were removed. Outliers were responses falling ±2.5 standard deviations from the mean after errors had been removed and resulted in the loss of 4.6% of the data. The total proportion of data removed as errors and outliers was 11.5%. Mean correct RTs can be seen in Table 5.1, and were subjected to the same mixed-effects modelling procedure as Experiment 1. The predictors were the same except that conceptual familiarity and English-word AoA were not included, as these measures were only available for the concrete nouns.

The final model for response latencies is presented in Table 5.6. Unsurprisingly, trial number and previous RT are significant predictors of RTs ($p<.001$ and $p<.05$, respectively), showing that participants got faster at responding as the task progressed and that longer responses on previous trials led to longer responses on subsequent trials. English frequency was significant ($p<.001$) but Japanese frequency was not ($p>.1$). English word length was significant such that longer words took longer to recognize ($p<.001$). Phonological similarity significantly speeded RTs ($p<.01$), indicating that L1 phonology is activated and facilitates recognition of L2 words. Greater semantic overlap significantly slowed RTs ($p<.05$), such that the greater the S overlap the slower the RTs. Potential reasons for this will be taken up in the General Discussion.

Table 5.6: Final model for L2 lexical decision with Japanese-English bilinguals

Fixed Effects	Estimate	MCMC mean	HPD95 lower	HPD95 upper	pMCMC	Pr(>|t|)
(Intercept)	6.542	6.542	6.492	6.593	0.001	0.000
Trial number	0.000	0.000	0.000	0.000	0.001	0.000
Previous RT	0.009	0.009	0.002	0.016	0.010	0.010
Log English word frequency	-0.070	-0.070	-0.083	-0.056	0.001	0.000
Length	0.067	0.067	0.055	0.079	0.001	0.000
P similarity	-0.024	-0.024	-0.035	-0.010	0.002	0.001
S similarity	0.049	0.050	0.013	0.082	0.004	0.011

Random Effects Groups		Std. Dev.	MCMC median	MCMC mean	HPD95 lower	HPD95 upper
Items	(intercept)	0.071	0.064	0.064	0.053	0.075
Participants	(intercept)	0.145	0.119	0.121	0.092	0.153
Residual		0.198	0.200	0.200	0.194	0.205

As in Experiment 1, an additional analysis was conducted where P similarity was replaced by a binary cognate/noncognate variable. This yielded the same final model with similar effect sizes as the model with P similarity (cognate status estimate=-0.0577, $p<.001$). To explore whether P similarity simply serves as a proxy for cognate status, we further explored the role of P similarity in the set of cognate items. In the mixed-effects model with response latencies for cognates only, the P similarity measure was predictive of response times for cognates (estimate=-0.1035, p <.0.01), with increased P similarity leading to faster RTs. Again increased S similarity lead to slower RTs (estimate=0.154, p<.001). Both of these effects were larger than in the full model with cognates and noncognates, illustrating the role of P and S similarity variables as useful measures to explain bilingual performance when items are restricted to cognates.

In sum, Experiment 2 shows that P similarity ratings are predictive of RTs for words in the L2 and that subtle differences in cross-linguistic similarity have a significant influence on lexical decision speed. The finding that P similarity is significant for cognates (with noncognates removed from the analysis) suggests that subtle differences in P similarity across cognates leads to variation in processing speed, specifically that *more* P similar cognates are processed faster than *less* P similar cognates. P similarity thus illuminates cross-linguistic language processing effects above and beyond traditional binary distinctions of cognate status, as it determines processing speed of cognates relative to one another.

Interestingly, we find that S similarity is also predictive of decision responses, but with increased similarity resulting in slower decision times. To further investigate the locus of this effect we decided to include concreteness ratings (described previously) and the number of English senses (collected from WordNet, Princeton University, 2010) as additional predictors in a post-hoc model for response latencies in lexical decision. If S similarity is predictive over and above these predictors (as well as those already included in the previous model, such as word frequency), then it can be assumed that S similarity accounts for cross-linguistic variation in responses that is not simply determined by the concreteness or number of senses that a word has in the target language (i.e., the L2, English). Correlated variables were dealt with using the procedure described previously and the residuals of these were used in the modelling process. Additional interactions between S similarity and concreteness, S similarity and English number of senses, and concreteness and English number of senses were also included in the initial model. The final mixed-effects model with concreteness and number of senses as additional predictors is shown in Table 5.7. Both additional predictors were highly significant (p<.001), such that increased concreteness led to slower RTs and increased number of senses led to faster RTs; moreover, S similarity remained significant (p<.01), revealing that S similarity does appear to predict variance in bilinguals' responses that is not simply due to concreteness or number of senses.

An interaction was also significant between S similarity and concreteness (p<.05), revealing that highly concrete items were responded to more quickly as S similarity increased, while words that were less concreteness (i.e., more abstract items) were responded to more quickly as S similarity decreased. An explanation for the latter may be found by considering the negative direction of the *number of senses* effect, which shows that items with more L2 senses are named faster than those with fewer senses: if words have a greater number of senses then these multiple senses may facilitate responses in lexical decision as shown in previous studies (e.g., Hino et al., 2002). Cross-linguistic S similarity is based on the number of senses and the number of these that are shared across languages, so it may be natural that S similarity and number of senses follow a similar pattern; however, we show here that both of these measures are significant. In sum, the findings from the lexical decision task show that concrete items are facilitated if they are more S similar across languages, while abstract words are instead facilitated by being less S similar across languages. Moreover, while S similarity and the number of English senses behave similarly, they appear to be at least partially independent.

Finally, a significant interaction was found between English word frequency and L2 proficiency (p<.05), such that the frequency effect was greater for bilinguals whose L2 proficiency was higher. This makes sense if we consider that as L2 proficiency increases, bilinguals are exposed to more English words and thus the subjective frequency of words also increases. This would lead to a larger L2 frequency effect for higher proficiency bilinguals.

Table 5.7: Final model with concreteness and number of English senses as additional predictors

Fixed effects

	Estimate	MCMC mean	HPD95 lower	HPD95 upper	pMCMC	Pr(>|t|)
(Intercept)	6.531	6.531	6.477	6.583	0.001	0.000
Trial number	0.000	0.000	0.000	0.000	0.001	0.000
Previous RT	0.009	0.009	0.002	0.015	0.002	0.009
Log English word frequency	-0.080	-0.078	-0.126	-0.035	0.002	0.001
Log Japanese word frequency	-0.006	-0.006	-0.017	0.006	0.294	0.297
Length	0.073	0.073	0.061	0.086	0.001	0.000
P similarity	-0.025	-0.024	-0.038	-0.011	0.001	0.001
S similarity	0.096	0.095	0.043	0.142	0.001	0.000
Concreteness	0.063	0.063	0.042	0.084	0.001	0.000
English number of senses	-0.015	-0.015	-0.020	-0.011	0.001	0.000
Log English word frequency: L2 proficiency	-0.008	-0.008	-0.015	-0.002	0.014	0.019
Log Japanese word frequency: P similarity	0.011	0.011	0.002	0.022	0.024	0.055
S similarity: concreteness	-0.042	-0.042	-0.074	-0.004	0.022	0.026

Random effects

Groups		Std. Dev.	MCMC median	MCMC mean	HPD95 lower	HPD95 upper
Items	(Intercept)	0.069	0.063	0.063	0.052	0.075
Participants	(Intercept)	0.146	0.121	0.121	0.093	0.151
Residual		0.198	0.199	0.199	0.194	0.205

General Discussion

There is a large literature showing that cognates are processed more quickly than noncognates. However, most research to date has been conducted on languages that share the same script, and thus cognates in these languages overlap in O, P and S, which means that O and P overlap are often confounded. Two studies on Japanese-English cognate processing, where cognates share P and S but differ in O, demonstrate cognate facilitation in L2 picture naming (Hoshino & Kroll, 2008) and in lexical decision (Taft, 2002). These studies are important because they establish that shared O does not necessarily underpin cognate facilitation.

However, because in these studies words are treated in a binary fashion, as cognates or noncognates, it is difficult to determine the potentially independent influence of P and S similarity on response times.

Experiment 1 showed that as the degree of cross-linguistic P similarity increases, *and* the degree of S similarity increases, words were produced faster. Thus, cognate items like *bus* (/basu/) and *radio* (/rajio/) were processed in English more quickly than noncognate items like *umbrella* (/kasa/) and *ashtray* (/haizara/), due to not only the degree of P similarity but also that of S similarity. However, the fact that the two similarity measures were not predictive as main effects suggests a limited role in word production, when accounting for other factors such as word frequency and word length. An alternative explanation for the lack of significant main effects in this experiment was the relatively slow responses overall to items, meaning that subtle influences of cross-linguistic similarity were less apparent. A replication of this study that includes a picture familiarization phase may help to speed up responses (as well as increase accuracy), leading to more observable cross-linguistic effects. Nevertheless, the interaction between P and S similarity observed in picture naming shows that bilinguals' L1 was activated and influenced processing in the L2.

The interaction between P similarity and English word frequency raises the question as to why responses to cognates benefited from increased frequency, while noncognates were slowed by it. If L1 translations are activated by the picture stimuli, then there may be competition when the L1 and L2 translations do not share form (noncognates). In particular, when the L1 competitor is high frequency, competition may increase at the form level, which would slow naming times. When translations do share form (cognates), the L1 form does not compete for selection but instead increases activation of the L2 form. Therefore, increased L1 frequency increases L2 activation, thereby speeding naming times. Such a pattern may not have been observed before, because few regression-type designs have investigated bilingual picture naming studies. Moreover, it may be that the participants in the current study are highly L1 dominant, living in a relatively homogenous, monolingual community, which means that competition from L1 during L2 processing is more apparent than in previous research.

It may be unsurprising that in a naming task, where script is less likely to influence cross-linguistic activation, that we observe some influence of P and S on response times in different script bilinguals. However, in Experiment 2 where script could provide a strong cue for activation, we see that words having greater cross-linguistic P similarity were recognised faster and more accurately than those that were less similar. Importantly, P similarity discriminated between cognates, such that greater P similarity lead to faster RTs within the category of cognates. This shows that, although cognate status has typically been treated as a single category in previous studies, speed of processing is influenced by the amount of phonological overlap between the two languages. For example, *radio* is less phonologically similar to its Japanese translation (/rajio/) than *bus* (/basu/) is, and therefore *radio* is responded to more slowly (even after potential length effects have been accounted for). This result is in line with previous research showing that continuous measures of cross-linguistic similarity were predictive of RTs in bilingual tasks, but with same-script languages (Van Assche et al., 2009; 2011) and with a language where some of the script overlaps and some does not (Voga & Grainger, 2007). This indicates that P similarity can serve as a measure of formal similarity for languages that differ in script and that the amount of P similarity influences single word processing. We also see that increased S similarity leads to slower response times in lexical decision (this issue will be discussed below). Crucially, the current findings, with languages that do not share a script, add to a growing literature showing that it is more informative to use continuous measures of P and S similarity than using binary categories (cognate/noncognate), due to the inherent variability of words along these two criteria (cf. Dijkstra et al., 2010; Tokowicz et al., 2002).

The influence of P similarity on L2 RTs in a lexical decision task suggests a strong influence of P in word recognition. There has been a long-running debate about the role of P in skilled readers' word recognition processes, specifically whether P information is activated during word recognition or whether skilled readers by-pass activation of P representations and instead utilise a direct route from O to S representations (e.g., Perfetti, 1999). In many studies O and P are confounded because the languages under investigation share a script. Because Japanese and English do not share a script we can investigate the role of P overlap without an influence of O (a similar situation arises for other language pairs such as Korean and English e.g., Kim & Davis, 2003). The present research suggests a strong influence of P information in word processing, such that activation of L2 P information activates L1 word representations, and with increased P overlap there is faster word processing in the L2. Thus, for bilinguals with languages that differ in script, P information is not only sufficient to create cross-linguistic activation (Hoshino & Kroll, 2008), but is critical in determining to what degree translation equivalents are activated in word recognition.

Interestingly, S similarity *speeded* response time in picture naming, at least in the interaction with P similarity and in the cognates only model, and *slowed* response time in lexical decision. This may be explained by task differences in Experiments 1 and 2. In lexical decision, activation of multiple meanings of words all lead to the same response, whereas a picture activates a particular word meaning and activation of alternative meanings may create competition during the word selection process. Previously with lexical decision it has been shown that words that have a greater number of meanings are recognised faster (e.g., Hino, et al., 2002), presumably because the activation of multiple conceptual representations increases the activation of the lexical representation. In the current study, ratings of S similarity relate to the number of meanings shared across languages, such that words with more meanings have lower S similarity because fewer senses are shared. Using Wordnet (Princeton University, 2010) to count the number of English senses for the words in the current studies, we found that the number of senses is a significant predictor of S similarity: less S similar words have more individual senses. Because decreased S similarity indicates more meanings, our results are in line with findings showing that activation of multiple conceptual representations speeds lexical decision times. Moreover, the analysis including English number of senses and concreteness supports the idea that multiple senses speed responses in lexical decision, but importantly also shows that S similarity adds significantly to the model. Therefore, both expert defined number of senses (as in WordNet) and S similarity ratings from bilinguals appear to be useful measures of bilingual performance, even once collinearity is removed through residualization.

It is important to keep in mind that picture naming and lexical decision typically use different stimuli, as picture naming is limited to depictable, usually concrete words, while lexical decision can include both concrete and abstract words. Thus, lexical decision tasks can investigate a wide variety of words that differ in terms of S similarity, making it easier to explore the role of S similarity in word processing. Our study takes advantage of the fact that lexical decision can be used to investigate the processing of a greater range of words. Thus, while the two studies are not directly comparable because the picture naming task was limited to concrete words and lexical decision task investigated both concrete words (like in the picture naming task) and abstract words, taken together our results indicate that the direction of S similarity effects are dependent on task demands, but potentially also stimulus composition, with increased S similarity leading to speeded responses in picture naming but slower responses in lexical decision. This provides further evidence to move towards increasing specification of S features of stimuli as opposed to binary classifications of cognates and noncognates.

In Experiment 1 there was a clear contribution of proficiency, but proficiency was not predictive of RTs in Experiment 2. This discrepancy may be due to difference in the participants' proficiency for speaking versus reading. In the present study, self-rated proficiency for reading considerably exceeded that for speaking (Experiment 1: reading M=6.5 (SD=1.3); speaking M=3.8 (SD=1.9); Experiment 2: reading M=7.4 (SD=1.2); speaking M=4.4 (SD=1.6)). The greater standard deviation for speaking in Experiment 1 suggests a wider range of proficiencies for production while that of reading in Experiment 2 suggests a smaller range for comprehension. Because Japanese learners of English must pass university entrance exams that do not include a speaking element, the focus in pre-tertiary education is on English comprehension. Thus, learners' spoken fluency is more varied and often depends on extra-curricular experience such as studying abroad or attending conversation courses. Therefore, Japanese-English bilinguals typically, and more importantly in the present study, can be said to have more uniform L2 reading comprehension abilities in comparison to L2 production abilities. This uniformity, as well as the higher overall reading comprehension skills, may explain why there was no observed effect of proficiency in lexical decision.

One concern is that the L2 proficiency difference across experiments is responsible for the difference in the observed cross-linguistic similarity effects. Language proficiency is an important factor when looking at cross-linguistic influences, with unbalanced bilinguals (lower L2 proficiency, higher L1 proficiency) showing typically greater L1 influences in L2 processing (e.g., Duñabeitia et al., 2010). However, this means that it should have been more likely to observe a cognate effect in Experiment 1 than in Experiment 2, because participants in the first experiment had a lower L2 proficiency. Because proficiency was not matched across experiments, it is not possible to rule out the possibility that the different pattern of results across the two experiments is due to the proficiency of the participant groups. Investigating the role of proficiency and its potential interaction with continuous measures of P and S overlap with different script bilinguals in both production and comprehension tasks is an interesting question for future research.

Conceptual familiarity was highly predictive in picture naming, while word frequency was highly predictive in lexical decision. It is unsurprising that conceptual frequency is a predictor of naming latency for concrete images. Equally, it is not remarkable that word-based frequencies from written corpora are a more accurate predictor of written word recognition.

The modulatory function of P similarity for Japanese-English processing can be discussed in terms of interactive activation models of language processing. Costa et al. (2005) discussed the results of a Spanish-English bilingual picture naming task in which P similar cognates were named faster than non-P similar noncognate controls. In their model of picture naming processing (*ibid*, 2005, p.101), shared features at both the S node and P node levels create cross-language facilitation effects. This model is compatible with the present results, which in turn clarify that the *number* of shared features (i.e., the *degree* of similarity) at both of these levels influences naming and that this effect can be quantified using mixed-effects modelling. Because picture naming does not directly involve any processing of script, the findings and the model are compatible for languages that share and differ in script. For word recognition, the revised Bilingual Interactive Activation model (BIA+; Dijkstra & Van Heuven, 2002) can explain the present findings. The BIA+ model proposes that all words (in both of the bilingual's languages) that share P and/or O features with the input become activated during the word recognition process. Residual activation of activated words feeds backward to the target item due to formal overlap of these items, increasing the activation of the target. Because Japanese and English do not share O, cross-linguistic activation is restricted to P similarity. The model predicts that as the number of shared P features increases, there should be increased feedback for the cognates, which can account for the current pattern of results. The S similarity measure in lexical decision reveals that words with more meanings are recognised faster. This is likely due to the task requirements of lexical decision where any activated meaning of a word sends activation back to the target, resulting in a negative relationship between number of senses and response speed. Thus, the current findings can be explained by a combination of activation of shared features and task demands within the BIA+ model.

The present study has demonstrated that a continuous measure of P similarity is a significant predictor of cross-linguistic activation and crucially that increased P similarity results in faster responses in L2 comprehension and also (in combination with S similarity) in production. A continuous measure of S similarity predicts response times and may be used, together with P similarity as a measure of 'cognateness' in languages that do not share a script. Importantly, using continuous measures of P and S similarity while controlling for other participant and lexical factors gives us a more complete picture of the role of cross-linguistic similarity on bilingual language processing than the more traditional binary distinctions.

Chapter 6: Japanese picture naming

Introduction

English picture naming (Chapter 5) showed that cognates were named faster than noncognates in L2 picture naming by Japanese-English bilinguals. This is important because it indicates that non-selective activation of L1 occurs in L2 tasks with bilinguals whose languages differ in script. Moreover, it was shown that continuous measures of P and S similarity account for significant amounts of variance in the time required to produce words in the L2. It might not be unexpected to find a cognate effect in L2 naming, as this has been frequently observed in same-script bilinguals (e.g., Costa et al., 2000) and there is recent evidence for it in different-script bilinguals (e.g., Hoshino & Kroll, 2008). That is, the similarity in P form creates a 'boost' in activation that facilitates the naming of cognates compared to matched noncognates. However, the question remains whether P similarity influences bilingual production when the task requires responses in the L1, as opposed to the L2.

Whether or not L2 influences are observed in L1 tasks may depend on the L2 proficiency of the bilingual. In studies with balanced bilinguals, that is, bilinguals who learnt both of their languages early in life and have a native-speaker level proficiency in both languages, cross-linguistic activation has been observed in L1 tasks (e.g., Basnight-Brown and Altarriba, 2007; Duñabeitia et al., 2010; Duñabeitia et al., 2011). However, if bilinguals are late-learners of an L2 and vary in proficiency (from elementary to advanced but not native speaker level), then observing cross-linguistic effects in L1 tasks is rare (Duñabeitia et al., 2011; but see Duyck & Warlop, 2012). In contrast, as shown in English picture naming (Chapter 5), unbalanced bilinguals are influenced in L2 production by their.

The role of proficiency (and age-of-acquisition) in determining cross-linguistic activation is central to psycholinguistic theories of bilingual language production. As discussed in Chapter 3, models of bilingual language processing (RHM, IC Model, BIA+, Costa et al.'s IA model of picture naming) explain this activation in a number of ways; however, all models predict an equal degree of cross-linguistic influence for balanced bilinguals and an unequal level for unbalanced bilinguals, specifically less of an influence of L2 in L1 tasks when proficiency is low than when it is high. However, a recent critique by Dimitropoulou et al. (2011) in fact argues that while the RHM and BIA+ both predict that as L2 proficiency increases cross-linguistic effects in L1 tasks should gradually come about as a function of proficiency, this usually turns out not to be the case. In their research the authors show that three groups of bilinguals (low, intermediate and high proficiencies) do not show gradually increasing cross-linguistic effects in masked priming with lexical decision in the L1, but instead that native-level L2 proficiency is required for these effects to emerge. Dimitropoulou et al.'s (2011) research suggests that native-like attainment is thus a necessary pre-requisite for bi-directional masked priming lexical decision effects to emerge.

In order to investigate the nature of cross-language activation in L1 language production with unbalanced bilinguals, a picture naming experiment was conducted modelled on that of the English picture naming experiment (Chapter 5). L2 proficiency was measured and treated as a predictor variable for L1 responses. Based on previous research (Duñabeitia et al., 2010, 2011), it is predicted that no L2 effects will emerge in the L1 task because the population in the experiment is highly L1-dominant, has a non-native level in L2, and are late L2 learners. A null-effect is predicted even though cognates are included in the stimuli, which should help to 'boost' L2 activation through shared P and S features. If L2 proficiency modulates the degree of L2 activation, however, higher proficiency would be expected to lead to greater L2 effects. These L2 effects would be realised as cognate facilitation, as observed in English picture naming (Chapter 5). P and S similarity will be used as measures of 'cognateness' as in the previous experiments in this thesis. Additionally, a continuous measure of proficiency may interact with P similarity, such that increased proficiency and P similarity may result in facilitation in picture naming. However, as stated above, the primary prediction is that no cross-linguistic effects will be evidenced, regardless of the degree of P similarity or L2 proficiency.

Method

Participants

Twenty-one first-year university students were recruited as participants for the experiment. One subject was removed from the analysis because she had participated in a previous rating study using the current items. Data from the remaining 20 participants is presented. All participants were native Japanese speakers (mean age= 21y, ± 3y) who had studied English to a similar level[34]. Most of the participants began learning English between the ages of 11 and 15 (*n*=12), with others beginning earlier (6-10years: *n*=2; 1-5years: *n*=4) and some beginning later (16+: *n*=2). L2 proficiency data is presented for the participants (Table 6.1) and includes the proficiencies of the participants in the L2 task from Chapter 5, to demonstrate comparability across tasks. The L1 and L2 experiment participant groups were similar in self-rated L2 proficiency. Only one difference was significant: self-rated writing proficiency in the L2 (t=-2.14, df=37.7, p<.04). The participants in the L1 task rated themselves as significantly more proficient than those in the L2 task regarding writing in English. However, given that picture naming involves speaking and does not rely on writing processes, this difference should not be of critical importance. Moreover, as the L1 task does not require explicit use of L2 this should not be problematic. Something that is important to point out is that in both the L2 production task (Chapter 5) and the current L1 production task, participants provided their language background information after completing the picture naming task. Thus, while the ratings appear to be equivalent for the two groups, it is not possible to rule out the possibility that the participants in the L2 production task

[34] All but three participants responded that they were born and have only lived in Japan, spoke Japanese at home and that their whole education (from elementary to university level) was conducted in Japanese. The three that did not fit completely with the above category rated themselves at native speaker level in Japanese in all four skills (listening, reading speaking; *M*=10.0, *SD*=0.0; writing; *M*=9.0, *SD*=1.0). Thus, all participants were considered native speakers of Japanese.

rated themselves more harshly. Doing an English task may have made them more aware of their shortcomings in the L2.

Table 6.1: Language proficiency data for the two picture naming tasks: Mean proficiencies are presented with standard deviations in parentheses

	L1 picture naming	**L2 picture naming**
L2 Reading proficiency	7.2 (1.2)	6.5 (1.3) **
L2 Writing proficiency	5.9 (1.8)	4.6 (1.7)
L2 Speaking proficiency	4.2 (2.2)	3.8 (1.9)
L2 Listening proficiency	5.5 (2.2)	5.5 (2.0)
Mean L2 proficiency	5.7 (0.1)	5.1 (0.3)

**Difference between L1 and L2 groups is significant to $p<0.05$.

Materials

Twenty-six matched pairs of cognate and noncognate items were selected for stimuli (Appendix 6.1). The stimuli pairs overlapped for both picture naming experiments but were not identical: Fifteen cognate pairs and 10 noncognate pairs were used in both L1 and L2 tasks, while the remaining item pairs (11 and 16, respectively) differed between the experiments. Differences in stimuli resulted from ensuring that L1 cognate and noncognate pairs were just as well matched, in terms of, for example, Japanese word frequency and length, as the L2 cognate and noncognate pairs.

The variables matched in this experiment were Length (i.e., number of mora), naming agreement (H statistic), mean naming latency, mean conceptual familiarity, mean age of acquisition, and objective word frequency. Information about the first five variables was taken from Nishimoto et al. (2005) and has been described previously (Chapter 5).

Word frequency measures used for matching were gained from two sources: Amano and Kondo's (2002) corpus of Asahi newspaper articles from 1985–1998 and JpWaC (Japanese Web Annotated Corpus; Kilgariff et al., 2004) a large web-corpus comparable is comparable in size and structure to the UkWac corpus used for matching L2 materials. The Amano and Kondo data has been used in numerous studies of lexical processing of Japanese (e.g., Nishimoto et al., 2005; Tamaoka &

Miyaoka, 2003). The total size of the corpus is 13.9 million words. One concern, however, is that in the picture-naming studies conducted by Nishimoto et al. (2005) the log-frequencies from Amano and Kondo (2000) were not predictive of response latencies. The authors suggested that the newspaper texts did not adequately match the productive vocabularies of native Japanese speakers: many of the items depicted in the pictures are well known from childhood but may occur rarely in newspaper texts. It may not be surprising that using written corpora frequencies as a predictor for picture naming production tasks is problematic, while written text frequencies tend to be more predictive in visual word recognition tasks (Bates et al., 2003).

As the previous paragraph highlights, using frequency information from a corpus as a predictor of latencies in a picture naming task is problematic. Thus, I investigated the potential predictive capabilities of different Japanese corpora for L1 picture naming latencies. Mean responses times for a set of 163 items selected from Nishimoto et al. (2005) were used as the dependent measures for the analysis. For comparison I used two additional Japanese corpora: the JpWaC (Japanese web corpus) which consists of 400 million words derived from web pages, including blogs, news, and product descriptions; and a sampler of the Kotonoha corpus of contemporary Japanese which will be structurally similar to the BNC once completed (estimated for 2011). For Japanese latencies, JpWaC was marginally the best predictor (r^2=.03) followed by Amano and Kondo (r^2=.02) and finally the sampler of the Kotonoha corpus (r^2=.02). All coefficients were significant predictors at (p<.05). It is surprising, however, that the frequency information from all of the corpora only predict 2-3% of the data compared to the best English corpora which predict around 13% of the variance. Because the Amano and Kondo corpus is better established than the JpWac corpus, it will be used as the primary measure of Japanese word frequency as a predictor in the mixed-effects analyses; however, both the JpWac and Amano and Kondo frequencies are used for matching purposes.

In addition to the above matched experimental item pairs, 30 noncognate filler items and 20 practice items were included and were the same as in the previous picture naming experiment.

Procedure

The procedure for the L1 picture-naming task was identical to that of the L2 task, except that the instructions given on-screen and by the experimenter were in Japanese.

Results and Discussion

All responses for the experimental task were analyzed for differences in accuracy between cognates and noncognates. Errors amounted to 3.3% (total=18) for cognates and 5.4% for noncognates (total=29). A Pearson's Chi-squared test with Yates' continuity correction revealed a highly significant difference (X^2=23.24, *df*=1, *p*<.001) between accurate responses for cognate and noncognates with fewer incorrect responses for cognates than noncognates. However, the number of errors was so low that the reliability of statistical tests are weakened and therefore these differences should be treated with caution.

Response latencies were trimmed for errors and outliers. The criteria for classifying non-target responses were as follows: all false starts, no responses, and items beginning with articles were classed as errors and removed. Regarding synonyms and non-target responses, certain deviations were allowed if they were extended forms (*nagabuttsu* for *buttsu, boots*) or synonyms of the expected name (e.g., *resha* for *densha, train*).[35] This trimming of data resulted 8.7% of the data being removed. In addition, two items were read as truncated-targets every, or almost every time (*yajirushi, ya,* 'arrow'; *mikatsuki, tuski,* 'moon'). Analyses were conducted with and without these two items and their matched cognate words (*curtain* and *gorilla*, respectively). Finally, one item was answered incorrectly by more than 30% of the participants, so

[35] Acceptable deviations in L1: *nagabutsu (butsu), heaburashi (burashi), suizara (haizara), kisha / resha (densha), kingyo (sakana), tanna (tansu).* The first two items were cognate, and the following four were noncognate.

this item and its matched cognate were removed from the analyses (3.7%). Responses that were less than 300ms or greater than 2500ms or ±2.5 standard deviations from the mean were also removed, resulting in a further 4% of items removed. The combined total percentage of errors and outliers removed was 16.3%.

The analyses were the same as those conducted in Chapter 5. For each analysis mixed effects models included participant-tied (proficiency) and item-tied fixed effects (cognate status, P similarity, S similarity, Japanese word frequency, English word frequency, conceptual familiarity and the number of mora as a measure of Japanese word length) and task variables (trial number, previous RT) as fixed effects. Participants and items were random effects. An interaction was included for P and S similarity. The response latencies for each experiment and the two measures of word frequency were log-transformed to achieve improved normality by minimizing random variance. The resulting residuals following partialling out variance for correlated variables shows that they were significantly correlated with their related variables (logBNC r=.81, logAK r=.65, Length r=.85, JpFam r=.89, PhonSim r=.95, SemSim r=.86; p<.001, in all cases).

The mean latency for cognates was 997ms (*SD*=251ms) and that for noncognates was 923ms (*SD*=228ms). A simple t-test comparison revealed that this difference was significant (t=2.824, df=974.01, p<.01), such that noncognates were named significantly faster than cognates. To test whether this effect was significant after accounting for frequency, length and other variables, mixed-effects modelling was conducted as planned. The final model for the L1 picture-naming latencies is shown in Table 6.2. There were no cross-linguistic effects of P or S similarity in this L1 task, which confirms that for late-acquiring, low/mid-proficiency bilinguals L2 similarity effects are not observed in L1 naming tasks. Previous research has typically utilised a binary measure of cognate status to predict differences in responses to cognate and noncognate items and thus a model with a binary cognate status variable in place of P similarity was fitted to confirm the influence of cognateness. However, this model revealed the same final model as the one with P similarity, showing that cognate status was *not* significant at predicting naming latencies (p>.1), once other factors had been accounted for in the model. In sum, the observed cognate inhibition observed with the t-test comparison was not replicated in the statistical modelling procedure. Given that mixed-effects models are more powerful for explaining the contribution of individual predictors upon responses, as they also account for other fixed and random effects and the variance attributable to them, the t-test result will not be considered further as a significant finding. If indeed noncognates were facilitated relative to cognates, this would have been borne out in the statistical models with the predictors, P similarity and/or cognate status.

Table 6.2: Final model for latencies in Japanese picture naming

Fixed Effects

	Estimate	MCMC mean	HPD95 lower	HPD95 upper	pMCMC	Pr(>|t|)
(Intercept)	6.825	6.825	6.773	6.870	0.001	0.000
L2 proficiency	0.036	0.036	0.010	0.065	0.016	0.016

Random effects

Groups	Name	Std. Dev.	MCMC median	MCMC mean	HPD95 lower	HPD95 upper
Items	(Intercept)	0.094	0.082	0.083	0.066	0.102
Participants	(Intercept)	0.097	0.089	0.091	0.065	0.125
Residuals		0.197	0.199	0.199	0.190	0.207

A main effect of L2 proficiency (p<.05) was the only significant predictor and this revealed that higher L2 proficiency bilinguals were *slower* at naming pictures than lower L2 proficiency bilinguals. To confirm whether this was true for both cognate and noncognate items, separate models were fitted for each data set (only-cognate, only-noncognate). The two models revealed similar effect sizes for L2 proficiency for cognate and noncognates, suggesting that increasing L2 proficiency slowed naming for items regardless of their cross-linguistic similarity. The question becomes why would increasing L2 proficiency lead to slower L1 naming? One explanation lies in the work by Bialystok (2009). In a review of differences between monolingual and bilingual performance on a range of cognitive and language-related tasks, Bialystok (2009) shows that monolinguals outperform bilinguals on vocabulary tests. This effect can be explained by the BIA+ and other connectionist models in terms of the *relative frequency* of activation of words. This is also detailed in the weaker links hypothesis by Gollan and colleagues (e.g., Gollan, Montoya, Cera, & Sandoval, 2008). For bilinguals who use two languages regularly, lexical representations in each language are activated less overall than for monolinguals; thus the connections between representations may be weaker for bilinguals than for monolinguals, because of the different relative frequency of use of each language. AoA may also determine the strength of these effects (Hernandez & Li, 2007), with earlier AoA resulting in stronger connections than later AoA. In the present study, higher proficiency did not necessarily mean lower AoA, and as mentioned in Chapter 2, AoA was not significant as a predictor in any of the experiments in this thesis and thus is not discussed further.

It is surprising that Japanese predictors of word frequency, length and conceptual familiarity were not significant in the task, as these were significant in L2 naming and one would expect L1 naming to exhibit even greater effects of lexical variables. One possible explanation was that in the present study phonological onsets of cognate and noncognate matched word pairs were not matched. When an item's P onset is a fricative (e.g., /ch/, /dj/), it usually takes longer to register the onset by microphone compared to non-fricative onsets (e.g., /m/, /d/). In other words, there may be a delay between the actual onset of speech and the recorded onset of speech, which may affect the results if the number of fricatives is greater in one category of words than another. However, the mean number of fricatives in the Japanese item set was 0.2 for cognates and 0.3 for noncognates, and this difference was not significant (t=-1.242, df = 53.9, p>0.2). Therefore, while it cannot be ruled out, it is unlikely that phonological onset is the reason for the lack of typical lexical effects in the present experiment. Japanese word frequency was also not predictive in previous L1 picture naming with Japanese participants (Nishimoto et al., 2005), which suggests a possible mismatch between production latencies and the corpus data, which is derived from

Japanese newspaper articles (Amano & Kondo, 2002). A Japanese subtitles corpus may prove a useful resource for Japanese language research, such as SUBTLEX (Brysbaert & New, 2009) for English, which is closer to spoken language than newspaper frequencies. Finally, conceptual familiarity has been shown to be a useful predictor of Japanese L1 naming latencies (Nishimoto et al., 2005) and also Japanese-English bilinguals' naming latencies in English L2 (Chapter 5), though it was not predictive in the present study. It is difficult to explain why conceptual familiarity was not predictive, as it was predictive in the L2 task with a similar group of participants.

In conclusion, cognate facilitation was not observed in L1 picture naming, which supports the idea that insufficient activation of L2 lexical representations occurs to influence L1 word production by unbalanced bilinguals. An important finding of this experiment was that participants' proficiency in their L2 significantly influences naming speed in the L1 (p<.01). This appears to show that higher proficiency bilinguals are slower at naming in the L1 than lower proficiency bilinguals. In other words, rather than being influenced by the L2 during the task, higher proficiency bilinguals are in general slower at L1 naming than lower proficiency bilinguals. This could be a result of the more proficient bilinguals using Japanese less than the less proficient ones, and as a result lexical access is slowed in the L1 for those bilinguals that use the L1 less. The fact that L2 proficiency led to slower responses for both cognates and noncognates suggests that this effect was independent of cross-linguistic similarity.

Chapter 7: Making sense of the Sense Model: Translation priming with Japanese-English bilinguals

Abstract

Many studies have reported that L1 translation primes speed responses to L2 targets, but L2 translation primes do not speed responses to L1 targets in lexical decision. The Sense Model (Finkbeiner et al., 2004) states that this asymmetry is due to the proportion of senses activated by the prime. Thus, because L2 primes activate only a subset of the L1 translations senses, priming is not observed. In this research we present a test of this theory by using Japanese-English cognates, which allow us to manipulate the number of senses that words have in each language. Contrary to the predictions of the Sense Model, our results replicate the typical asymmetrical priming effects, suggesting that it is not the total activation of senses that drives the priming effect. Rather the results are more in line theories that postulate slower, and thus ineffective, activation of semantics by L2 primes.

Introduction

A central concern of bilingual research is how the overlap of formal and conceptual/semantic features across languages influences bilingual processing and representation. Formal and semantic overlap has been shown to be influential in bilingual processing and the direction of the effect depends upon both the type of overlap and the task (Dijkstra et al., 1999; Dijkstra et al., 2010). Research using cognates has repeatedly shown that overlap in both form and meaning leads to greater cross-linguistic activation than for noncognates, which share only meaning (see Dijkstra, 2007, for a review). This cognate facilitation effect has been found in multiple studies with languages that share script (e.g., Costa et al., 2005; Duñabeitia et al., 2010; Lemhofer et al., 2008; Van Assche et al., 2009; Van Assche et al., 2011) and those that do not (e.g., Gollan et al., 1997; Kim & Davis, 2002; Hoshino & Kroll, 2008; Voga & Grainger, 2007).

Recently, the masked priming paradigm has been utilized to investigate cross-linguistic processing mechanisms. The masked priming technique utilizes a mask before and/or after the prime in order to conceal the prime from the participant; this leads to unconscious processing of the prime stimuli, which removes the concern of participants applying a conscious strategy to the task. In masked translation priming, participants are presented with a prime (e.g., TOWN) preceded and/or followed by a mask (e.g., ####), then a target, which is the translation of the prime in the other language (e.g., 町 /machi/). One key finding using this technique is that priming often occurs in only one direction i.e., L1-L2 (L1 prime, L2 target), and not at all or is very weak in the other i.e., L2-L1 (L2 prime, L1 target). This finding has been reported for both languages that share script (Duñabeitia et al., 2010; Duyck, 2005; Grainger & Frenck-Mestre, 1998; but see Duyck & Warlop, 2009, and Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009, and Schoonbaert, Holcomb, Grainger, & Hartsuiker, 2011) and those that differ in script (Gollan et al., 1997; Finkbeiner et al., 2004; Jiang, 1999; Jiang & Forster, 2001). This asymmetry appears to reveal some qualitative difference in the processing of L2 primes compared to L1 primes, and this may in turn reveal important information about how the bilingual lexicon is organized. The following paragraphs will briefly review the findings of research that uses masked translation priming with a lexical decision task, and then summarize how current models of bilingual processing and representation attempt to explain these findings.

In masked translation priming, the prime is theorized to activate semantic/conceptual information and this activation facilitates responses to related targets (in the L1-L2 direction at least). However, in cases where cognates are used as primes, the facilitation may be due to activation of formal (orthographic O and/or phonological P) as well as semantic (S)/conceptual information (De Groot & Nas, 1991; Dimitropoulou et al., 2011; Gollan et al., 1997; Voga & Grainger, 2007). In languages that differ in script, such as Japanese and English, overlap of formal features is restricted to P because O is not shared. Thus, different script languages simplify the picture in that only P and S activation need to be considered as possible determining factors causing the translation priming effect.

When languages differ in script, formal similarity across languages (i.e., shared P) plays a role in priming but does not reverse the asymmetry in observed priming patterns. Nakayama et al. (2011) conducted a lexical decision task with Japanese-English bilinguals, in which primes were in the L1 (Japanese) and targets were in the L2 (English). In order to test the role of phonology in cross-script priming, they manipulated the primes using three conditions: for the English targets (e.g., GUIDE), they used cognates, which share both form and meaning with the target, (e.g., ガイド /gaido/ 'guide'), phonologically similar but conceptually different words (e.g., サイド/saido/ 'side'), and unrelated primes, which share neither form nor meaning (e.g., コール /kooru/ 'call'). In their study, they found a significant priming effect for both cognate (94ms) and phonologically related primes (30ms), but not unrelated primes, suggesting cross-linguistic activation of phonological representations regardless of differences in script. Thus, in the L1-L2 direction, form plays an important role in creating cross-linguistic priming. The combination of form and meaning (as in the case of cognates), however, creates a considerably larger effect suggesting a major role of the activation of semantic features as well as formal features. Although Nakayama et al. (2011) did not conduct an L2-L1 experiment, other research suggests that formal influences are limited in this direction.

Further support for the role of P in different-script masked priming in the L1-L2 direction comes from Voga and Grainger (2007) who conducted lexical decision experiments with Greek-French bilinguals. They found, similar to Nakayama et al. (2011), that L2 (French) cognate targets were responded to more quickly than noncognates when primed by L1 (Greek) translations. In addition, Voga and Grainger (2007) found that the degree of phonological overlap of prime-target cognate translations (high vs. low overlap) significantly influenced the responses to targets when compared to noncognates such that targets with high P overlap cognate primes were responded to more quickly than those with low overlap P cognate primes. It is important to note, however, that in Greek and English, there is some overlap in O (e.g., the cognates ‘kilo’ and ‘κιλό’ have three graphemes that are very similar), which makes it difficult to completely disentangle the influence of P and O in their priming effect. In a different experiment, Gollan et al. (1997) conducted a masked priming lexical decision task with Hebrew-English bilinguals. They found a greater priming effect for cognate translation pairs compared to noncognate translation pairs in the L1-L2 direction, suggesting an additive effect of formal similarity to the degree of priming. However, they found no cognate facilitation in the L2-L1 direction, nor any priming effect for L1 targets in general, suggesting that P+S similarity does speed processing in the L2-L1 direction.

The role of semantic activation is well attested in within-language semantic priming studies (Neely, 1991) and has also been found across languages (Schoonbaert et al., 2009). Semantically related primes speed responses to targets. Similarly, translation primes are believed to activate shared conceptual features (via semantic links between lexical representations in both languages and the conceptual features). In what follows we briefly discuss how different models of bilingual representation and processing attempt to explain the asymmetry in priming.

Firstly, the Revised Hierarchical Model (Kroll & Stewart, 1994) proposes weaker links between L2 lexical representations and concepts relative to the links between L1 lexical representations and concepts. This difference in the strength of connections could account for the observed masked priming asymmetry. However, this model also includes, intra-lexical links between lexical representations; these links are stronger in the direction of L2-L1 than in the direction of L1-L2, which would predict a stronger priming effect in the L2-L1 direction (Brsybaert & Duyck, 2010; Wang & Forster, 2010). This prediction is the opposite of the typical reported finding for developing bilinguals. Moreover, the RHM is argued to be a model of production and translation (Kroll et al., 2010), meaning that it is not wholly appropriate to apply it to a discussion of lexical decision findings.

A bilingual model of word recognition, the revised Bilingual Interactive Activation model (BIA+; Dijkstra & Van Heuven, 2002) proposes that the subjective frequency of input determines how quickly activation of formal and conceptual features occurs. Because the L2 is the less frequent source of input, processing of L2 stimuli and cross-linguistic activation resulting from L2 input will be slower than that of the L1: this is known as the "temporal delay hypothesis". Another key feature of the BIA+ is that it assumes non-selective activation of SPO codes, such that L2 primes should activate L2 as well as L1 codes. The temporal delay hypothesis states that this activation will, however, be delayed relative to the activation resulting from L1 input. Thus, the lack of finding of L2 to L1 priming is due to the slower activation of L2 SPO codes.

A third explanation was formulated by Finkbeiner and colleagues, which states that rather than delay in activation, it is the degree of semantic activation *per se* that determines the translation priming asymmetry. This model, the Sense Model (Finkbeiner et al., 2004), assumes bundles of conceptual features to be 'senses'. Translations in both languages will share a number, but necessarily all, of these senses, as shared meaning is the basis of translation equivalency. To achieve priming, complete activation of senses (or activation of a high ratio of senses) in the target language is required. Finkbeiner et al. (2004, p.8) state,

> *what is critical in observing translation priming is the degree to which the complete lexical semantic representation (as opposed to just the features in common between translation equivalents) has been activated by the prime* (2004, p.8).

Because fewer senses will typically be known in an L2 (at least for unbalanced bilinguals), in L1-L2 priming the proportion of the target's senses that are primed should be very high, while for L1 targets this should be very low (2004, p.9). The Sense Model assumes that "*L2-L1* *priming does not occur (or is very weak) because an insufficient number of senses are pre-activated by the L2 prime"* (2004, p.10). In contrast to the BIA+, the Sense Model does not specify any difference in speed of activation of L1 and L2 lexical and semantic representations. Instead, the priming asymmetry is due to differences in the ratios of activated senses in the two directions (L1-L2 / L2-L1).

Japanese-English cognates and the Sense Model

Japanese-English cognates provide a unique opportunity for testing whether asymmetries in sense activation underlie the priming patterns predicted by the Sense Model. Cognates are words that share formal (i.e., orthographic and/or phonological) and semantic similarity across languages (Dijkstra, 2007). Japanese-English cognates share phonological and semantic but not orthographic similarity, and are in fact loanwords, which are borrowed into Japanese. It is important to note that when cognates in Japanese are borrowed from English, they almost always derive their meaning from the English word. Thus, it is rare that a Japanese cognate takes on a different meaning that is not originally derived from English. Moreover, loanwords typically have fewer senses than that of the original language. This is due to a feature of language borrowing termed *semantic narrowing* (Shibatani, 1990), which describes the fact that a Japanese cognate often has only one of the senses of the English word, which fills a very specific lexical gap in Japanese. Consequently, while Japanese cognates derive their sense(s) from English, the English words may potentially have unadopted meanings as well. These unadopted meanings often have corresponding Japanese words to refer to them, but they are not associated with the Japanese cognate word.

Crucially, we can distinguish between two types of Japanese cognates depending on the number of senses that the borrowed word has in English. The first type has complete semantic overlap with its English equivalent; in other words the ratio of shared senses is very high (i.e., 1:1 ratio of shared senses; e.g., バナナ/*banana*/ - *banana*). This is because the English word itself has one sense (or very few senses) and this is borrowed into Japanese. The second type of Japanese cognate has much less semantic overlap with its English equivalent, because the English word has many senses that are not borrowed into Japanese (e.g., コール /*kooru*/ - *call*; see Figure 7.1). In the left-hand panel, コール /kooru/ 'call' as a prime activates a shared subset of senses of *call*, whereas *call* as prime activates both the senses shared with コール (the total senses/conceptual features of the L1 word) and the unshared senses that are specific to the L2 word. In the right-hand panel both バナナ/banana/ and *banana* as primes activate the total number of conceptual features of the target translation, which has one sense (or very few senses, all of which are shared).

In their formulation of the Sense model, Finkbeiner et al. (2004) suggest that a representational asymmetry exists due to the reduced knowledge of L2 senses relative to L1 senses. When considering Japanese-English cognates, the representational asymmetry is in the opposite direction than what is predicted by the Sense Model. As will be established in a norming study, the mapping of senses of Japanese-English cognates can be few-few (or 1:1, Japanese-English), few-many (1:1+, Japanese-English), but *not* many-few (1+:1, Japanese-English). According to the Sense Model, this leads to two predictions, one for each direction of priming. Firstly, in L1-L2 priming, the L1 prime should differentially activate the L2 target according to the proportion of senses activated: Items in the few-few condition should show greater priming than those in the few-many condition, as the ratio of activated senses is higher in the first case. Secondly, in L2-L1 priming, English primes should activate the full range of senses associated with the Japanese translations. Thus, according to the Sense Model, L2 primes should speed responses to ALL targets in the L1. Additionally, because the Sense Model assumes that a higher ratio of shared senses leads to increased priming effects, responses in the few-few condition should be faster than in the many-few condition.

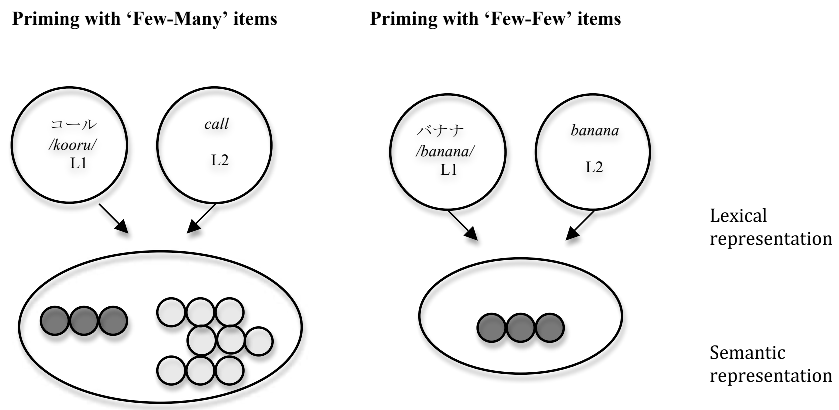

Figure 7.1: Visual representation of semantic activation in masked priming lexical decision. Dark circles represent conceptual features that are shared across languages; light circles represent conceptual features that are only associated with the English word; circles are grouped to represent the 'sense bundles' as specified in the Sense Model.

Role of phonology

It is important to note that many previous studies on translation priming, have been careful to avoid the inclusion of cognate words as stimuli when comparing L2-L1 and L1-L2 priming (e.g., Finkbeiner et al., 2004; Hoshino et al., 2010). By excluding cognates, any priming could be attributed to S overlap *only* between translation equivalents. The problem with this is that, while noncognate translation equivalents activate similar semantics, there may be competition at the O and P level. In studies of L2-L1 priming, where effects might be small, such competition may make priming difficult to find. Thus, the desire to prevent O and P overlap from contaminating S priming effects may have yielded competition at the O and P, which may in fact have hidden S priming. Fortunately, the more recent use of mixed-effects modelling allows for analyses to determine which factors contribute to any priming effect. In the present study all of the experimental items are cognates and a measure of P similarity, established in a norming phase, is used to assess whether the degree of P similarity modulates priming. Crucially, the use of cognates provides the greatest possibility of finding elusive L2-L1 priming. The use of cognates should maximize the degree of cross-linguistic activation, which may reveal an influence of the L2 on the L1.

Overview of experiment design and hypotheses

The present study uses masked translation priming with a lexical decision task. Participants are Japanese-English bilinguals with intermediate or above reading proficiency in English. Given that previous studies using this paradigm have not observed L2-L1 priming, but have observed L1-L2 priming, a similar pattern of priming may be expected. However, the target items used in lexical decision are all cognates, which may influence the degree of overall L2 activation, thereby maximizing the possibility that L2-L1 priming effects can be observed. Crucially, the amount of P similarity is an important factor in the current study. It is predicted that as P similarity of prime-target cognate translation pairs increases, priming will be greater. Importantly, the more ephemeral priming in the L2-L1 condition may only be observed when there is a high degree of P overlap in Japanese-English.

The present research also seeks to test two predictions that are based on the Sense Model's explanation of cross-linguistic activation of senses, which are presumed to underpin the asymmetry in masked translation priming with lexical decision: Specifically, in the L1-L2 direction prime-targets that share all (or most) of their senses (i.e., few-few items) should have a greater priming effect than prime-targets that share fewer of their senses (i.e., many-few items); secondly, in the L2-L1 direction, there should be a priming effect for both few-few and many-few prime-target pairs.

Norming studies

In order to test the predictions of the Sense Model and to determine what if any priming is attributable to S (and P) similarity, it is important to assess the cross-linguistic similarity of translations. Cross-linguistic S similarity can be measured in a number of ways. Tokowicz et al. (2002) used translation tasks and S similarity ratings to assess the degree of S overlap of Dutch-English translation equivalents. In their study, they asked participants for the primary translation of a word. The degree of S overlap is assumed from the translations given by participants. If participants consistently give the same translation for each word and in each translation direction (L1 to L2 and L2 to L1), then the two words have considerable S overlap. However, if across participants various translations are given, it is assumed that there is some divergence in the amount of S overlap of the items. This divergence can be in both directions or only in one direction.

In the present study, 21 Japanese-English bilinguals (Mean L2 proficiency=4.6 on a scale of 1-10 with 0=no proficiency and 10=native speaker-level proficiency; *SD*=1.2) translated cognate words into English or Japanese. Participants were asked to think of the first translation that comes to mind for each item and to enter that word in the space provided (see Chapter 4). In the direction of L1-L2 (translating L1 cognates into L2), there was a single primary English translation (*M*=1.0, *SD*=0) whereas in the L2-L1 direction there was a wider range of responses. Consequently, the items were separated into two groups based on the number of translations given in the L2-L1 direction. One group of words was translated with the same translation each time (*M*=1.0, *SD*=0) and was defined as the 'few-few' group, that is, they had few translations in either direction (i.e., a ratio of 1:1). The other group was translated using more than one L1 word (*M*=3.0, *SD*=1.0), that is, they had more than one Japanese translation in the L2-L1 but only one English translation in the L2-L1 direction. Note that in the L1-L2 direction, while the 'few-few' group still has the same ratio (i.e., 1:1), the second group becomes 'few-many', in other words, the ratio is reversed (i.e., 1:1+). These groups form a categorical variable in the present study labeled *number of senses (NoS)*.[36]

[36] We also considered a measure of S similarity as utilized in Tokowicz et al. (2002) and Chapter 4. However, our measures of NoS and S similarity were highly correlated (r^2=.72, p<.001) and are essentially measuring the same construct, though the latter is continuous and thus potentially more explanatory. We conducted separate analyses with

Finally, though 'expert' definitions of number of senses are often problematic in terms of measuring speakers' actual word knowledge (Gernsbacher, 1984), the number of senses for the Japanese-English cognates was compared using Japanese (Meikyo Japanese dictionary, 2008 edition) and English (WordNet, Princeton University, 2010) sources. The English number of senses for the few-few category was 4.0 (*SD*=3.0) and that for the many-few category was 11.8 (*SD*=6.7), which shows that the many-few items had three times more senses than the few-few items according to WordNet database, and this difference was significant ($p<.001$). The Japanese source revealed that items in the few-few category had a mean of 1.3 senses (SD=0.5) and that for the many-few was 2.6 (*SD*=1.6), a difference which was significant ($p<.001$). Thus, while Japanese cognates have very few senses overall, there is a difference in the number of senses with the many-few items having twice as many senses in Japanese as the few-few items. Crucially, the senses given in the Japanese source are all similar to those of the English translation, which means the Japanese translations' senses should all be activated by the English translation. On the other hand, Japanese translations should activate all of the English senses for few-few items but only a subset of the English translations' senses for few-many items due to the smaller number of senses assumed by the Japanese cognate.

P similarity

Because the orthography in Japanese and English is different, cognates only overlap in S and P. Thus in addition to establishing S overlap in the two languages, P similarity was assessed in a rating study, which was reported in Chapter 4. Japanese-English bilinguals rated word pairs (e.g., *television*-テレビ/terebi/) on a scale of 1 to 5 (1=completely different, 5=identical) for P similarity. The mean P similarity ratings for cognate items used in the present study was 3.4 (*SD*=0.4).

S similarity in place of NoS but the overall pattern of findings was identical; thus we only discuss NoS in the paper.

Method

Participants

Forty volunteers participated in the study but two were removed: one participant did not have Japanese as a first language and English as a second language, and one volunteer was removed for being much more proficient in English than the remainder of the participants (±2 SDs from the mean). Therefore, data from 38 participants is presented. All participants completed informed consent forms prior to the experiment. All participants were undergraduate students (34 males; *M* age=19y, ±0.6yrs) recruited from the University of Tokyo and received 500 yen (roughly 4 GBP) for participating. All but four participants responded that they were born and have only lived in Japan, spoke Japanese at home and that their whole education (from elementary to university level) was conducted in Japanese. The four that did not fit completely with the above category rated themselves at native speaker level in Japanese in all four skills (listening, reading, writing, speaking; *M*=9.75, *SD*=0.5). Thus, all participants were considered native speakers of Japanese. Most participants began learning English between 11-15 years of age (*n*=24) with some beginning earlier (6-10 years: *n*=11; 1-5years: *n*=3). Mean L2 (English) proficiency was 5.1 (*SD*=1.3), calculated by averaging individual ratings for mean self-rated speaking (*M*=3.3, *SD*=1.4), reading (*M*=6.9, *SD*=1.1), writing (5.3, *SD*=1.4) and listening (*M*=4.9, *SD*=1.5) proficiencies. Because lexical decision is a word recognition task, the reading proficiency measure may be a more relevant measure of proficiency than a composite proficiency that includes spoken, aural and written proficiency as well. To test this idea both proficiency measures were included as potential measures in the mixed-effects models, and the one that accounted for the most variance was used in the final models.

Materials

Sixty items were selected as the experimental stimuli for the lexical decision task. All items were cognates in English and Japanese. These included 30 items classed as having few senses in both English and Japanese languages (‘Few-Few’) and 30 items classed as having many senses in English but few senses in Japanese (‘Many-Few’). These groups were matched as closely as possible on lexical characteristics: Japanese word frequency (Amano & Kondo, 2000); English word frequency (British National Corpus including both the spoken and written components; BNC, 2007); Japanese word length; and English Orthographic Neighbourhood Size (taken from the Elexicon Project, Balota et al., 2007; p's<.1). Items differed marginally in terms of English word length, such that few-few items were slightly longer on average (p<.06). This is not considered an issue as length is also accounted for in the mixed-effects modelling process.

In addition, 60 nonwords matched on word length were selected for each task. The nonwords for the English task were taken from the Elexicon project (Balota et al., 2007) and the nonwords for the Japanese task were created by changing one mora within an existing katakana word. Each experimental item was preceded by a prime in the other language that was either a translation equivalent (e.g., ラジオ /rajio/ ‘radio’ – radio) or an unrelated word (e.g., coffee – タスク/tasuku/ ‘task’). Primes were matched on length and frequency in L1 and L2 across translation and unrelated pairs (p's<.1). Nonwords, like words, were preceded by word primes in the other language. The full list of stimuli is presented in Appendix 7.1.

Procedure

The task was divided into two parts that were fixed in order: an English L2-L1 lexical decision task, followed by a Japanese L2-L1 lexical decision task. Because the L2 English task is first, this might boost the global activation of L2 words such that they serve as effective primes in the L1 Japanese task (Elston-Güttler, Gunter, & Kotz, 2005).

The language used in the on-screen instructions for the first part of the task and in oral communication with the experimenter prior to the experiment was English; Japanese on-screen instructions preceded the second part of the task.

All 60 experimental items were presented in both the English and Japanese tasks. However, the target was seen in different conditions in the two tasks. For example, if *radio* was preceded by its translation in the L2 task, then ラジオ /rajio/ 'radio' was preceded by an unrelated prime (e.g., *coffee*) in the L1 task. Two counter-balanced lists were created such that an equal number of participants saw targets in the translation and unrelated conditions in each language. Ten practice items preceded each task and were followed by feedback ('correct' or 'incorrect') and the response latency; items in the main task were not followed by any feedback.

Stimuli were presented in lower case (Arial, size 14). The presentation of primes and stimuli was similar to Finkbeiner et al. (2004). A forward mask was presented for 500ms followed by the prime for 50ms, then a backward mask that differed in size and font to the forward mask was presented for 150ms, and finally the target item appeared on the screen until a response was made or after 3000ms. The forward and backward masks were made in a similar fashion to those used in Hoshino et al. (2010), that is, mosaics of roman letters and katakana letters were created by overlapping strings of characters from these scripts. This proved to be effective in masking the prime, as participants reported not being able to see a word when prompted at the end of the task.

Participants were tested in a quiet room. Participants were seated in front of a computer (Dell, English OS) and responses were made via a keyboard press. The experiment was run using DMDX (Forster & Forster, 2003). Subjects sat around 40-50cm away from the screen with eyes level with the centre of the screen. Participants were asked whether they were right or left handed (of the 38 volunteers tested, only two were left-handed); "Yes" responses were always made with preferred hand. Participants were told to make word/nonwords responses; they were urged to respond as quickly and accurately as possible. Response times and accuracy were recorded automatically via keyboard presses. Following the experiment, subjects completed a short survey detailing their language proficiency.

Results

The overall error rate for nonwords was 9.8% (8.4% in the English (L1-L2) task and 1.4% in the Japanese (L2-L1) task). The overall mean RT for nonwords was 766ms (*SD*=375ms). The mean RT for nonwords in the English task was 991ms (*SD*=376ms) and that for the Japanese task was 578ms (*SD*=251ms). The nonwords were removed form the analysis.

Errors

The number of inaccurate responses made up 7.7% of the total responses for word items across both English and Japanese tasks. Table 7.1 shows the Mean number of errors for each language task, translation and unrelated prime conditions, and number of sense categories for prime-targets.

Table 7.1: Errors in L1-L2 (English target) and L2-L1 (Japanese target) masked priming tasks*

	English Target			Japanese Target		
No. of Senses (Prime-Target)	Prime: Related	Prime: Unrelated	Overall	Prime: Related	Prime: Unrelated	Overall
Few-Many / Many-Few	0.04 (0.20)	0.05 (0.22)	0.05 (0.21)	0.08 (0.28)	0.09 (0.28)	0.09 (0.28)
Few-Few	0.18 (0.39)	0.14 (0.34)	0.16 (0.37)	0.03 (0.17)	0.01 (0.08)	0.02 (0.13
Overall	0.11 (0.32)	0.09 (0.29)	0.10 (0.3)	0.06 (0.23)	0.05 (0.21)	0.05 (0.2)

*Mean errors are shown with standard deviations in brackets

To assess whether the errors were more likely to occur in any particular condition, mixed-effects modeling (Baayen et al., 2008) was used. All analyses were conducted with R version 2.11.1 (R Core Development Team, 2010) and the R packages MASS, lme4, lattice and Design. The procedure for using mixed-effects models with accuracy data is the same as using them with latency data except that the probability distribution is binomial. Three primary contrasts were investigated: language (Japanese-English and English-Japanese), prime type (translation-unrelated), number of senses (few-few or many-few/few-many). These were added into a mixed-effects model as fixed effects, with subjects and items as random effects and response accuracy as a binary response variable. The following model (Table 7.2) reveals that significantly fewer errors were made in Japanese lexical decision as opposed to English lexical decision (p <.001), as was expected due to the language abilities of the participants. Prime condition (translation-unrelated) was not significant, indicating that primes did not lead to improved accuracy in the task overall. Importantly, there was no significant interaction between language and prime type conditions, demonstrating no effect of prime regardless of the language direction. There were overall fewer errors made for items in the many-few category (M=0.07, SD=0.25) than in the few-few category of items (M=0.09, SD=0.29; p <.01). The interaction between language and number of senses category was also significant indicating that there were more errors made to English targets in the few-few category (M=0.16, SD=0.37) than in the many-few category (M=0.05, SD=0.21; p <.001;

however, Japanese targets in the few-few category (*M*=0.02, *SD*=0.13) were responded to more accurately than those in the many-few category (*M*=0.09, *SD*=0.28; *p* <.01). Interactions between priming condition and number of senses, as well as the three-way interaction, were not significant (*p*>.5). Taken together, while the number of senses does impact performance accuracy, this is independent of prime type.

Table 7.2: Response accuracy in lexical decision for words across both English and Japanese tasks*

Fixed Effects				
	Estimate	Std. Error	*Z*-value	Pr(>|z|)
(Intercept)	-2.240	0.398	-5.623	0.000
Language direction (Japanese)	-2.158	0.622	-3.467	0.001
Prime (Unrelated)	-0.484	0.560	-0.866	0.387
Number of senses (Many-Few)	-2.120	0.665	-3.188	0.001
Language direction (Japanese): Prime (Unrelated)	-1.075	1.078	-0.998	0.318
Language direction (Japanese): Number of senses (Many-Few)	2.686	0.940	2.858	0.004
Prime (Unrelated): Number of senses (Many-Few)	0.595	0.916	0.649	0.516
Language direction (Japanese): Prime (Unrelated): Number of senses (Many-Few)	0.948	1.446	0.656	0.512

* The first column gives the predictor name or interaction term. The second column gives the estimate of the effect sizes; for factors (e.g., prime) this represents the adjustment from the intercept for the factor level relative to the reference level, and for continuous predictors this represents the slope. The remaining columns give the standard error, z-value and p-value based.

Latencies

Incorrect responses were removed for the latency analysis. Items that were responded to with an error rate of over 30% were removed from both translation and unrelated conditions within the language that the error was made; for example, if *ball-booru* was responded to with an error rate of over 30% in the Japanese lexical decision task, then *fan-booru* was also removed from the Japanese task. The aim here was to keep the design balanced in terms of the main contrast of prime status (i.e., the translation-unrelated condition). This led to 9 items in each prime condition being removed from the whole experiment (total 18 items, 495 responses; 10.9% of data). Finally, responses that were less than 300ms or greater than 3000ms, and ±2.5 standard deviations from the mean were identified as outliers and removed (2.2% of total data; 102 responses). The total of amount of errors and outliers removed was 13.1% (596 responses).

Initial statistical comparisons across tasks and regarding prime type and number of senses were made using *t*-tests, and further analyses are shown in the following section using linear mixed effects models that include a range of predictors. Responses to Japanese targets were significantly faster (*M*=536ms, *SD*=100ms) compared to responses for English targets (*M*=726ms, *SD*=149ms; *t*=46.07, df=3112.7, *p*<.001). In the L1-L2 priming direction, responses to targets preceded by related primes (*M*=713ms, *SD*=148ms) were significantly faster than those to targets preceded by unrelated primes (*M*=739ms, *SD*=148ms; *t*=-3.74, df=1815.23, *p*<.001), revealing a significant priming effect of 26ms for L1 primes. In the L2-L1 priming direction, responses to targets preceded by related primes (*M*=536ms, *SD*=104ms) were not significantly different than those to targets preceded by unrelated primes (*M*=537ms, *SD*=98ms; *t*=-0.11, df=2132.78, *p*>.9), revealing no effect of L2 primes. In the L1-L2 direction, comparisons of RTs for related and unrelated prime-target items according to their number of senses (few-few vs. few-many) revealed that the priming effect for few-few items (21ms) was almost significant (*t*=-1.82, df=799.23, *p*<.0.07), while that for few-many items (30ms) was highly significant (*t*=-3.50, df=1013.16, *p*<.0.001). These results are contrary to the predictions of the Sense Model: L1 primes that share greater overlap with L2 targets (i.e., few-few) should have a stronger priming effect than L1 primes that share less overlap with L2 targets (i.e., few-many). Comparisons for RTs in the L2-L1 direction revealed no difference in the priming effect for few-few and many-few items (4ms and -3ms, respectively; *p*'s>.5). Again, these results are contrary to the predictions of the Sense Model, which predicts that because L2 primes share all of the senses of L1 targets, a priming effect should be observed for both few-few and few-many items. In fact, regardless of the number of shared senses, no effect of L2 primes was observed.

The lexical decision tasks in the two languages were then analyzed separately. The main predictors of interest are the categorical factors prime type (translation-unrelated) and number of senses (few-few, many-few/few-many). An interaction term was also included for two these predictors, as it is specified in the hypotheses of the study. Mean P similarity was also included as a cross-linguistic predictor and an interaction between this and prime type was included as it was predicted that increased P similarity may increase the likelihood of priming, particularly in the L2-L1 task. The following additional lexical predictors were also considered: English log-transformed word frequency (BNC, 2007); Japanese log-transformed word frequency (Amano & Kondo, 2002); and word length (length refers to the number of letters per word in the English task and the number of mora per word in the Japanese). Finally, mean self-rated L2 reading proficiency was included to control for variation in participants' proficiency.[37] The response latencies and measures of English and Japanese word Frequency were log-transformed to increase normality and minimize random variance. The package 'LMER Convenience Functions' (Tremblay, 2012) was used to back-fit fixed effects using *F*-values and with conservative, lower bound *p*-values as the decision criterion for removing (or preserving) main effects and interactions.

L1-L2 masked translation priming lexical decision

A correlation analysis was performed for item predictors to ascertain which were significantly correlated. When two or more predictor variables were significantly correlated, this collinearity was removed by

[37] Mean self-rated L2 proficiency, which was calculated as a composite mean of four individually rated language skills (speaking, listening, reading and writing), was used as the initial proficiency measure but Mean self-rated L2 reading proficiency outperformed in every case as shown by ANOVA to compare models with the two predictors. Thus, Mean self-rated L2 reading proficiency was used as the primary predictor for L2 proficiency effects. Mean self-rated speaking proficiency was also considered, as this theoretically may impact more on learners abilities to perceive P similarity, but this measure was also poor in comparison to the reading proficiency measure.

fitting a linear model in which one variable predicted the other correlated variables. The residuals of these models were used as predictor variables in the final analyses. The resulting residuals were significantly correlated with their related variables ($p<.01$): log English Frequency ($r=.62$), log Japanese frequency ($r=.87$), English word length ($r=.90$), P similarity ($r=.98$) and number of senses ($r=.72$). The coefficients of the fixed effects, their Higher posterior Density (HPD) intervals, *p*-values based on 10,000 Markov Chain Monte Carlo samples of the posterior samples of the parameters of the final models and the *p* values obtained from *t*-tests are presented for each statistical model. The final model for the L1-L2 masked priming lexical decision task is presented in Table 7.3. By-subjects and by-items random slopes for significant predictors were added to the final model and ANOVAs were conducted to compare the model with and without these random slopes; however, no significant improvements were made to the final model, which is presented below.

Table 7.3: Final model for latencies in L1-L2 masked priming (Japanese primes, English targets)

Fixed Effects	Estimate	MCMC mean	HPD95 lower	HPD95 upper	pMCMC	Pr(>|t|)
(Intercept)	6.555	6.555	6.521	6.587	0.000	0.000
Prime (Unrelated)	0.040	0.040	0.012	0.068	0.004	0.010
Previous RT	0.013	0.013	0.003	0.022	0.010	0.012
Log-transformed English word frequency	-0.071	-0.071	-0.092	-0.049	0.000	0.000
Word Length	0.037	0.036	0.020	0.052	0.000	0.000
Number of senses	-0.131	-0.129	-0.183	-0.078	0.000	0.000

Random Effects		Std. Dev.	MCMC median	MCMC mean	HPD95 lower	HPD95 upper
Items	(Intercept)	0.070	0.060	0.060	0.050	0.071
Participants	(Intercept)	0.102	0.085	0.086	0.070	0.104
Residual		0.154	0.156	0.156	0.150	0.161

Prime type was highly significant ($p<.001$) showing that items preceded by unrelated L1 primes were responded to more slowly than items preceded by L1 translation primes. This is expected as L1 primes have been shown to create priming effects in cross-linguistic tasks with Japanese-English bilinguals (Hoshino et al., 2010; Nakayama et al., 2011). Also, the number of senses factor was highly significant (*p*<.001) such that items that had fewer shared senses (few-many; *M*=691ms) were responded to faster than items with more shared senses (few-few; *M*=741ms; *p*<.001). However, the interaction between prime and number of senses was not significant (*p*>.2), indicating that once other factors such as frequency were accounted for in the model (unlike in simple *t*-tests), there was no significant difference in the priming effect depending on whether prime-target pairs were few-few or few-many. In other words, the number of senses that a target word has in English is predictive of response times and this is independent of prime type.[38] More specifically, it appears that words with more senses in the target language are responded to faster in lexical decision because of greater semantic activation (Hino & Lupker, 1996; Hino et al., 2002) or because they are easier to make a decision for, not because the prime activates a greater or lesser proportion of these senses (this point is taken up further in the Discussion). This finding does not support the hypothesis of the Sense Model, which proposes that when the full range of senses of the translation equivalent are activated by the prime, the target response is speeded. In the present experiment, if this hypothesis were true, we would expect the few-few condition to be responded to faster because the Japanese prime, which has only one or very few senses, should activate a greater proportion of the senses of English targets that also have fewer senses and these are shared with Japanese.

P similarity ratings were not significant (p>.1) at predicting responses and neither was the interaction between P similarity and prime type. This may be because in comparison to other studies in which both noncognates and cognates were used (e.g., Chapter 5), all of the items

[38] Because L1 translation equivalents also had a greater number of senses in the few-many condition (in comparison to those in the few-few condition), we cannot rule out the possibility that this is the source of cross-linguistic activation, which drives the number of senses advantage observed for L2 targets. However, the lack of any advantage in the priming effect for few-many items suggests that this is unlikely.

were cognates, and thus P similarity varied only within the upper end of the scale (i.e., mainly between 'very similar' and 'similar'). English log-transformed word frequency was highly significant (p<.001) with higher frequency items being processed more quickly than low frequency items. Conversely, Japanese log-transformed word frequency was not significant (p>.5). L2 word length was also significant showing that longer words took longer to respond to (p<.01). As expected, there was also a significant task effect of previous RT (p<.05), indicating that response times are affected by the previous trial (Baayen et al., 2008).

L2-L1 masked translation priming Japanese lexical decision

The same procedures for analysis described above were used for the L2-L1 masked priming lexical decision task. Firstly, collinearity was removed for the five word-related predictors considered in the mixed-effects modelling (number of senses, P similarity, English log-transformed word frequency, Japanese log-transformed word frequency, Japanese word length). The resulting residuals were significantly correlated with their related variables (p<.01): number of senses (r=.69); P similarity (r=.99); English log-transformed word frequency (r=.57), Japanese log-transformed word frequency (r=.83), and Japanese word length (r=.85). Table 7.4 shows the final model for Japanese lexical decision with English masked primes. By-subjects and by-items random slopes for significant predictors were added to the final model and ANOVA was used to compare the model with and without these random slopes; however, no significant improvements were made to the final model, which is presented below.

Table 7.4: Final model for latencies in L2-L1 masked priming (English primes, Japanese targets)

Fixed Effects

	Estimate	MCMC mean	HPD95 lower	HPD95 upper	pMCMC	Pr(>|t|)
(Intercept)	6.269	6.268	6.241	6.296	0.000	0.000
Previous RT	0.014	0.014	0.006	0.021	0.000	0.001
Log-transformed Japanese word frequency	-0.016	-0.016	-0.024	-0.007	0.000	0.000
Number of senses	0.063	0.063	0.034	0.090	0.000	0.000

Random Effects

		Std. Dev.	MCMC median	MCMC mean	HPD95 lower	HPD95 upper
Items	(Intercept)	0.046	0.041	0.041	0.034	0.049
Participants	(Intercept)	0.101	0.081	0.082	0.067	0.097
Residual		0.134	0.135	0.135	0.131	0.139

There was no effect of prime type on response time (p>.9), with mean responses following translation primes and unrelated primes being almost identical (536ms and 537ms, respectively). This finding confirms the well-known asymmetry in translation priming between the L1 and L2 tasks. In terms of the Sense Model, the prediction that a greater number of overlapping senses (total activated senses) should lead to priming is not supported by these results. All targets had few senses, which should have been activated by the L2 prime as they are shared across languages. More specifically, because an English translation maps on to the sense of the Japanese word, translation primes should speed processing relative to unrelated primes. As no priming effect was observed for translations, the results do not support the prediction of the Sense Model.

The number of senses categorical variable was highly significant (p<.001), indicating that for items that had a higher ratio of shared senses (i.e., few-few) responses were speeded relative to those for items that had a lower ratio of shared senses (i.e., many-few). The interaction between prime type and number of senses was not significant (p>.2), however, demonstrating that the differences in the RTs for few-few and few-many items were independent of prime type and thus due to the semantic characteristics of the target stimuli. Interestingly, the effect of number of senses in the L2-L1 task is the contrary of that in the L1-L2 priming task. In the L1-L2 task, it appeared that having more senses facilitated processing of targets In the L2-L1 task, on the other hand, having fewer senses appears to speed processing. This result is somewhat surprising as all L1 Japanese targets had few senses, therefore any effect of the number of senses of targets should be minimal. This issue is returned to in the Discussion.

P similarity ratings were not significant ($p>.1$) at predicting responses, and the interaction between this and prime type was also not significant ($p>.1$), as in the L1-L2 task. L2 proficiency was also not significant as a predictor in the final model. Japanese word frequency was a significant predictor of response times, such that responses were faster for higher frequency items ($p<.01$). Conversely, English word frequency was not significant as a main effect. The task variable previous RT was highly significant, as expected ($p<.001$).

Discussion

In the present research, bi-directional lexical decision tasks with masked translation primes revealed that L1 (Japanese) is clearly faster overall than L2 (English; $p<.001$). This is unsurprising as participants were highly L1 dominant and replicates previous findings in lexical decision.

An important question in this paper is whether masked cognate translation primes speed lexical decision times in an L2 and more importantly in an L1. Thus, the first main predictor considered in the mixed-effects models was prime type (translation/unrelated). In the L1-L2 task, Japanese translations (related prime) significantly speeded responses to English targets, revealing similar findings to previous studies (Finkbeiner et al., 2004; Nakayama et al., 2010). This provides further evidence that significant cross-linguistic priming can occur for languages that differ in script. The priming effect was found for all items regardless of whether item pairs had few-few or few-many senses (-30ms and -21ms). In contrast, in the L2-L1 task, related L2 English primes, whether they have many or few senses, provide no apparent benefit in processing L1 targets (+3ms and -4ms). This is in line with the often observed priming asymmetry, that is, only L1 primes lead to a priming effect. Although these findings are in line with previous research, the present study attempted to maximize the possibility of observing L2-L1 priming effects by including only cognates, repeating items across tasks (L2 targets in the first task were also L2 primes in the second task), and by performing the L2 task first. This experimental design was unsuccessful at achieving L2-L1 priming, suggesting that the asymmetry is robust to global context effects (i.e., boosting of one language) as has been shown in previous research (Elston-Guttler et al., 2005). To test whether there was any influence of global context effects on the earlier part of the Japanese task, the first half of the Japanese data (i.e., the first 60 trials for each subject) was used for a mixed effects model with log-transformed RTs as response and prime type as the predictor variable. However, the influence of a translation prime remained non-significant at this early part of the experiment ($p<.1$), indicating that the English part of the task did not boost the level of activation of the L2 such that masked English primes could speed responses to Japanese targets.

The Sense Model

The primary aim of this research was to investigate whether the Sense Model's predictions could be applied to Japanese-English cognates. The Sense Model holds that activating a complete translation creates the priming effect. Thus, in the L1-L2 direction, few-few items should have a greater priming effect because the L1 prime should activate all of the senses of the L2 target, whereas the same would not occur for L2 targets which have many senses that are not shared with the prime. Our results demonstrated that number of senses did not interact with prime type and that the priming effect was not different for targets that had few or many senses. In the L2-L1 task, all L1 targets had few senses and all of these are shared with the L2 prime, which would predict complete activation of L1 targets by L2 primes. However, in the present experiment no priming effect was observed for either many-few or few-few items in the L2-L1 direction. Thus, activating the total number of senses (complete translation) does not appear to be the key to determining the priming asymmetry (i.e., lack of L2 priming of L1 targets) and therefore the Sense Model appears unable to account for the current findings.

Alternative explanations for priming asymmetries

While there appear to be problems with the Sense Model's account of semantic overlap in masked translation priming, it should be emphasized that overlapping conceptual features are still likely to be critical for most forms of priming to occur in the L2-L1 direction. Schoonbaert et al. (2009) offer convincing evidence that this is the case. In their study, they observed significant priming effects for noncognates in both L1-L2 and L2-L1 directions in two tasks, masked translation priming with lexical decision (we return specifically to this later) and masked semantic priming with lexical decision, with Dutch-English bilinguals. While priming was observed in both tasks, the priming effect was smaller in semantic priming than in translation priming. Schoonbaert et al. (2009) argued that the difference between tasks arose due to translation prime-targets sharing more conceptual features than semantically related prime-targets (also see De Groot & Nas, 1991; Perea et al., 2008). While these findings highlight the importance of overlapping S features, the argument that the degree of S overlap between L2 and L1 translations is the only requirement for L2-L1 priming (i.e., Finkbeiner et al., 2004) does not appear valid as our manipulation showed.

Alternative explanations implicate the strength of *lexical-conceptual* connections in the process of S activation (De Groot, 1993; Kroll & Stewart, 1994). In this approach, L2 primes may not activate shared conceptual features due to weak lexical-conceptual connections (or do not activate them sufficiently), while strong L1 lexical-conceptual connections could be the basis for L1-L2 priming (De Groot, 1993; Kroll & Stewart, 1994). However, such views need to specify more precisely the lexical-conceptual links that underpin empirical findings. Thus, are connections weighted less, which could mean that the information does not reach a necessary threshold, or is the representation activated more slowly? Importantly, research suggests that L2 words do activate conceptual features directly, and the lexical-conceptual links in the L2 are stronger than previously thought (Brysbaert & Duyck, 2010), which would appear to rule out a strong version of this argument (i.e., that there are no lexical conceptual links for L2 words).

Another type of account holds that cognates share lexical representations (e.g., Sanchez-Casas et al., 1992; also see De Groot & Nas, 1991; Gollan et al., 1997) or bi-directional *lexical-lexical links* between translations (Kroll & Stewart, 1994).[39] However, these theories also cannot explain the priming asymmetry as they predict equal or greater priming in the direction of L2-L1 relative to L1-L2 (Brysbaert & Duyck, 2010; Wang & Forster, 2010).

Another critical aspect relating to observed L2-L1 priming is the degree of formal overlap in addition to S overlap. The formal and S overlap of cognates (+P+O+S) has previously been shown to be an important determinant of L2-L1 translation priming in same-script languages. When O and P similarity exist, as in same-script languages, L2-L1 cognate priming has been observed while noncognate priming has not or is limited (De Groot & Nas, 1991; Sanchez-Casas et al., 1992; but see Schoonbaert et al., 2009, 2011, for contrary results for noncognates). The advantage conferred initially by O overlap between primes-targets may lead to greater overall cross-linguistic activation of O sublexical and lexical representations in both L1 and L2 due to feedback between the respective O codes. Consequently, this would lead to increased overall P and S activation relative to noncognates.

In contrast, in studies with different-script language cognates (such as Japanese-English in the present study and Hebrew-English in

[39] Kroll and Stewart's (1994) Revised Hierarchical Model (RHM) posits both lexical-conceptual links for L1 and L2 and lexical-lexical links between the L1 and L2 lexical representations. These two accounts of activation between L1 and L2 lexical representations and conceptual representations have been posited to account for a wide range of aspects of bilingual representation and processing. However, as they are both limited in their explanations of the priming asymmetry they are not dealt with in detail in the present discussion.

Gollan et al., 1997), L2-L1 priming has not been observed. In other words, when languages share script, the formal overlap of cognates (+O+P) facilitates masked priming in the L2-L1 direction but this is not the case when languages do not share script (-O+P). Theoretical models such as the BIA+ assume that when there is no shared O, L1 O cannot be activated via L2 O (Dijkstra & Van Heuven, 2002). Thus, there should be no cross-linguistic activation between O codes. This would lead to less overall activation of L1 SOP codes compared to the same task with same-script bilinguals. In other words, cross-linguistic activation is greatly reduced due to the absence of O (i.e., a shared-script). In sum, based on the available evidence script differences appear to be critical for cognate facilitation in L2-L1 priming.

Although cognate facilitation in L2-L1 has been observed in same-script languages (De Groot & Nas, 1991; Sanchez-Casas et al., 1992), it is much rarer to see noncognate priming in the same direction. Recent evidence does, however, suggest that formal overlap is not essential for L2-L1 priming to occur when languages share script (Schoonbaert et al., 2009, 2011). Schoonbaert et al. (2009) reported L2-L1 masked priming in lexical decision with Dutch-English and Schoonbaert et al. (2011) reported a similar finding with English-French bilinguals. In these studies, noncognates were used to minimize the role of formal overlap between prime-target translations. While priming effects were stronger in the L1-L2 direction, significant facilitation was reported in the L2-L1 direction. This rare observation of L2-L1 masked priming in an unbalanced bilingual population could be due to two factors.

Firstly, Schoonbaert et al. (2009, 2011) argued that the significant priming effect in the L2-L1 direction was due to the presentation of primes for 100ms, which allowed greater processing time of the L2 prime. They suggested that L2-L1 priming requires more processing time at the prime presentation stage. If this explanation is correct, the asymmetry reported in previous research is due to the short prime presentation duration. In terms of theoretical models such as the BIA+, L2 processing is delayed relative to L1 processing due to the relative differences in subjective frequency of use of the two languages (Dijkstra & Van Heuven, 2002). Thus, the explanation of needing increased processing time is appropriate if one assumes that this leads to greater overall activation between L2 lexical representations and conceptual information based on reciprocal activation between these elements of the bilingual processing system. Longer durations for L2 masked primes in lexical decision tasks with languages that share script, and more importantly with languages that do not share script, should be evaluated in terms of the resulting priming effects. In this case, a necessary additional question is whether participants are aware of the primes: the issue with increasing prime duration is that participants may become aware of the prime and adopt a translation strategy that would make it impossible to draw conclusions on the underlying architecture of the lexicon.

This account is particularly interesting if we look at languages that differ in script. In most accounts of word recognition, P processing is thought to occur at a later stage in visual word recognition than O processing. The time required to activate L1 P from an L2 prime in a different script should be longer than the processing time required to activate L1 O via an L2 prime that shares script. In line with the temporal delay hypothesis (Dijkstra & Van Heuven, 2002), this would lead to slower spreading cross-linguistic activation from L2 P. Moreover, for cognates, while O can be shared completely (as in *metro-metro* in Dutch-English) in same script languages, P is rarely identical across languages (regardless of script). This may further reduce the cross-linguistic effects of P similarity relative to those of O in shared script languages.

The second important factor in Schoonbaert et al.'s studies (2009, 2011) is that O processing of Dutch and English stimuli is carried out by the same 'L1 machinery'. As Schoonbaert et al. (2009) put it "an advantage of a shared script is that many of the early processes in word recognition (e.g., letter identification, phonological coding) can be shared between L2 and L1, so that L2 word recognition can profit from the already well-established and fast-operating L1 machinery […] In contrast, the processing of words in a different script relies on other processes that are not as well practiced as the processes of L1, so they take more time to complete." (p. 582). Thus, the lack of a L2-L1 priming effect for different script bilinguals is unsurprising in this account.

It is currently an open question as to whether increasing prime duration can induce a priming effect in the L2-L1 direction when languages differ in script. By increasing prime duration, not only will different script bilinguals have more time in which to decode the less familiar L2 script, but the additional time would also potentially allow for greater build up of cross-linguistic activation between L2 and L1 P and S codes, which is particularly important because P features are rarely identical across languages. As stated previously, it would be essential to test whether participants are aware of the primes as this may influence the strategies they employ during the task. These tentative hypotheses hold promise for future research investigating translation priming with different script bilinguals.

The role of the number of senses in word recognition

Interestingly, in the current study, the number of senses of the target words was shown to significantly influence responses in both the L1 and L2 independent of prime type. To explain the influence of the number of senses on lexical decision, previous findings from non-primed lexical decision are considered.

Words with multiple senses have been shown to speed responses relative to single-sense words in monolingual lexical decision (e.g., Hino et al., 1996; Hino & Lupker, 2002) and bilingual lexical decision (Chapter 5). This advantage for words with multiple senses can be explained by assuming that such words have richer semantic representations, which create greater S activation during the word recognition process. Because any sense can contribute to the general level of activation of a word and because once the threshold level of activation is reached a decision can be made, a greater number of senses would be expected to speed responses in lexical decision. This appears to have been the case in the present L1-L2 task.

If this is the case, then monolingual English speakers should show the same processing advantage for English word that have more senses. Because, they have no knowledge of Japanese, prime type (Japanese cognate vs. control word) would not be expected to influence response times. We conducted a control experiment with 24 monolingual English-speaking university undergraduates. The materials and procedures were repeated as described for the bilingual study, except that only the L1-L2 half of the experiment was conducted. Thus, monolinguals responded to English targets preceded by related or unrelated Japanese primes. The final model revealed significant effects of previous response time, log-transformed English word frequency (BNC), and number of senses ($p<.05$). Prime type, trial number, Japanese word frequency and P similarity were not significant ($p>.05$). In other words, the pattern of results showed no influence of Japanese language (prime, P similarity, Japanese word frequency), but revealed the expected English word frequency effect and previous RT as observed in the bilingual study. Most importantly, the advantage for words with more senses in English (few-many) was replicated for monolinguals (estimate=-0.053, $p<.05$). This suggests that a richer semantic network (i.e., a greater number of senses) speeds for responses in lexical decision. Taken together, the findings of the monolingual and bilingual studies show that the number of senses advantage in lexical decision applies to both L1 and L2 processing.

Interestingly, for the Japanese-English bilinguals in the lexical decision task with Japanese targets, the reverse effect was observed: items that had fewer senses were speeded relative to those that had a greater number of senses. Importantly, the number of senses for L1 words in the few-few group was significantly less than those in the many-few group. This difference paralleled the difference in the number of L2 senses (i.e., words with more senses in English also had more senses in Japanese and words with fewer senses in English also had fewer in Japanese).[40] Thus, while there is perhaps ample variability in senses to impact L1 processing, it is unclear why the direction of the effect was different from the L1-L2 task. If anything, we would expect to see facilitation for the targets that more senses than for those that had few senses.[41]

One potential explanation may derive from the influence of multiple senses on processing concerns whether the senses are related or distinct. Rodd et al. (2002) showed that words with more than one distinct meaning (like *bank*) were processed more slowly in monolingual lexical decision, compared to words with multiple related senses (like *television,* as device and media). This difference was explained in terms of competing senses in the case of the homonyms and co-activation of non-competing senses leading to speeded responses in the case of the polysemous words (which is how the majority of studies above could be explained). However, due to the small number of Japanese homonyms (5 items, 8%), it is unlikely that this could be the reason for the advantage for few-sense targets.

Another potential explanation could be gained from previous studies using items that differed in both number of senses and concreteness (Tokowicz & Kroll, 2007). Tokowicz and Kroll (2007) tested monolinguals in lexical decision with items that had one sense or more than one sense and manipulated the concreteness of the items. They found that when items had only one sense there was a significant

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[40] Although this does not pose a problem for testing the assumptions of the Sense Model (as all Japanese senses are shared with the English translation), it does make it difficult to completely rule out the potential effect of the L2 primes. For example, one may hypothesize that because L2 primes in the many-few category could activate multiple senses and thus multiple translations (as not all L2 senses are shared with the L1 translation), this could lead to competition that inhibits responses in to the L1 targets in this group. However, due to the complete lack of a priming effect it is perhaps more likely that S activation from the L2 prime was minimal if existent at all.

[41] Note that it was not possible to conduct a Japanese monolingual experiment because it is very difficult to find comparable participants in Japan who have had no English education. English is taught as a compulsory subject throughout junior and senior high school, and in addition, most students take English at university.

concreteness advantage for responses. Conversely, when items had more than one sense, the concreteness advantage was actually reversed, such that more abstract items were responded to more quickly.

To test whether concreteness could explain the variation in the responses to the targets used in the present study, it was added as a term in the model along with an interaction term between the number of senses category and concreteness, and the mixed effects modeling process described previously was repeated. Collinearity was removed using the same residualization procedure described previously, making the predictors orthogonal. The concreteness measure was derived from a previous rating study (Chapter 4), in which Japanese-English bilinguals rated Japanese words on a scale of 1-7 from *very concrete* to *very abstract*.

Concreteness did not emerge as a significant main effect in the final model for L2 lexical decision ($p>.1$), while the number of senses remained highly significant ($p<.001$). In contrast, in L1 lexical decision concreteness was significant as a main effect ($p<.05$), revealing that more concrete words were named more quickly. The number of senses remained highly significant ($p<.001$). The interaction term was significant ($p<.01$), showing that, unsurprisingly, the concreteness advantage was found for the few-few items, as they were comprised of more concrete items, while items in the many-few category showed little influence of concreteness. In sum, both predictors accounted for significant portions of the variance in the L1 lexical decision task but not in the L2 task.

These results are partially in line with those reported for monolinguals by Tokowicz and Kroll (2007). That is, items with one or very few senses were facilitated by concreteness while processing of more polysemous items was unaffected. Similarly, in L2 lexical decision, where items had more senses in than in the L1 task, there was no additive effect of concreteness. In sum, the difference in the number of senses/concreteness of targets (both in English or Japanese) appears to be the primary cause for the different impact of polysemy in lexical decision. These findings raise interesting questions about the respective roles of concreteness and polysemy in word recognition, and thus warrant further research. However, it is critical for the present research that the influences of these variables upon responses were independent of prime type and are thus superfluous to the discussion of priming asymmetry and the Sense Model's account of this phenomenon.

Conclusion

In the present research it was shown that the priming asymmetry is robust for Japanese-English cognates in lexical decision with L1 primes speeding responses but L2 primes having no effect. The manipulation of semantic overlap in the present experiment showed that there was no processing benefit when L1 primes activated all of the senses of L2 targets compared to when primes activated a smaller proportion of L2 senses of targets. More importantly for testing the Sense Model, when L2 primes activated the full range of the L1 targets' senses, no priming effect was observed. The findings are problematic for the Sense Model, which assumes activating the total number of senses is what drives priming in cross-linguistic language tasks such as lexical decision and semantic categorization. These findings are more compatible with a view that L2-L1 priming is not observed in different scripts due to delayed activation of P and S codes, as opposed to the proportion of activated senses.

Chapter 8: Control experiments

Introduction

Three monolingual English language control experiments are presented in this chapter: picture naming, lexical decision and lexical decision with Japanese masked primes. These monolingual control studies are all replications of experiments reported previously in this thesis (Chapters 5 and 7). The purpose of the monolingual experiments was to ascertain whether the effects of P and S similarity observed in the bilingual tasks could be replicated with monolinguals; if they were, then the effects could be due to the properties of the stimuli as opposed to the cognitive processes unique to the bilingual; on the other hand, if the findings revealed that P and S effects are only observed in the bilingual but not the monolingual task, then this would lend support for the specifically cross-linguistic nature of the measures.

Monolingual picture naming

In order to confirm that the cross-linguistic effects identified in the bilingual L2 English picture naming experiment (Chapter 5) were not attributable to general properties of the stimuli and instead were due to the Japanese-English bilingual's representations and processing of cognates, the same task was repeated with English-speaking monolinguals. If the stimuli were well designed, cross-linguistic P and S similarity were predicted to be non-significant as predictors of monolingual picture naming latencies.

Method

Participants

Twenty-three first-year undergraduates from the University of Nottingham participated in the study for class credit. All of the participants were monolingual English speakers. One participant was removed from the analysis because his responses included over 30% outliers, primarily comprising of those less than 300ms, which appeared to be due to technical issues (i.e. microphone was too close resulting in it being triggered too easily). Data from the 22 remaining participants is presented.

Materials and procedure

The materials and procedures were identical to those described in Chapter 5 for the bilingual picture-naming task.

Results and Discussion

Recordings were analysed for errors including false starts and incorrect responses. These errors amounted to 1.5% of the total data and were removed from the data set in preparation for the response latencies analysis. The number of errors is too low for a reliable accuracy analysis to be conducted. Outliers were identified as responses that were less than 300ms, greater than 2500ms, or ±2 standard deviations from the mean. These outliers amounted to a further 5.6% of the data and were removed from the data set. In total 7.1% of the data was removed as outliers and errors.

Mean correct RTs were 680ms (SD=197ms) for cognates and 665ms (SD=172ms) for noncognates. This difference was not significant (t=1.33, df=1092.01, p>.1). This minor difference is in the opposite direction to the hypothesis for bilingual picture naming, with cognates being named slower than noncognates. The RTs were subjected to the same mixed-effects modeling procedure as the bilingual picture naming (Chapter 5). The predictors were the same, except that L2 proficiency was not included. Fixed effects included task predictors (trial, previous RT) and lexical predictors (English word length, English word frequency, Japanese word frequency, P similarity, S similarity, conceptual familiarity, English objective AoA) and participants and items were random effects. Word frequencies and RTs were log-transformed. Before the analysis collinearity was investigated and removed using the procedures described in Chapter 5. The final model for response latencies is presented in Table 8.1.

Table 8.1: Final model for RTs in English picture naming with monolinguals

Fixed Effects	Estimate	MCMC mean	HPD95 lower	HPD95 upper	pMCMC	Pr(>|t|)
(Intercept)	6.478	6.478	6.419	6.535	0.001	0.000
Log-transformed English word frequency	-0.024	-0.024	-0.043	-0.004	0.026	0.022
Word length	0.020	0.020	0.004	0.037	0.018	0.021
Conceptual familiarity	-0.041	-0.042	-0.068	-0.017	0.001	0.003
English AoA	0.034	0.035	0.003	0.066	0.036	0.039

Random Effects

Groups	Name	Std.Dev.	MCMC median	MCMC mean	HPD95 lower	HPD95 upper
Items	(Intercept)	0.079	0.070	0.071	0.056	0.090
Participants	(Intercept)	0.151	0.123	0.125	0.097	0.157
Residuals		0.209	0.211	0.211	0.202	0.220

The final model for monolingual English picture naming including both cognates and noncognates revealed a significant main effect of word length (p<.05), with slower latencies recorded for longer words. English log-transformed word frequency was significant (p<.05), such that more frequent words were named more quickly. Conceptual familiarity and English AoA were also significant (p<.05), such that more familiar items and those learnt earlier in life were named more quickly. It is interesting that conceptual familiarity, which is derived from Japanese participants' perceptions about their familiarity with the items depicted in the pictures, was predictive for English monolinguals. Clearly conceptual familiarity bares some resemblance across cultures.

S similarity was not significant (p>.2). Because all items were concrete, as is common in picture naming, it is unlikely that the degree of concreteness would account for any variance in the model. Another possibility is that the number of senses of the target words impact naming. Specifically, if words have more senses then this may cause momentary conflict when selecting the target word for naming; on the other hand, few senses should cause little conflict, resulting in a similar direction of effects as those actually observed. To test this idea, an additional predictor number of senses (taken from WordNet, Princeton, 1990) was added to the analysis and the procedure was repeated. However, this number of senses predictor was not significant as a main effect (p>.2), while the final model remained largely unchanged.

It is important to note that P similarity did not feature in the main model, which was expected for monolinguals that have no knowledge of Japanese. Because P similarity was not significant and only a small difference between cognate and noncognate latencies was observed (15ms slowing of cognate RTs), it can be ascertained that there was no difference between cognate and noncognate groups in regard to lexical processing in English only. For this reason, a binary factor of cognate status was not considered as a replacement for P similarity in the mixed-effects models.

The results of this monolingual picture naming study show that there was no difference between cognates and noncognates in terms of cross-linguistic P and S similarity. Therefore, the influence of these variables in L2 bilingual picture naming can be attributed to the bilinguals' knowledge of Japanese language and not some other property of the stimuli. Importantly, the well-known effects of word frequency, familiarity, age-of-acquisition and word length were attested in this study, and show influence of these lexical characteristics

Monolingual lexical decision

In order to confirm that the cross-linguistic effects identified in the bilingual lexical decision (Chapter 5) were not attributable to general properties of the stimuli and instead were due to the cognitive processes unique to the bilingual, the same lexical decision task was repeated with English-speaking monolinguals.

Method

Participants

Thirty-seven first-year undergraduates from the University of Nottingham participated in the study for class credit. All of the participants were monolingual English speakers.

Materials and procedure

The materials and procedures were identical to those described in Chapter 5 for the bilingual lexical task.

Results and Discussion

Inaccurate responses were identified as errors amounting to 1.9% of the total data. As the number of errors was extremely low, no reliable accuracy analysis could be conducted. Outliers were identified as responses that were less than 300ms, greater than 2500ms, or ±2 standard deviations from the mean. These were removed in preparation for the latency analysis, resulting in a loss of 1.3% of the data. In total 3.2% of the data was removed as outliers and errors.

Mean correct RTs were 556ms (SD=123ms) for cognates and 557ms (SD=126ms) for noncognates. Unsurprisingly, the 1ms difference was not significant (t=-0.40, df=4295.96, p>.6), showing that there was no difference between cognate and noncognate categories in monolingual lexical decision. Nevertheless, the RTs were subjected to the same mixed-effects modeling procedure as the bilingual lexical decision. The predictors were the same except that L2 proficiency was not included. Fixed effects included task predictors (trial, previous RT) and lexical predictors (English word length, English word frequency, Japanese word frequency, P similarity, S similarity) and random effects of participants and items. Word frequencies and RTs were log-transformed. Before each analysis collinearity was investigated and removed using the procedures described in Chapter 5. Therefore, each predictor in the present analysis can be considered orthogonal. The final model for response latencies is presented in Table 8.2.

Table 8.2: Final model for RTs in English lexical decision with monolinguals

Fixed effects

	Estimate	MCMC mean	HPD95 lower	HPD95 upper	pMCMC	Pr(>|t|)
(Intercept)	6.300	6.300	6.270	6.330	0.000	0.000
Trial	0.000	0.000	0.000	0.000	0.020	0.010
Previous RT	0.010	0.010	0.010	0.010	0.000	0.000
Log-transformed English word frequency	-0.020	-0.020	-0.030	-0.010	0.000	0.000
Word length	0.020	0.020	0.010	0.030	0.000	0.000

Random effects

Groups	Name	Std. Dev.	MCMC median	MCMC mean	HPD95 lower	HPD95 upper
Items	(Intercept)	0.060	0.050	0.050	0.040	0.060
Participants	(Intercept)	0.100	0.090	0.090	0.070	0.101
Residuals		0.170	0.170	0.170	0.170	0.180

In the model, the task variables trial and previous RT were significant ($p<.05$, $p<.001$, respectively), showing that participants' responses slowed over the course of the task (i.e., a fatigue effect) and longer responses on previous trials led to longer responses on subsequent trials. Similar effects of these task predictors have also been observed in other language processing experiments (Miwa, 2013). English word frequency was significant, with higher frequency words being responded to faster than lower frequency words ($p<.001$). English word length was also significant with longer words being responded to more slowly than shorter words ($p<.001$). These effects are well known in monolingual lexical decision and therefore show the experiment is representative of normal language processing. Moreover, all of the significant predictors are English language measures, as opposed to Japanese measures (e.g., Japanese word frequency) and cross-linguistic measures (P and S similarity). The crucial finding is that P and S similarity were not significant predictors of monolingual naming latencies, showing that this measure is only predictive of Japanese-English bilinguals' language processing.

As there was no difference in RTs for cognate and noncognate word categories (556ms and 557ms, respectively), there was no need to conduct an additional analysis where P similarity was replaced by the binary cognate/noncognate distinction. Also, P similarity was not significant as a main effect in the analyses suggesting that, as expected, there was no influence of cross-linguistic P similarity in the monolingual task. This result qualifies the primary finding of the bilingual study, that P similarity leads to facilitation for Japanese-English bilinguals, but not for monolinguals.

In the bilingual lexical decision task, S similarity was predictive of responses such that increased similarity led to slower responses. In the bilingual study, concreteness (ratings collected from Japanese-English bilinguals, see Chapter 4) and the number of English senses (taken from WordNet, Princeton, 1990) were added in a post-hoc analysis, revealing that more abstract items and those that had more senses were responded to more quickly than more concrete items those that had fewer senses. To confirm whether concreteness or English number of senses could explain any of the variance in the monolingual study, and also illuminate why no effect of S similarity was found for monolinguals, a post-hoc analysis was conducted on the monolingual data. The final model after including concreteness and English number of senses shows that while concreteness did not make the final model, the number of English senses almost reached significant (p<.08), but significantly improved the model according to log-likelihood tests (p<.05). The effect showed that a greater number of senses tended to speed responses, though this effect size was small (estimate=-0.003). While neither S similarity or English number of senses were significant predictors, English number of senses did significantly improve the model, suggesting that this measure better appropriates semantic knowledge of monolinguals than S similarity, as one would expect since S similarity is a cross-linguistic measure.

One reason why concreteness and the number of senses measures may not be more predictive in the monolingual model is that when making lexical decisions in the L1, responses are much faster than in the L2 (556 ms vs. 717 ms). This means that less processing time is available for semantic information to become activated and influence responses. Monolingual lexical decision has, however, been shown to be influenced by the number of senses (Hino et al., 2002), therefore this is not likely to be the sole reason why stronger semantic effects were not observed for monolinguals.

In summary, the present monolingual lexical decision task showed no effect of P or S similarity supporting the argument that these measures are indicative of bilingual and not monolingual processing. As latencies were almost identical for cognates and noncognates, this indicates that the P similarity effects in bilingual lexical decision are attributable to shared P features of words in Japanese and English, which impact L2 processing. The S similarity effects observed in the bilingual task were not replicated in the monolingual task. However, the direction of the effect for the number of senses predictor in the post-hoc analysis revealed that semantic richness plays a role in L1 word recognition, but in the present research at least, this role was greater in L2 processing. Finally, most of the lexical predictor effects (e.g., word frequency and word length) observed in this task conform to previous research in monolingual lexical decision.

Monolingual English lexical decision with Japanese masked primes

In order to confirm that the cross-linguistic effects identified in the bilingual English lexical decision with masked L1 primes (Chapter 7) were not attributable to general properties of the stimuli and instead were due to bilingual nature of the participants, the same lexical decision task was repeated with English-speaking monolinguals. Because the participants were English-speaking monolinguals, only the first part of the experiment reported in Chapter 7 was conducted with this group; that is, the English lexical decision with Japanese primes, and not the Japanese lexical decision with English primes. A similar control experiment was not performed for Japanese monolinguals as it is not possible to find a similar group of participants that have not studied English before.

Method

Participants

Twenty-four first-year undergraduates from the University of Nottingham participated in the study for class credit. All of the participants were monolingual English speakers.

Materials and procedure

The materials and procedures were identical to those described in Chapter 7 for the bilingual masked priming lexical task, except that only the first part of the task (Japanese primes, English targets) was conducted.

Results and Discussion

Inaccurate responses were identified as errors amounting to 6.3% of the total data including nonword responses; only 2.4% of responses to real words were inaccurate. As the number of errors was extremely low no reliable accuracy analysis could be conducted.

Responses to nonwords were removed from the data. Outliers were identified as responses to items that were less than 300ms, greater than 2500ms, or ±2 standard deviations from the mean. These were removed in preparation for the latency analysis, resulting in a loss of 3.7% of the remaining data. In total 6.1% of the response data for words was removed as outliers and errors.

Mean correct RTs for words, all of which were Japanese-English cognates, were 571ms (*SD*=90ms). The mean RT for correct responses to words followed by related primes was 568ms and that for items preceded by unrelated primes was 576ms. This difference was not significant (t=-1.56, df=1349.96, p>.1). The RTs were subjected to the same mixed-effects modeling procedure as the bilingual lexical decision. The predictors were the same except that L2 proficiency was not included. Fixed effects included task predictors (trial, previous RT) and lexical predictors (English word length, English word frequency, Japanese word frequency, P similarity, number of senses (a factorial predictor: few-few or few-many) and random effects of participants and items. Word frequencies and RTs were log-transformed and previous RT was inverse transformed (-1000/previous RT) to increase normality and reduce random variance. Before each analysis collinearity was investigated and removed using the procedures described in Chapter 7. The final model for response latencies is presented in Table 8.3.

Table 8.3: Final model for RTs in monolingual English lexical decision with Japanese primes

Fixed effects

	Estimate	MCMC mean	HPD95 lower	HPD95 upper	pMCMC	Pr(>|t|)
(Intercept)	6.340	6.340	6.310	6.371	0.001	0.000
Previous RT	0.026	0.026	0.018	0.034	0.001	0.000
Log-transformed English word frequency	-0.027	-0.027	-0.041	-0.015	0.001	0.000
Number of senses	-0.053	-0.052	-0.089	-0.010	0.012	0.013

Random effects

Groups	Name	Std. Dev.	MCMC median	MCMC mean	HPD95 lower	HPD95 upper
Items	(Intercept)	0.030	0.027	0.027	0.018	0.036
Participants	(Intercept)	0.077	0.066	0.067	0.051	0.085
Residuals		0.126	0.127	0.127	0.122	0.132

In the final model, prime type was not significant ($p>.05$) which showed no effect of Japanese related or unrelated primes upon responses to English targets. Also, P similarity was not significant ($p>.1$), showing that the similarity across languages did not influence monolinguals' responses to English targets. Both of these effects were expected given that the participants had no knowledge of the Japanese language. These results confirm that the effect of Japanese prime type observed in the bilingual L1-L2 masked priming lexical decision task was due to the priming manipulation and not due to the characteristics of the stimuli.

The task variable previous RT was significant ($p<.001$), as in the bilingual task, such that longer responses on previous trials led to longer responses on subsequent trials. Also, similar to the bilingual study the task predictor trial was not significant ($p>.1$). English word frequency was significant, with higher frequency words being responded to faster than lower frequency words ($p<.001$). This effect was also observed in the English lexical decision task with Japanese-English bilinguals, showing that the word frequency of the target item is critical for determining RTs when processing in both the L1 and L2. Also, Japanese word frequency was not significant ($p>.1$), which was expected as English word frequency plays the greater role in processing English words. This finding supports the observed pattern in the bilingual task: English word frequencies predict responses in English lexical decision and Japanese word frequencies predict responses in Japanese lexical decision. English word length was not significant ($p>.1$), though this was a significant predictor in the same task with bilinguals. This difference may be due to the slower RTs in the bilingual experiment (729ms vs. 571ms): because bilinguals are slower at processing L2 than monolinguals processing their L1 (only language), word length effects may become more apparent in the former case.

Most importantly, the number of senses category (few-few, few-many) was significant ($p<.05$), showing that when words had more senses in English they were responded to more quickly than words that had fewer senses. For example, *banana* and *helmet*, which have few senses in English, were responded to more slowly than items that had a greater number of senses, such as *care* or *scale*. In the bilingual study, English items that had many senses were also responded to significantly more quickly than items that had few senses. Because this effect of number of senses was independent of prime type in the L2 study (as shown by the facilitatory effect of related primes for all items regardless of their number of senses category), it can be attributed to processing of the L2 targets. Taken together, these results suggest that the number of senses of items impacts processing of stimuli in lexical decision and this effect can be observed when processing stimuli in both the L1 and the L2.

As in Chapter 7, to determine more precisely the nature of the semantic effect observed with the number of senses categorical variable, concreteness was added to the above model, and the modelling procedure was repeated as described previously. Collinearity was removed from all predictors prior to modelling. The final model reveals that concreteness was highly predictive of responses to English targets (estimate=0.02; $p<.05$). Thus, words that are more concrete were responded to more slowly than words that were more abstract. The number of senses factor was not significant and was effectively replaced by concreteness. This may be because concreteness was a continuous predictor and number of senses a factorial predictor, the latter of which is not as good at capturing subtle changes in variance attributable to semantic characteristics of words. In sum, in the bilingual model both concreteness and number of senses were significant; however, in the monolingual model, concreteness replaced number of senses.

To investigate these effects further, the English number of senses (from WordNet) was used in place of number of senses and the modeling procedure was repeated. In the final model (Table 8.4), both concreteness and English number of senses were significant ($p<.05$) showing an advantage for abstract words and those that had more senses. There was a concreteness disadvantage for items that had both few and many senses and a number of senses advantage for both concrete and abstract items ($p<.05$) . This finding is similar to that for the bilingual lexical decision; however, in the monolingual study, the factorial number of senses predictor was not significant when concreteness was added to the model, but English number of senses was, showing that the greater variability in English number of senses was better at explaining variance in RTs than the factorial number of senses variable.

Table 8.4: Final model for RTs in monolingual English lexical decision with Japanese primes when including concreteness and number of senses

Fixed effects						
	Estimate	MCMC mean	HPD95 lower	HPD95 upper	pMCMC	Pr(>|t|)
(Intercept)	6.340	6.340	6.311	6.372	0.001	0.000
Previous RT	0.026	0.027	0.018	0.035	0.001	0.000
Log-transformed English word frequency	-0.026	-0.025	-0.038	-0.012	0.001	0.000
English number of senses	-0.003	-0.003	-0.005	-0.001	0.002	0.004
Concreteness	0.019	0.019	0.006	0.036	0.011	0.011

Random effects						
Groups	Name	Std. Dev.	MCMC median	MCMC mean	HPD95 lower	HPD95 upper
Items	(Intercept)	0.030	0.027	0.027	0.018	0.038
Participants	(Intercept)	0.077	0.066	0.067	0.051	0.085
Residuals		0.126	0.127	0.127	0.122	0.132

As with the explanation provided for the bilingual lexical decision, this result is similar to that of Tokowicz and Kroll (2007) who observed a reversal of the concreteness effect when items varied in the number of senses that they had. Here, concreteness is disadvantageous for all items, and instead the number of senses is critical for determining RTs. The results presented here support the advantage for items with richer semantics (i.e., a greater number of senses) that has been observed elsewhere (Chapter 5; Hino et al., 2002; Hino et al., 1996).

In summary, the present monolingual English lexical decision task with Japanese primes showed no effect of prime type or P similarity, but did reveal similar results for the number of senses predictor. Thus, while Japanese language characteristics could not influence processing in English-speaking monolinguals, the number of senses of English targets significantly influenced responses in both monolingual and bilingual experiments. Moreover, the lexical (word frequency) and task (previous RT) effects observed in this task follow conform to previous research in monolingual lexical decision.

Chapter 9: The influence of cross-linguistic similarity in an authentic L2 reading task

Introduction

In the previous chapters of this thesis, it has been established that the P and S similarity of Japanese-English cognates varies continuously (Chapter 4) and that this variation in cross-linguistic similarity influences bilingual's processing in a second language (i.e., English; Chapters 5 and 7). Although a great deal of work has been done to investigate the influence of SOP overlap, the majority of research has been done using single-word tasks, such as lexical decision or word naming. This places a limit on how well the positive transfer or cognate facilitation applies to more natural tasks, as people rarely read words in isolation. Consequently, it is not clear how much benefit bilinguals gain from cross-linguistic similarity in more real life reading tasks. A start has been made to address this issue by studies that have conducted sentence-reading tasks in which cognates/controls are embedded within sentences (Duyck et al., 2007; Libben & Titone, 2008; Schwartz & Kroll, 2008; Van Assche et al., 2009, 2011; Van Hell & De Groot, 2008).

A key issue addressed by these studies is the role of context in modulating cross-linguistic effects from the L1 when bilinguals read in the L2. Monolingual studies of sentence processing demonstrate that when people read, upcoming words are predicted based on the lexical, syntactical and semantic context provided by the sentence (e.g., Balota et al., 1985; Ehrlich & Rayner, 1981; Rayner & Well, 1996; Stanovich & West, 1983). When a word is highly predictable from its sentence (e.g., *we went to the cinema to watch a* _____), it is read more quickly than when a sentence context does not allow prediction of the upcoming word (e.g., *she bought her daughter a* ______). Additionally, when the meaning of a word is ambiguous (e.g., *bank* in English), the relative frequency and number of meanings of words may also be important for predictability in sentence context see (Rayner & Duffy, 1987). As Van Assche et al. (2011) note, the bilingual case is likely to be very similar at least when word meanings are unambiguous.

The key question for the present research concerns whether formal features of the L1 target translation are activated sufficiently upon reading the L2 translation in a general L2 textual context (i.e., reading an L2 text consisting of multiple consecutive paragraphs) and whether this creates a facilitatory effect of reading cognates relative to controls. In other words, does the context provided by the text provide a cue to the bilingual's processing system that biases it towards activating only L2 SOP codes, and not L1 SOP codes? Alternatively, are L1 codes activated sufficiently to influence reading in the L2? More specifically, because Japanese-English cognates share only S and P (and not O), are these L1 codes sufficiently activated during L2 reading to influence processing of English words? In the following section, studies that have investigated cognate processing in sentence and longer textual contexts are reviewed with the primary aim being to assess the likelihood of whether L1 (Japanese) information will be sufficiently available to influence L2 (English) reading.

Cognate processing in sentences

The Schwartz and Kroll (2006) study was one of the first studies to use cognates in sentence contexts. They were interested in whether high and low-constraint sentences influenced L1 activation for two different groups of Spanish-English bilinguals (high and intermediate proficiency). They predicted that cognates (+O+P+S) would be more strongly activated than homographs (+O+P-S) in sentence contexts because of the additional shared semantics. Sentences were presented word-by-word using serial visual presentation (SVP) methodology and participants named the highlighted target word. They found that cognates were named faster in low constraint sentences but this effect disappeared in high-constraint sentences. This finding was replicated in both proficiency groups suggesting the effect of rich semantically constraining sentences is important at both intermediate and high stages of L2 development. Homographs were named no differently from controls in both sentence types and by both proficiency groups. Thus, the critical result here is that for intermediate and high proficiency bilinguals, cognate (+P+O+S) effects are only present in low-constraint sentences. Schwartz and Kroll's (2006) study was primarily looking at L2 production as participants named words presented in sentence-contexts. While this task involves comprehension of words/sentences it also includes a production component. The cognate effect observed thus could be due to an advantage in either (or both) comprehension or production.

Other studies have focused more specifically on cognates in comprehension tasks. Duyck et al. (2007) used identical and non-identical Dutch-English cognates (e.g., *banaan-banana*) and controls as final words of sentences presented using SVP. Dutch-English bilinguals made lexical decisions for English (L2) words in sentence context. Only low-constraint sentences were used so the target was plausible but not necessarily predictable from the sentence context. Duyck et al. observed a significant facilitatory effect of both identical and non-identical cognates relative to controls. In a follow-up experiment, Dutch-English bilinguals read the same targets in a free reading sentence task while monitoring eye-movements. While all eye-tracking measures (first-fixation durations, henceforth, FFD; gaze duration (also referred to as first-run/pass duration, henceforth, GD); and total reading time, henceforth, TRT) reported significant facilitation for identical cognates in the L2 reading task, non-identical cognates were read no differently to controls. Thus, similar to the results of Schwartz and Kroll's (2006) study, cognate facilitation was observed in L2 reading in low-constraint sentences. Furthermore, it was shown that the degree of cross-linguistic activation is modulated by the degree of formal (OP) overlap, such that reduced formal overlap (as in the case of near-identical cognates) nullifies any cognate advantage in L2 reading.

In another study, Van Hell and De Groot (2008) tested the influence of cognate status (cognate/noncognate) and concreteness (concrete-abstract) of targets following high or low constraint sentences and targets presented in isolation. Dutch-English bilinguals made lexical decisions for targets presented in English (L2). Following high-constraint sentences, there was no effect of cognateness (or concreteness), though facilitatory effects of these variables (i.e., faster responses for cognates and concrete items) were observed in the low-constraint and no sentence conditions. Similar findings were reported for a translation task (i.e., a comprehension-production task), though effects of cognateness and concreteness were still observed in high-constraint sentences, albeit greatly reduced. Thus, this study converges with Schwartz and Kroll (2006) and Duyck et al. (2007) in that cognate effects may not be observed in high-constraint sentences.

Libben and Titone (2009) investigated the effect of sentence context (high/low constraint sentences) on the processing of French-English cognates (e.g., *piano*) and homographs (or *false friends*, e.g., *coin*, which means 'corner' in French) compared to controls. French-English bilinguals read L2 (English) sentences that included cognates, homographs or matched controls while their eye-movements were monitored. Early eye-tracking measures (FFD, GD) showed that homographs were read significantly more slowly in both sentence types compared to controls, while cognates were read faster in both sentence types relative to controls. For the late measures (TRT and go-past time, henceforth, GPT), there was a significant difference for the two types of sentences. When sentences were low-constraint, reading of homographs took longer and reading of cognates was shorter than controls, as observed in the early measures. However, there was no significant difference between processing of homographs or cognates relative to controls in high constraint sentences. This suggests that high-constraint sentence contexts can nullify the effects of cognates and homographs, in line with previous studies (Duyck et al., 2007; Schwartz & Kroll, 2006; Van Hell & De Groot, 2008).

Libben and Titone (2009) also found a significant correlation of proficiency, such that as L2 proficiency increased, less cognate facilitation was observed. However, this reduced cognate effect was found only for the high proficiency subjects in high constraint sentences, whereas no difference was found by proficiency for cognates in low-constraint sentences. Thus, when the sentence context constrains the meaning of words, activation of L1 is weaker, but only for highly proficient bilinguals. This effect was only reported for FFD, suggesting that any reduction of cognate facilitation for high proficiency bilinguals is observed only in very early processing. In contrast, there was no effect of proficiency on homograph interference, suggesting that homographs are a source of ‘negative transfer’ that affects bilinguals equally regardless of proficiency.

The influence of cross-linguistic O overlap has also been shown for cognates when reading sentences in the first language (Van Assche et al., 2009). Using Van Orden’s (1987) measure of O similarity for word pairs, Van Assche et al. (2009) showed that as O overlap increased for Dutch-English cognates, cognates were read more quickly and this effect did not differ depending on whether sentences were high or low constraint. In another study, Van Assche et al. (2011) demonstrated significant effects of both O overlap (based on a continuous, objective measure of O similarity, Van Orden, 1987) and a combined measure of O and P overlap on lexical decision times to Dutch-English cognates presented in the L2 (English). In a second experiment, the facilitatory effect of these measures was replicated in sentence context for both early (FFD, GD) and late (GPT) measures of eye movements during reading. As in Van Assche et al. (2009) sentence constraint (high vs. low) did not greatly affect the facilitation due to O and P overlap. The results of Van Assche et al. (2009, 2011) are largely compatible with previous research except that previous research has shown no effect of cognates in high-constraint sentences (Libben & Titone, 2008; Schwarz & Kroll, 2006; Van Hell & De Groot, 2008).

Importantly, Van Assche et al. (2009, 2011) demonstrate that cross-linguistic OP similarity is continuous in nature and the degree of overlap is an important predictor of reading times for cognates. However, because Dutch and English share script, the O measure of cross-linguistic formal overlap necessarily provides the most significant contribution to the observed cognate facilitation, when considered in terms of the BIA+.

This is because O input is processed before P input, and thus cross-linguistic activation arises primarily because of O similarity, and additionally through P similarity. Given the high correlations between the O and P similarity ratings for Dutch-English cognates, it is difficult to assess the singular contribution of P similarity on bilingual word recognition and sentence reading. Moreover, when language share script it is more difficult to disentangle P and O from participants' ratings of these features. When participants are rating the P overlap of words that are presented visually, they may also be influenced by the degree of overlap in terms of O. More objective measures of P overlap, for example those that break words down into their constituent phonemes and compare the overlap across languages, are not only time-consuming to develop and implement, but also have to deal with features such as stress placement and phonotactic features at the word level.

In summary, previous studies of cognates in sentence context show a crucial role for the constraints imposed by semantic and syntactical features of sentences on cross-linguistic effects. When sentences are highly constraining then cognate effects are reduced (except in Van Assche et al., 2011). Moreover, when cognates are not identical in terms of OP, the facilitatory effect is reduced. Crucially, all of the above studies have used languages that share script, while none have investigated whether P alone (in addition to S), as in the case of Japanese-English cognates, is sufficient to influence L2 reading. Given the reduced facilitation observed for non-identical cognates that share O, it can be hypothesized that reduced P similarity will lead to reduced cross-linguistic activation and hence reduced cognate facilitation. However, because of the absence of O, facilitation for Japanese-English cognates may be further reduced in comparison to cognates in same-script languages.

Authentic reading tasks

While sentence tasks are perhaps more ecologically valid than single word tasks, due to targets being placed in or preceded by context, they are still far from real-life reading tasks. Further, if the study makes use of lexical decision or word-naming following or during sentence reading, this is considerably different from everyday reading tasks. Of the above studies, the only one to measure the effects of cognateness in more natural reading contexts (i.e., not lexical decision, translation, or naming) was Duyck et al.'s (2007) third experiment. Although this task used sentences that were constructed by the experimenters and then presented in isolation, the design was 'natural' in the sense that participants simply read sentences and answered questions about them (one in four sentences were followed by a comprehension question), as opposed to making lexical decisions or naming specific words within the sentences. A significant facilitatory effect was found for identical cognates on FFD, GD and TRT, but no facilitation was observed for near-identical cognates. This is perhaps the closest indication of the studies reviewed thus far that L1 effects can be obtained in more natural reading contexts. However, as there was only an effect for identical cognates (+P+O+S), the impact of cross-linguistic similarity appears highly limited. Particularly, for languages that differ in script, there is no 'complete' formal overlap (because P is rarely identical across languages), as in Duyck et al.'s study, which may mean that, similar to the null effect for non-identical cognates, no cognate effect will emerge for such languages.

To date there has been only one other study that has looked at cognates in more naturalistic reading contexts (Balling, 2012). Balling (2012) studied the processing of Danish-English cognates embedded in English-language (L2) newspaper articles. Highly proficient Danish-English bilinguals read newspaper articles at their own pace while their eye-movements were recorded. Target items were English words that fell into one of three categories: cognates that were cognate in context with Danish words (i.e., the meaning of the English word would be translated using a cognate in Danish; henceforth, 'appropriate cognates'); cognates that were cognate but not in the context (i.e., the English word had a cognate translation but the meaning of the Danish cognate was not appropriate for the context; henceforth, 'inappropriate cognates'); and words that were noncognate. These were further grouped by whether they were morphologically simple (e.g., *pen*) or complex (e.g., *called*), defined by the number of morphemes in the English word.

The results of this study are not as straightforward as other sentence-based tasks, due to the inclusion of an additional type of cognate (inappropriate cognates) and morphological complexity. Nonetheless, a significant difference between appropriate cognates and noncognates was observed in free reading, such that the cognates were read more quickly. This cognate facilitation effect was found, however, only in TRT and not in FFD or GD, suggesting that cognateness generally influences later-stage processing. This result is contrary to previous research that has found cognate effects in both early and late measures (Duyck, 2007; Libben & Titone, 2009; Van Assche et al., 2011; Van Hell & De Groot, 2008). It is also contrary to Libben and Titone's finding (2009) that for higher proficiency bilinguals (as in Balling's study), cognate facilitation was reduced in TRT but was not reduced for early reading measures (FFD, GD).

Importantly, cognate facilitation missed significance for GD, but was significant in an interaction with morphological complexity, such that simple appropriate cognates were read more quickly relative to noncognates but complex appropriate cognates were read more slowly relative to noncognates. This interaction was also present in TRT, while there was no effect of either cognate status or complexity in the FFD analysis. Also, no cognate facilitation was observed for inappropriate cognates, which were instead similar to noncognates in that they were read more slowely relative to appropriate cognates, at least when they were morphologically simple. When words were complex, both types of cognates (appropriate and inappropriate) were read more slowly relative to noncognates. The authors assumed these slower reading times for morphologically complex cognates was due difficulties in decomposing cognates that have noncognate morphemes (such as *Wednesday* and *Ons-dag*, or *personal* and *person-lig*).

In addition to binary cognate measures, Balling (2012) used Van Orden's (1987) measure of O similarity for Danish-English targets (i.e., the English target and its most likely Danish translation). However, this measure was not significant in any of the analyses, contrary to recent findings by Van Assche et al. (2009, 2012) for Dutch-English cognates in sentence contexts. Perhaps most importantly for the present study, a simple binary measure of cognateness (cognate vs. noncognate) showed that cognates were facilitated in a free reading task. The results of Balling (2012) are critical because they are the first findings of cognate effects in an authentic reading task.

It is important to contextualize such findings in terms of models of bilingual visual word recognition. According to the BIA+, cross-linguistic influences from bottom-up processing are predicted for both single-word and in-context reading. However, there are two ways in which continuous text reading may bias the processing system towards more language-specific processing. Firstly, the general linguistic context may bias processing to the language of the text. The fact that all words are in the same language and are presented in sentences and paragraphs, visual word recognition mechanisms will become tuned to activation of sublexical and lexical representations in the language of the text. Thus, the general linguistic context may provide a source of increased bottom-up activation that biases processing to the language of the text. Secondly, the semantic level in the BIA+ can potentially reduce cross-linguistic activation at the sublexical and lexical levels through additional top-down spreading activation to lexical features in the language of the text. In other words, increased activation of semantic representations in the language of the text further boost activation of that language's lexical representations via top-down semantic-lexical connections. In Balling's study, participants read long L2 texts (around 260 words each), which means that according to the BIA+, the continuous presence of L2 input should increase the overall level of L2 activation from bottom-up processing mechanisms. Moreover, increased S activation resulting from processing the L2 text should further boost L2 O/P activation at the lexical level.

One difference between authentic reading context and high-constraint contexts is likely to be the stark differences between low and high constraint sentences used for sentence-processing tasks. Because low/high constraint sentences need to be very clearly distinguished, they tend to be very highly or very weakly constraining. However, sentences in authentic texts may vary more greatly in terms of semantic constraint compared to sentence reading tasks that specifically manipulate the degree of constraint. Because Balling's study did not provide a measure of constraint for sentences within the text in which critical items were situated, it is not possible to discuss the degree of semantic constraint specifically. However, when participants read a continuous text, the amount of general linguistic and semantic context is much greater overall than when reading isolated and unrelated sentences. According to the BIA+, such context may be sufficient to bias the processing system towards the language of the text and thus reduce cross-linguistic activation from the other language. However, contrary to this prediction, Balling (2012) showed that when such context is provided, cognate effects can still be observed, at least in same-script languages. The aim of the present study is to investigate whether bilinguals whose languages differ in script are similarly influenced by the L1 when reading texts in the L2.

The present experiment

Evidence suggests that different script bilinguals utilise P similarity information when recognising words in single-word tasks (Chapter 5; Gollan et al., 1997; Hoshino & Kroll, 2008; Kim & Davis, 2003; Miwa, 2013; Taft, 2002; Voga & Grainger, 2007). However, no research has shown whether these effects are observable in either sentence-reading or more natural reading contexts. The present study sought to bridge the gap between experiments using single-word tasks and more authentic, extended reading tasks, by investigating cognate processing in a free reading task while participants' eye-movements are monitored. The use of early and late reading measures will provide information on the time-course of any observed cognate processing advantage. If a cognate advantage is found for Japanese-English bilinguals in free reading, then this will demonstrate cross-linguistic P activation even when linguistic context may bias processing to the language of the text.

The alternative prediction is that if the linguistic context provided by continuous text modulates cross-linguistic effects then this would be reflected in null cognate effects in both early and late measures. Additionally, S activation generated from L2 reading may feed back to the lower levels and limit the effect of bottom-up P similarity across languages. However, if participants are sensitive to cross-linguistic bottom-up information (i.e., P similarity), as shown in single word tasks, then this may be shown particularly in early measures, but perhaps not in late measures. In other words, first fixations and first run fixations should be shorter for Japanese-English cognates due to facilitatory effect of L1 P similarity at the initial stage of processing due to bottom-up processing of P features.

Previous research has shown that bilinguals are sensitive to the degree of cross-linguistic similarity and that this is reflected in response times during word recognition (Chapter 5; Dijkstra et al., 2010; Van Assche et al., 2009, 2011). The use of continuous measures of P and S similarity thus provide a more sensitive measure of the influence of cross-linguistic similarity. As lexical decision times and fixation measures have been shown to be comparable (Schilling, Rayner, & Chumbley, 1998), it is possible that similar gradient cross-linguistic effects might be observed using continuous similarity measures with eye-tracking. If continuous effects are observed for cognates, then this provides evidence in favour of models that assume gradient effects of formal similarity in word recognition (e.g., BIA+; Dijkstra & van Heuven, 2002). However, first it is necessary to clarify whether any cognate effect is present at all in L2 text reading in a different script language.

Second language proficiency has been shown to modulate cross-linguistic effects in sentence reading (e.g., Libben & Titone, 2009). The BIA+'s temporal delay hypothesis states that L2 processing is delayed when subjective frequency of L2 sublexical, lexical and semantic representations is lower than that of L1. Moreover, cross-linguistic effects are generally larger in the L2 than in the L1 due to relative language dominance, or in terms of the BIA+, relative subjective frequency of words in the two languages. Bilinguals with lower L2 proficiency may be expected to show greater effects of L1 in L2 tasks because of the relative dominance of L1, and also due to the slower processing of L2 relative to L1. In contrast, higher proficiency L2 bilinguals should perhaps show weaker L1 effects in the L2 as L2 processing is fast in both languages (e.g., Libben & Titone, 2009). By including participants of different proficiencies it is possible to account for the role of proficiency, if any, in modulating cross-linguistic effects.

Method

Participants

Twelve Japanese-English bilinguals (5 male; mean age=26y, ±5y) participated in the experiment. One participant was removed as he identified himself as having had a vision-impairment. All remaining participants had normal or corrected-to-normal vision. All participants were Japanese-English bilinguals who were enrolled in language and/or undergraduate/postgraduate programs at the University of Nottingham. Following the eye-tracking experiment, participants completed a language history and experience questionnaire (Table 9.1). Self-ratings for reading, writing, speaking and listening proficiency in both English and Japanese were collected and an average proficiency across these skills was calculated. This averaged measure is presented in Table 9.1 below. Additionally, age-of-acquisition (AoA) and length of stay information were collected to establish language history.

Participants were proficient in both English (M=7.6, SD=2.2) and Japanese (M=8.8, SD=1.6). All participants except one began learning Japanese from birth (0 years) while English in all but two cases (participants 9 and 10) was acquired later in life (starting between 6 and 15 years). However, proficiency varied meaning that five participants rated themselves as more or almost equally proficient in both languages;

in other words, five of the participants appeared to be balanced bilinguals, dominant in either English or Japanese, while the other six were clearly unbalanced, being more dominant in Japanese. This was reflected in the length of stay in the UK, with the higher English proficiency group tending to have resided in the UK for longer (over 10 years). Based on this information, the participants were grouped into a high and a low L2 proficiency group, of 5 and 6 participants, respectively. The two groups differed significantly in average English proficiency (t=-6.590, df=6.24, p<.001)[42] but did not differ in average Japanese proficiency (t=1.425, df=5.72, p>.2).

Table 9.1: Japanese/English proficiency, age-of-acquisition and length of stay information for participants

High L2 Proficiency

Participant Number	Age	English Proficiency	English AoA	Length of Stay in UK	Japanese Proficiency	Japanese AoA
7	22	10.0	6-10yr	10yr+	8	0yr
8	20	9.5	6-10yr	10yr+	8.75	0yr
9	20	9.8	0yr	10yr+	4.75	0yr
10	19	10.0	0yr	1-2yr*	9.5	0yr
12	23	9.0	6-10yr	10yr+	9.25	0yr
M (SD)	20.8 (1.6)	9.7 (0.4)			8.1 (1.9)	

Low L2 Proficiency

Participant Number	Age	English Proficiency	English AoA	Length of Stay in UK	Japanese Proficiency	Japanese AoA
2	34	6.0	6-10yr	<1yr	9.25	0yr
3	26	6.5	11-15yr	3-4yr	9.75	0yr
4	30	7.3	11-15yr	4-5yr	10	0yr
5	34	5.3	11-15yr	<1yr	10	6-10yr
6	31	7.0	11-15yr	<1yr	10	0yr
11	22	3.8	11-15yr	<1yr	7.5	0yr
M (SD)	29.5 (4.7)	6.0 (1.3)			9.4 (1.0)	

* Participant 10 had only stayed in the UK for 1-2 years but had an English-speaking mother who always used English with her

[42] In addition, English reading proficiency was significantly different for both groups (t=-6.5, df=6.551, p<.001), with higher proficiency bilinguals being more proficient at reading. This is important as the present study utilises a reading task.

The participants were paid 7.50 GBP for their participation and completed informed consent forms prior to the experiment as per the University of Nottingham's ethics regulations.

Materials and procedure

Authentic texts (e.g., newspaper articles) such as those used in Balling (2012) are most appropriate for authentic reading tasks as they are unmodified and were written with an authentic communicative purpose for an identified audience. However, it proved impossible to find an existing English text (e.g., from proficiency examinations, such as IELTS or TOEFL) that contained a sufficient number of items that could be reliably confirmed as Japanese-English cognates in context. Consequently, a fictional text (1105 words; Appendix 9.1) was written by the researcher for the purpose of the experiment. The content of the text, as well as the vocabulary, were selected to be accessible to all participants. The text, which is a simple narrative story, was written to include a range of unequivocal Japanese-English cognates (i.e., English words that are always translated as cognates in Japanese) as well as similarly unequivocal noncognates.

To confirm the cognate status of the words in the text, five highly proficient Japanese-English bilinguals, all of whom had done translating work in the past and did not take part in the eye-tracking experiment, performed a translation task. This task was in two parts. In the first part, the bilinguals decided which of four categories the target item belonged. The categories were as follows: 1) the item could *only* be translated as a cognate in Japanese; 2) the item could be translated as a cognate but another (noncognate) alternative translation is also possible; 3) the item had a cognate translation but that translation was inappropriate for the context; 4) the item did not have a recognizable cognate translation and therefore was *only* translatable into Japanese as a noncognate. Items that fell into the first and last categories were shortlisted for the experiment.

In the second part of the task, the same five bilinguals translated each item into Japanese. Participants provided the most appropriate translation for each item in the context of the text. Items previously identified as being only translatable into a ‘cognate’ or ‘noncognate’ (categories 1 and 4, respectively) were always translated as such. For example, *penguin* was identified as a cognate in Japanese (ペンギン /pengin/) that could not be translated using a noncognate alternative translation, and all bilinguals translated *penguin* using this cognate Japanese translation; on the other hand, *zoo* was identified as a noncognate in Japanese (動物園/doubutsuen/) that did not have a cognate translation (i.e., ズー/zuu/*) and was always translated using a noncognate translation.

While all cognates were translated unequivocally, a number of the noncognates were translated using different translations by different bilinguals. For example, *destination* was translated as 目的地 /mokutekichi/ by four participants and 行き先/ikisaki/ by one. While this is not a problem for the present study because all items were translated as either cognate or noncognate (but never a mixture of the two), it does mean that the noncognate Japanese translations are less predictable than those of the cognates.[43] To account for this difference the number of different translations provided by the bilinguals was used as a control variable in the analysis. However, this measure was not significant in any of the analyses, indicating that there was no influence upon reading measures. Therefore, the measure is not discussed further.

Based on the translation task, 28 cognates and 28 noncognates were selected as targets (Appendix 9.2). All were content words (i.e., not function words) and no items were at the beginning or end of lines or sentences. Target words had not previously been presented in the text, though often appeared thereafter. Importantly, we took measures from only the first presentation of the word so that effects of subsequent repetitions (e.g., Rayner et al., 1995) did not confound the reading measures. Further characteristics of the target items that were statistically controlled for are discussed in the following sections.

[43] The most common translation given by bilinguals was used as the ‘expected Japanese translation’ for translation pairs (Appendix 9.2).

The experiment was conducted using an SMI Eye-Link 1 (250Hz) head-worn eye-tracker and Experiment Builder software (SR Research Ltd., Canada). The screen used for presenting materials was 17" and had a screen resolution of 1280 x 1024 pixels. The texts were presented in 14-point Courier New, black text on white background and the lines were double-spaced. Each paragraph was presented on a separate page and participants pressed spacebar on the keyboard to move to the next page.

Participants were fitted with the eye-tracker and calibration was performed using a 9-point grid. Instructions were presented orally and on-screen. Participants were instructed to read the text and answer two comprehension questions that would follow, thereby focusing the participants on reading for comprehension. A practice task was performed first, which served as a model for the main task. A second calibration was performed prior to the main reading task. While both participants read the texts normally using both eyes, eye-movements for the left eye only were recorded.

Predictors

As noted by Balling (2012) a regression analysis is suitable for reading studies in which item and text related characteristics impact processing. In order to control for lexical effects that could not be matched, such as frequency and length, these effects were added as predictors in mixed effects models (see Table 9.2).

Table 9.2: Characteristics of target stimuli for eye-tracking experiment

	Cognate	Noncognate	*P*-value
P similarity	3.4 (0.5)	1.0 (0.1)	*p*<.001
S similarity	4.5 (0.4)	4.2 (0.6)	*p*<.05
Log-transformed word frequency (BNC)	6.9 (1.6)	7.8 (1.3)	*p*<.05
Raw word frequency (BNC)	2493 (3183)	5918 (10379)	*ns*
Word length	6.0 (1.7)	6.3 (2.2)	*ns*
Number of morphemes	1.3 (0.6)	1.7 (0.6)	*p*<.05
Number of senses (WordNet)	4.9 (3.7)	5.6 (5.7)	*ns*
Concreteness (on a scale of 1-7, 7= highly concrete, 1=highly abstract)	5.6 (0.4)	4.7 (1.2)	*p*<.001

Word class*	15 N, 1 Adj, 11 NV, 1 NAdj	10 N, 4 Adj, 7 NV, 2 NAdj, 1 VAdj	NA

*N = noun, Adj = adjective, V=verb, NV = noun and verb, NAdj = noun and adjective, VAdj = verb and adjective

The primary aim of this chapter is to assess whether Japanese-English cognates, which share form and meaning across languages, influence bilinguals' L2 reading processes. The critical predictor in this study therefore is P similarity. This measure is derived from bilinguals' ratings on a scale of 1 to 5 (1=completely different, 5=identical) of how phonologically similar translation pairs, such as *radio* – ラジオ/*rajio*/, are perceived to be. P similarity is a continuous measure of cognateness that provides more explanatory power than a binary measure (Chapters 4 and 5). Moreover, it is easy to distinguish cognates from noncognates by using this measure (cognates *M*=3.4, *SD*=0.5; noncognate *M*=1.0, *SD*=0.1; *t*=24.11, df = 27.59, *p*<.001), such that any item rated above 1.5 is cognate.

Many of the ratings were taken from the study reported in Chapter 4. However, for the present study, a number of items did not already have ratings for P similarity (or S similarity or concreteness) and so a rating study was conducted. (Refer to Chapter 4 for a more detailed description of collection of ratings data). Eleven participants (5 female, 6 male; all undergraduate university students; *M*=21yrs, *SD*=2.8) completed the similarity rating tasks and concreteness rating task. All participants rated P and S similarity and concreteness for *all* items in the study.

A second cross-linguistic similarity measure, S similarity, was used to assess the degree of semantic overlap of translations. Participants rated word pairs (e.g., *bed* – ベッド/beddo/) on a scale of 1 to 5 (1=completely different, 5=identical). Further information on S similarity is provided in Chapters 4 and 5. The cognate items used in the present experiment were rated as significantly more S similar than noncognates (cognate *M*=4.5, *SD*=0.4; noncognate *M*=4.2, *SD*=0.6; *t*=2.546, df=49.45, *p*<.05), which reflects the fact that cognates included more concrete nouns, which typically have fewer senses, while noncognates were more abstract words of a variety of classes, which typically have a greater number of senses (see Table 9.2; see also Chapter 4).

The number of different meanings of words has been shown to be important in reading, such that when words have two or more very different meanings, and these meanings are of a similar frequency, then extended fixations on these words are typically recorded (Rayner & Duffy, 1986; Rayner & Frazier, 1989). However, this is only the case when the prior context does not bias the interpretation in favour of one of the meanings. When the context makes one meaning more likely than another, there is no observed effect of multiple meanings on reading times (Rayner & Duffy, 1986; Rayner & Frazier, 1989). The cognates and noncognates used in this research did not have multiple distinct meanings (except for *skirt*). Other research suggests that when words can be used as verbs or nouns (e.g., *perfect*) and both could be possible in the sentence, then reading times can be inflated (Pickering & Frisson, 2001; Rayner & Frazier, 1989). However, none of the words used fell into this category and moreover, because context is being created in an ongoing fashion as participants read paragraph after paragraph, this type of ambiguity is likely to be very rare in authentic reading situations.

Another issue which is related to meaning but less so to ambiguity, is the role of number of senses of words. Whereas few words have starkly different meanings, many if not most words tend to have a number of different senses. When words have more senses, responses in word recognition tasks such as lexical decision are speeded relative to words that have few senses (Chapters 5 and 7; Hino et al., 1996; Hino et al., 2002). This sense advantage is explained by the greater amount of semantic activation created following recognition of polysemous words relative to single-sense words. In the present reading task, such a sense advantage may be difficult to observe because the appropriate sense is selected according to context and this may serve to restrict activation to inappropriate senses. If the number of senses influences reading times for target items, the direction of the effect was expected to be negatively linear. That is, as the number of senses increases across languages a polysemy advantage may be observed. Even if different senses exist in the L1 and L2, these are not likely to influence (inhibit) reading times due to the existence of textual context and also because almost no targets do have starkly different meanings in the L2.[44]

In order to account for the potential effect of polysemy upon reading times, the number of English senses for words (WordNet, Princeton, 1990) was used as an additional predictor in the analysis. The number of senses was considered to be a potentially useful measure of L2 semantic processing that is not influenced by L1 knowledge, in comparison to the cross-linguistic S similarity measure. In other words, while S similarity accounts for S similarity across languages, the number of senses is more narrowly defined to account for the polysemy of words in the L2 only.

As discussed previously, participants were placed in either a high or a low L2 (English) proficiency group depending on their self-rated L2 proficiency, age of English acquisition and length of stay in the United Kingdom. To account for any differences in performance for these two groups, a two-level (high/low) factorial predictor was included in the statistical analyses.

Word length was controlled because as word length increases, the probability of fixating a word increases (Rayner & McConkie, 1976), and therefore the probability of a word being skipped decreases. However, word length is highly correlated with word frequency, such that shorter words tend to be more frequent. Thus, the likelihood of fixations on (and skipping) words may be due to both length and word frequency (Rayner, Sereno, & Raney, 1996). Both length and frequency have been shown to be important in predicting fixation duration (Rayner, 1998; Rayner & Duffy, 1986) and are thus are included as predictors in the statistical modelling procedure. Word frequency was taken from the BNC (2007)

[44] It is more problematic to consider the effect of the number of senses of the 'expected translation' in Japanese because this translation is not certain (i.e., a number of possible translations are possible in some cases). In fact, an English word may activate multiple translations in some cases, while activating only one translation in others. A number of translations measure was used to account for this possible confound but revealed no significant influence in the statistical models. In contrast, it is expected that any influence of S similarity will heavily derive from the number of senses of the English word, as the general linguistic context is expected to bias readers' S activation to L2 words.

and log-transformed to improve linearity and reduce random variance (Baayen, 2008).

Other inherent lexical characteristics of targets that could influence processing were also considered: mean letter bigram frequency, lemma frequency (a count of all occurrences of derivatives of the target word in the BNC, 2007) and orthographic neighborhood size (the number of orthographically similar words taken from the Elexicon website, Bates et al., 2007). However, these predictors (particularly bigram and lemma frequency) are highly correlated with the strongest lexical predictors in word reading, frequency and length, and thus to avoid issues related to collinearity they were omitted from the analyses. (Even though residualization was used to control for collinearity of predictors, including many highly correlated predictors that predict very similar types of variance, such as word frequency and lemma frequency or bigram frequency, is disadvantageous in statistical modelling.) Orthographic neighborhood size was not significant in any analyses when added and is thus not discussed further.

Morphological complexity was measured by counting the number of morphemes in each word. This was included this as an additional predictor in the analyses. Morphological complexity has been shown to be important in reading English (Andrews, Miller, & Rayner, 2004; also see Balling, 2012) as readers decompose words into their constituent morphemes as they read. Moreover, in an L2 (English) reading task with Danish-English bilinguals, Balling (2012) showed that morphologically complex cognates were processed more slowly than morphologically simple cognates. Therefore, it could be expected that single morpheme words confer a processing advantage, as no decomposition is required.

As mentioned previously, a number of control variables were included to control for effects related to the text. Firstly, a binary measure of whether or not the word was followed by a comma was included to control for any potentially extended fixations on targets due to this factor. An influence of commas, which indicate clause boundaries, could be observed as it is known that words at the beginning and end of sentences receive slightly larger fixations (Rayner, 1998). Thus, words at the end of clauses that are followed by commas may be similarly extended. A total of 6 (out of 28) cognates and 5 (out of 28) noncognates were followed by a comma in the text. However, in the final analyses, this variable was not significant and thus is not discussed further. Secondly, the numerical position of the word in the text (where the first word is 1) was included to assess the possible build up of contextual information that dictates overall reading speed. This factor also acts as an indicator of any reading/task fatigue, which would be demonstrated by reading times becoming slower as the text progresses.

The predictability of subsequent words in a text has been shown to be an important indicator of reading times (e.g., Balling, 2012; McDonald & Shillcock, 2003). From these studies it appears that readers use statistical information about the probability of words co-occurring in particular sequences, or *n*-grams, to predict upcoming words in sentences. To account for the predictability of targets appearing in the text, a measure was added which used the frequencies of word sequences from the BNC (2007). To calculate this measure, the frequency of the trigram in which the item appears as the last word was divided by the frequency of the bigram that precedes the target word (for example, for the target item *bed*, the frequency of the trigram *lying in bed* was divided by the bigram *lying in*). Because zeros are common in the bi/trigram frequencies, a +1 transformation was applied to all frequencies in order to correct for these zero frequencies.[45]

Dependent measures

Three early reading measures and one late measure were used as the response variables in the analysis. First-fixation duration (FFD), which is the duration of the first fixation on the target word, was used as a measure of early processing. Gaze duration (GD or first run/pass

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[45] It is also possible to account for zero frequencies of *n*-grams by using Kneser–Ney smoothing (Chen & Goodman, 1998; see Balling, 2012 for an example of this approach to a similar task), which estimates the frequencies of *n*-grams based on smaller attested *n*-grams and the number of words that the target co-occurs with in the text.

duration), which is the sum of all durations of fixations on target from the first fixation to the time of leaving the word, was also used as a measure of early processing because GD accounts for all fixations on a word before proceeding (or regressing) in the text. The FFD and GD on a word are believed to reflect lexical access and word recognition processes. The third early measure used was the percentage of skipped targets. Natural reading involves parafoveal processing of upcoming words in the text (Rayner, 1998); if a word is not directly fixated upon then it is likely that the word has been processed sufficiently processed while the reader was fixated upon the preceding word. This measure provides an indication of the overall familiarity, as well as predictability, of the word, because less predictable and familiar words will be skipped less often. Finally, one late measure of reading was included, total reading time (TRT), which is the total time spent fixated on the target word including regressions. This measure provides the best indicator of overall difficulty of the targets words as it includes regressions to the word following initial processing.

Results

Data cleaning

Only fixations that fell into the interest areas defined around the target words were considered for analysis. Interest areas were defined using an auto-segment function. Single fixations that were shorter than 100ms were excluded as these are likely to reflect oculomotor programming. Those over 800ms were also removed as these are likely due to blinks or momentary track loss (Rayner, 1998; Morrison, 1984). Fixations that were due to blinks and track loss but which had durations of less than 800ms were also identified and removed. This procedure lead to the removal of 7.2% of the total fixations that fell within the interest areas. Analysis by group indicated that 78% of cleaned fixations came from the low proficiency bilinguals' trials, which could be expected given the increased duration spent reading by this group relative to the high proficiency group. The number of fixations removed for the high proficiency group is in line with previous research with monolinguals (e.g., McDonald & Shillcock, 2003). To reduce any additional within-subject random variance, data points on all continuous dependent measures (FFD, FRD, TRT) that were +/-2 SDs of each participant's mean for that measure were removed. This lead to an additional 6.2% of data being removed.[46]

All participants except for one answered the six multiple-choice questions correctly (one participant answered one question incorrectly) immediately after finishing. This showed that all participants were reading the text for meaning comprehension and consequently all data can be used for statistical analyses.

The general pattern of fixation durations and number of items skipped is shown in Table 9.3. Importantly, there was no observed cognate advantage in any of the measures of fixation times. Conversely, for GD and TRT noncognates were fixated for shorter durations than cognates. This pattern of results was the same for both proficiency groups, though low proficiency participants fixated longer on words than higher proficiency participants (according to all continuous measures: FFD, GD and TRT). Thus, while proficiency strongly influenced the fixation durations of all measures, there appears to be no effect of proficiency on cognate/noncognate processing.

Table 9.3: Summary RT data for all dependent measures*

	SKIP		**FFD**	
Prof.	Cognate	Noncog	Cognate	Noncog
All	41 (8%)	30 (6%)	235 (76)	233 (78)
High	10 (2%)	10 (2%)	235 (78)	226 (69)
Low	31 (6%)	20 (4%)	245 (92)	245 (96)

	FRD		**TRT**	
Prof.	Cognate	Noncog	Cognate	Noncog
All	315 (144)	306 (131)	386 (218)	364 (174)
High	297 (137)	271 (108)	341 (156)	313 (144)
Low	365 (216)	360 (193)	458 (288)	434 (223)

*Proportions / standard deviations in parentheses

[46] Analyses both with and without the trimmed means (+/-2SDs) showed no significant difference between the final models for all dependent measures.

Overall, cognates were significantly more likely to be skipped than noncognates (8% vs. 6% of total data; X^2=10.37, df=1; *p*<.01). Low proficiency participants skipped more words than high proficiency groups overall (10% vs. 4%, respectively), though this difference was not significant (*t*=-0.408, df=229.589, *p*>.6). There was no difference for cognates and noncognates for the high proficiency group (both 2%, *p*.>.9). Low proficiency readers skipped more cognates than noncognates (6% vs. 4%, respectively), though this difference was not significant (*t*=1.196, df=319.351, *p*>.2).[47] Skipped items were treated as missing results in the analyses of FFD, FRD and TRT.

To investigate why some words were more likely to be skipped than others, a mixed effects model was fitted using the binomially distributed skipping data as the response variable and the aforementioned predictor variables. Random effects of items and subjects were included and analyses were conducted with lme4 (Bates, 2007). The final model resulted in one significant predictor, *word length* (*z*=1.975, *p*<.05), demonstrating that words were more likely to be skipped if they were shorter (skipped words *M*=6.1, *SD*=1.9; non-skipped words *M*= 6.6, *SD*=1.7; confirmed with a *t*-test comparison *t*=-2.372, df=99.091*, p*<.05). This is in line with previous research showing that words that are short are more likely to be skipped (Rayner & Duffy, 1988). P similarity was not predictive in the model once other factors were controlled for statistically, suggesting that cognates are not skipped significantly more often than noncognates (as was shown by the initial X^2 comparison). Given that cognates and noncognates were not matched on other factors (e.g., length, frequency), the mixed-effects model will be taken as the superior statistical test in this case. Thus, regarding the number of items skipped, there appears to be no reliable difference for cognates and noncognates.

[47] While X^2 tests are preferred for binary data, not all comparisons (e.g., the number of cognate and noncognate items) contained an equal number of occurrences for each group. In such cases, *t*-tests were used for comparisons.

Mixed effects modelling

To explore the contribution of the various factors on reading times, mixed-effects modelling (Baayen, et al., 2008) was conducted with R version 2.11.1 (R Core Development Team, 2010). The following predictors were considered in the model: Mean P similarity; mean S similarity; L2 proficiency (high/low); log-transformed English word frequency (BNC, 2007); word length; number of morphemes; context predictability; and position in the text. Finally, an interaction between P and S similarity was included in the model.

A correlation analysis was performed for all item predictors to ascertain which were significantly correlated (see Chapter 5 for this procedure). The resulting residuals were significantly correlated with their related variables (p<.01). Continuous predictors (not residualised) were centred but this made no difference to models (p>.2). By-subjects random slopes for predictors tied to items and by-items random slopes for predictors tied to subjects were also fitted but these did not make any significant difference to the final models (p>.05).

A backward simplification procedure was automated using the package LMER Convenience Functions (Tremblay, 2012), such that all terms and the interaction between P and S similarity were in the initial model and non-significant interactions and individual terms were removed step-by-step. Interaction terms were always removed prior to individual terms, and each time a term was removed an ANOVA (Analysis of Variance) and log-likelihood ratio testing was performed to test whether this removal significantly affected the predictive capability of the model. If the removal was significant (p<.05) then the term was retained in the model. The coefficients of the fixed effects, their Higher posterior Density (HPD) intervals, p-values based on 10,000 Markov Chain Monte Carlo samples of the posterior samples of the parameters of the final models and the p-values obtained from t-tests are presented. The standard deviation, median and mean coefficients based on MCMC sampling, and HPD intervals for random effects of participants and items in the final model are shown below each table.

The final models for FFD, GD and TRT are presented below in Tables 9.4, 9.5 and 9.6, respectively. Surprisingly, there were no significant predictors in the final model for FFD (p<.05). The reasons for this finding are taken up in the Discussion. In the following section, only the GD and TRT models are discussed.

Most importantly, there was no significant effect of P similarity on GD or TRT, indicating no effect of cognate status on L2 reading with these Japanese-English bilinguals (p>.1). The interaction between P and S similarity was also not significant (p>.1). A binary measure of cognate status was used instead of P similarity, but this made no difference to the final model.

S similarity was not significant for either GD or TRT reading measures (p>.1). In a previous experiment, S similarity was shown to be independent of other semantic variables, such as number of senses and concreteness (lexical decision, Chapter 5). However, S similarity partially reflects the number of senses known in each language and how much these senses overlap across languages. As there appears to be greater influence of L2 measures on the bilingual's reading times (frequency, length, and so on), an additional L2-specific semantic variable, the number of English senses (WordNet, Princeton, 1990), was added to the model. If readers are utilising L2 lexical-semantic knowledge when reading, more-polysemous words may show greater facilitation than less-polysemous words due to the increased S activation associated with more-polysemous words, as has been observed in single-word recognition tasks (e.g., lexical decision; Hino et al., 2002; Rodd et al., 2002). However, if sentence context restricts the meanings of words to those relevant in context, the number of English senses may be irrelevant to reading times. To test these predictions, the number of senses of the English word was added to both GD and TRT models. The number of English senses was significant in both final models (p<.01 and p<.05, respectively), such that more-polysemous words were read more quickly than less-polysemous words. The models were unchanged except for this additional effect. Another semantic variable, concreteness, has also been shown to be predictive of RTs in lexical decision (Chapters 5 and 7). Concreteness was also added to the model in addition to the English number of senses and S similarity, however, it was not significant in either GD or TRT models (p>.1). In sum, while S similarity and concreteness did not affect reading times, the number of English senses explained a significant portion of the variance in reading times. The reasons for these findings are taken up in the Discussion.

Second language proficiency was significant in both GD and TRT final models (p<.06 and p<.01, respectively), such that higher L2 proficiency led to reduced fixation times. L2 proficiency was more highly significant in the TRT model compared to the GD model. In other words, the early measure of fixations shows that processing was influenced by proficiency, such that participants made a greater number of fixations during the first gaze period, but that proficiency made a greater impact on the late measure of fixation times. This suggests that lower proficiency bilinguals made a greater number of regressions to the targets than higher proficiency bilinguals, as the late measure incorporates all fixations on the target.

Log-transformed English word frequency was highly significant in both GD and TRT models (p<.001), such that more frequent words were fixated on for shorter durations. Word length was also was highly significant in both GD and TRT models (p<.001), showing that longer words received longer fixation times. Both word frequency and word length effects on reading times are well documented. Importantly, this study establishes that bilinguals show effects L2 lexical properties in reading in a similar fashion to monolinguals (e.g., Rayner, Sereno & Raney, 1996).

The number of morphemes (morphological complexity) was significant in both GD and TRT models (p<.001 and p<.01, respectively). This shows, similar to Balling (2012), that L2 readers spend more time reading words that are morphologically complex than those that are morphologically simple. However, in contrast to Balling (2012) no cognate effect was observed in the present study, even when an interaction term was added for morphological complexity and P similarity (or the binary cognate status predictor; p's>.1).

The position of words in the text was significant in the GD model only ($p<.05$), showing that readers appeared to fixate more on targets as the task progressed. This may reflect the level of processing required during reading a continuous text. As more information is processed, readers must construct meaning from the text based on previous context. This effect appears in early reading measures, such that words that came later in the text received longer fixations at the initial processing stage. This variable was not significant for TRT, suggesting that once readers have processed the word initially during the first run, the build up of contextual information has no further effect. That is, readers do not regress to words more when reading has continued for some time, but the initial processing of words is affected by the build up of contextual information.

Finally, context predictability was a significant predictor in the GD model ($p<.05$) but not the TRT model ($p>.1$). This effect shows that as the predictability of a word increased, based on the predictability of the word following the previous two words, reading times were less. This was only significant for the GD measure, suggesting that predictability influences first-pass reading times but not total reading time. This finding is similar to that reported by Inhoff (1984), who found that FFD and GD were both affected by word frequency, but only GD was affected by the predictability of the word in the context. This led him to conclude that GD and TRT measure different processes, a finding which has since been shown to be at least partially true (Rayner, 1998). Crucially, this shows that predictability influences bilingual reading in the same way that it influences monolingual reading.

Table 9.4: Final model for log-transformed first fixation durations (FFD) for targets

Fixed Effects	Estimate	MCMC mean	HPD95 lower	HPD95 upper	pMCMC	Pr(>|t|)
(Intercept)	5.406	5.405	5.343	5.475	0.001	0.000

Random Effects						
Groups	Name	Std. Dev.	MCMC median	MCMC mean	HPD95 lower	HPD95 upper
Item	(Intercept)	0.014	0.013	0.017	0.000	0.049
Participant	(Intercept)	0.097	0.094	0.097	0.050	0.146
Residual		0.294	0.295	0.294	0.277	0.312

Table 9.5: Final model for log-transformed first run durations (FRD) for targets

Fixed Effects	Estimate	MCMC mean	HPD95 lower	HPD95 upper	pMCMC	Pr(>|t|)
(Intercept)	5.484	5.482	5.300	5.627	0.001	0.000
L2 proficiency	0.179	0.180	-0.007	0.367	0.070	0.057
Word frequency	-0.068	-0.068	-0.096	-0.038	0.001	0.000
Word Length	0.112	0.112	0.075	0.143	0.001	0.000
Morphological complexity	0.180	0.181	0.085	0.279	0.001	0.000
Position in text	0.000	0.000	0.000	0.000	0.026	0.034
Context predictability	-0.147	-0.148	-0.275	-0.036	0.018	0.010

Random Effects						
Groups	Name	Std. Dev.	MCMC median	MCMC mean	HPD95 lower	HPD95 upper
Item	(Intercept)	0.022	0.020	0.024	0.000	0.065
Participant	(Intercept)	0.145	0.140	0.146	0.080	0.231
Residual		0.378	0.378	0.379	0.357	0.403

Table 9.6: Final model for log-transformed total reading time (TRT) for targets

Fixed Effects	Estimate	MCMC mean	HPD95 lower	HPD95 upper	pMCMC	Pr(>|t|)
(Intercept)	5.655	5.651	5.514	5.783	0.001	0.000
L2 proficiency	0.263	0.269	0.09	0.456	0.004	0.002
Word frequency	-0.088	-0.088	-0.117	-0.049	0.001	0.000
Word Length	0.145	0.144	0.107	0.187	0.001	0.000
Morphological complexity	0.169	0.168	0.063	0.295	0.002	0.007

Random Effects

Groups	Name	Std. Dev.	MCMC median	MCMC mean	HPD95 lower	HPD95 upper
Item	(Intercept)	0.086	0.055	0.052	0.000	0.109
Participant	(Intercept)	0.127	0.126	0.133	0.063	0.218
Residual		0.414	0.419	0.419	0.393	0.445

Reading measures

The eye movement data was used to provide a further measure of the respective reading abilities of the bilinguals in the two proficiency groups. The dependent measures of reading performance were number of fixations, average fixation duration, number of saccades, average saccade amplitude, and average reading time (all measures are per trial, in other words, per paragraph). Table 9.7 shows significant differences in all of the comparisons across proficiency groups (p<.05). The number of fixations and average fixation duration was greater for the low proficiency group and the number of saccades and reading time was shorter, all indicating increased difficulty in processing the texts relative to the high proficiency group. The average saccade amplitude was shorter for the low proficiency group suggesting lower reading fluency compared to the higher proficiency group. Taken together, these results demonstrate that the two proficiency groups were significantly different in their reading fluency and thus qualify the distinction between the two groups in terms of their language proficiency.

Table 9.7: Measures of reading performance for the two proficiency groups

	High Proficiency (*n*=5)	Low Proficiency (*n*=6)	*p*-value
Number of fixations	72.2 (28.5)	96.8 (20.7)	<.001
Average fixation duration	223.3 (17.2)	229.7 (19.9)	<.05
Number of saccades	81.8 (22.9)	116.9 (37.4)	<.001
Average Saccade amplitude	4.8 (0.7)	4.2 (0.7)	<.001
Average reading time	21010ms (6269ms)	30762ms (10306ms)	<.001

*Standard deviations in parentheses

Discussion

The present study set out to test whether formal and semantic similarity across different script languages influenced bilinguals' reading times of cognates and noncognates in a free reading task. Participants read an extended text in their own time and correctly answered comprehension questions related to the text, which indicates that the task was successful in getting participants to process the text for comprehension. The influences of P and S similarity are discussed in the following sections, followed by a discussion of other important predictors of reading times, such as L2 proficiency.

Most importantly, no effect was found of P similarity on any of the dependent measures of reading times. Moreover, a binary cognate status measure was similarly not significant at predicting variance in reading times. In terms of the predictions of the experiment, when O is not shared, as in English and Japanese, P cross-linguistic similarity between languages appears to be insufficient to influence reading times in the L2. This finding runs contrary to previous findings in single-word L2 word recognition tasks (i.e., lexical decision) that utilised Japanese-English cognates (Chapters 5 and 7; Taft, 2002). The primary difference between the free reading task in the present experiment and lexical decision tasks used previously (Chapters 5 and 7) is the availability of linguistic context provided by the text compared to the absence of context in lexical decision. The findings can be interpreted in terms of the BIA+ for word recognition, in that bottom-up linguistic tuning towards the language of the text boosts activation of L2 O/P lexical representations, thus minimizing activation of L1 P representations. Additionally, top-down activation of L2 O/P lexical representations via L2 S representations may also contribute to minimizing any influence of bottom-up cross-linguistic P similarity. Thus, while L1 P similarity significantly facilitated bilinguals' responses to cognates in lexical decision tasks (Chapters 5 and 7), there was no such facilitation observed in free reading. This finding has important implications for language learning and teaching, which are discussed in the following chapter (Chapter 10, Discussion).

The role of S similarity was shown in previous chapters of this thesis to vary depending on the type of task and items used. In the present free reading task S similarity was shown to be a poor predictor of reading times. The reason for this may be similar to explanation for the null effect of cross-linguistic P similarity discussed previously. Because L2 SOP features are strongly activated by the L2 context, L1 P/S activation is presumed to be minimal in comparison. Thus, S similarity, which measures the degree of S overlap *across* languages, appears to be insufficient to explain any variance in reading times due to its reliance on both L1 and L2 semantic knowledge.

If the context biases activation of L2 SOP codes then presumably an effect should be observed for a measure of the semantic content of targets in the L2. In the present study, the number of English senses derived from WordNet (Princeton, 1990) was used to test this idea. Analyses revealed that it did indeed significantly predict variance, such that words having a greater number of senses lead to speeded reading times relative to those having fewer senses. This polysemy advantage in reading parallels the findings for L2 lexical decision using (Chapters 5 and 7). However, whereas both the number of English senses and S similarity were significant (after correlations had been dealt with through the process of residualization) in L2 lexical decision, only the L2 (WordNet) measure was significant in the free reading task. This appears to support the idea that semantic features of items in the language of the text are activated in free reading and that semantic features unique to the

L1 are only minimally activated in a similar manner to L1 P features. If L1 S and P features are activated, the level of activation did not seem to impact processing in this L2 free reading task.

The present findings suggest that cognate effects for languages that differ in script are not observed in tasks that provide a rich, language-specific context. This finding may be likened to how high-constraint sentences tend to reduce/nullify cognate effects (e.g., Duyck et al., 2007; Libben & Titone, 2008; Schwartz & Kroll, 2008; Van Hell & De Groot, 2008), in that semantic constraints imposed by the text bias activation in favour of the language of the sentence. While the present study did not manipulate the degree of constraint of sentences, the overall increased L2 S activation driven by reading an extended L2 text may have partially contributed to reducing the impact of L1 P similarity effects. While these results do not necessarily support the idea of a language-selective mechanism for bilingual processing, they do support the notion that rich language-specific contexts can lead to effects that resemble language-selective processing (note also that previous findings in this thesis show strong support for inherent non-selectivity in L2 tasks; Chapters 5 and 7). In other words, boosted L2 lexical representations via bottom-up and top-down mechanisms lead to reduced effects of cross-linguistic P/S similarity in L2 reading.

In contrast, in the present study no effect was found for L1 formal or semantic similarity, even when continuous measures were used. This is likely due to the fact that Japanese and English differ in script, which means that in terms of the BIA+, no O cross-linguistic activation occurred. Moreover, due to phonological and phonotactic constraints, phonology is never completely shared across languages, and Japanese-English cognates are never completely phonologically identical. Thus, the BIA+ predicts an overall reduced degree of cross-linguistic activation for different script languages than for same script languages due to the absence of O overlap. This overall reduced level of formal facilitation, in combination with the boosted L2 linguistic features, appears to be the most likely explanation for the lack of cross-linguistic similarity effects in the present study. In other words, while it was possible to observe a cognate effect in sentence-processing tasks with languages that share script (Van Assche et al., 2009, 2011), this does not appear to be the case for different script languages, at least in free reading. Having said that, there are currently no sentence-processing tasks that have been documented and that use different-script languages, thus this is an empirical question that warrants further exploration. In sentences that have low S constraint, bottom-up effects of P similarity even in different script languages may be possible, while it would be unlikely to observe any influence of P similarity in high-constraint sentences. This would be an interesting question to address in future research.

The observed cognate effect in the free reading task conducted by Balling (2012) is in contrast to the present study. Similar to the above discussion of Van Assche et al. (2012), the shared script of Danish-English cognates may be a primary factor leading to the increased facilitation of cognates relative to noncognates. Because Danish-English cognates overlap considerably in terms of both O and P, there is likely to be greater activation of L1 O and P features during L2 reading. An important related factor is that processing of L2 words that share script is likely to be faster than that of L2 words that differ in script (Schoonbaert et al., 2009, 2011). When bilinguals process an L2 that shares the script of the L1, the machinery used to process both languages is more likely to be better developed than when learners are processing an L2 that differs in script. Thus, the faster activation of both L1 and L2 O and P features could be due to a faster visual word recognition system. This would consequently lead to greater cross-linguistic effects that would be observable during L2 tasks.

Another important question addressed in the present study is that of the influence of L2 proficiency on reading times, particularly with respect to the impact of cross-linguistic similarity. Two different groups of bilinguals read texts in the present study: bilinguals with native (or near-native proficiency) and those with a lower level of L2 proficiency. The balanced bilinguals (native speakers in both languages) and unbalanced bilinguals (native speakers of L1 and intermediate-level L2 proficiency) did differ in their reading times on both GD and TRT measures, such that the balanced bilinguals fixated for shorter durations overall than the unbalanced bilinguals. Importantly, when interaction terms were added for L2 proficiency and P / S similarity this did not impact the degree of cross-linguistic influence as no interaction was found between L2 proficiency and P or S similarity. Even when analyses were conducted separately for the to groups, no effects emerged for P or S similarity. Previous research has shown a reduced cognate effect for high-proficiency bilinguals in high-constraint sentences (Libben & Titone, 2009). In the present study, which provided a rich L2 linguistic context, no difference was found between the two groups. As discussed previously, the absence of L1 influence on L2 reading times is likely to derive from both the boosted L2 linguistic context and the lack of shared O, and this was the case for both groups of bilinguals in the present study. It remains to be seen whether a similar study in the future with much lower level L2 proficiency bilinguals would reveal cross-linguistic effects of P similarity.

The morphological complexity of words was shown to be a significant predictor of L2 word reading for both early and late measures, such that words with more morphemes require increased processing time. This finding parallels that of Balling (2012) who found a similar effect for processing Danish-English cognates. However, contrary to Balling (2012), the morphological complexity of items did not influence the likelihood of observing a cognate effect. In Balling (2012) the facilitatory effect of cognate status was only observed for morphologically simple words, whereas a trend for slowed reading times was found for morphologically complex words. Given the fact that P and S similarity were very poor predictors of reading times in the present study, it is unsurprising that no additional modulation of this effect was found when looking at the interaction with morphological complexity.

Finally, it is important to address the question of why FFD was not a good measure of reading times in the present study. While GD and TRT showed the standard effects of word frequency and word length (Rayner & Duffy, 1986; Rayner, 1998), these variables were not predictive of FFDs. It is particularly difficult to explain the absence of frequency and length effects on initial fixations because they were such highly significant predictors of GD and TRT (p's<.001). One may suppose that some additional behavioural factor must have influenced FFDs, with the result that the initial fixations were not representative of normal reading processes. However, looking at the data is unclear how the FFDs could have been adversely affected by some behavioural factor, when the other measures revealed the standard word frequency and length effects.

Conclusion

Previous research using single-word recognition tasks (i.e., lexical decision) has shown that Japanese-English cognates (e.g., *television*-テレビ/terebi/) are processed more quickly than noncognates by Japanese-English bilinguals reading in the L2 (English). However, in the free reading task presented herein, Japanese-English bilinguals of native and intermediate level L2 proficiency did not exhibit any advantage for processing cognates relative to noncognates. The present study thus shows that when reading texts, as opposed to words in isolation, the linguistic context provided by the text promotes L2 word activation, which reduces the influence of the cross-linguistic similarity of cognates. Whereas previous studies have found cognate facilitation in L2 sentence-reading (Van Assche et al., 2011) and authentic text reading tasks (Balling, 2012), these are believed to stem from combined influences of shared script and the resulting increased SOP activation relative to that for different-script languages, such as Japanese and English.

Chapter 10. Discussion

Overview of the chapter

Cross-linguistic similarity is known to be an important aspect of language knowledge that influences bilingual processing and representation (e.g., Dijkstra, 2007; Ellis, 2008; Jarvis & Pavlenko, 2008; Odlin, 1989). As discussed within this thesis, the effects of cross-linguistic similarity on bilingual processing vary depending on the degree of overlap in terms of formal O-P and S features across languages, the degree of language proficiency in each language (language dominance) and the type of task being performed. In this chapter, I provide a synthesis of the findings presented in this thesis including a discussion of the implications in terms of bilingual models of processing and representation as well as the directions for future research.

The Japanese language and Japanese-English cognates were described in detail in Chapter 2. It was shown that while there are many thousands of English cognates existing in Japanese (e.g., there were 23,000 cognate entries in a comprehensive Japanese dictionary (*Kojien*, 1998) and around 90% of such loanwords are typically imported from English (Shinnouchi, 2000)), there are considerable differences in the structural make-up of Japanese and English languages that may impact the degree of similarity (or cognateness) that bilinguals perceive. Following previous studies that define cognates in terms of formal (P and/or O) and S overlap (e.g., Dijkstra et al., 1999; Dijkstra et al., 2010; Tokowicz et al., 2002), the perceived overlap in terms of P and S features was proposed as a basis for understanding cross-linguistic similarity of Japanese-English cognates, as they do not share O. In Chapter 3, various models of bilingual processing were considered in terms of how they can account for the effects of cross-linguistic similarity in bilingual production and recognition tasks. The conclusion from that chapter was that while all of the existing models have limitations, the interactive activation models were the most theoretically well developed in terms of their explanations of cross-linguistic similarity. Specifically, the BIA+

for word recognition (Dijkstra & Van Heuven, 2002), Costa et al.'s (2005) model of picture naming and Multilink (Dijkstra & Rekké, 2012) for word translation were shown to be superior to other models in regard to the level of detail provided about the role of cross-linguistic similarity in bilingual processing.

In the following sections, I synthesize the findings for P similarity and then S similarity measures.

Summary of the role of P similarity

A key finding from Chapter 4 was that bilinguals perceive Japanese-English cognates to vary in terms of P overlap and thus continuous measures of these lexical characteristics were suggested to be more appropriate than a simple binary measure of cognate status. The cross-linguistic P similarity measure derived from Chapter 4 was subsequently shown to predict bilingual performance in both L2 picture naming and lexical decision tasks (Chapter 5). These findings support previous research that has observed facilitatory effects of cognate status in L2 tasks with languages that share or differ in script (e.g., Christoffels et al., 2006; Costa et al., 2000; De Groot et al., 1994; De Groot & Nas, 1991; Dijkstra et al., 1999; Gollan et al., 1997; Kroll & Stewart, 1994; Sánchez-Casas et al., 1992; Schwartz et al., 2007). Importantly, the use of continuous measures of cross-linguistic similarity was argued to be superior to a binary measure of cognate status.

In this thesis, the role of P similarity in bilingual processing was shown to vary depending on the type of task, the stimulus list composition, the level of L2 proficiency and whether encountering single words or sentences. Firstly, it was shown that as the degree of P similarity increased pictures were named more quickly in the L2, though only when they also had high S overlap (Chapter 5). In other words, the facilitatory role of P similarity in picture naming was evidenced only in the interaction for P and S similarity and not in the main effects of these measures. In contrast, P similarity was a much stronger predictor of responses in L2 lexical decision, such that increased P similarity led to faster and more accurate responses (Chapter 5). The potential of P similarity as a measure of performance was thus shown to depend on the task. Specifically, in word recognition, which is faster than picture naming, the facilitatory role of P similarity was more apparent.

The finding that P similarity was highly predictive of responses in lexical decision when stimulus lists included both cognates and noncognates (Chapter 5), but not when stimulus list were restricted to cognates only (Chapter 7) suggests that stimulus list composition is an important factor in observing P similarity effects in bilingual processing. In Chapter 5, not only was P similarity predictive of responses in lexical decision with cognate and noncognate items, an additional analysis of the cognate-only items used in the lexical decision task revealed a significant facilitatory effect of the degree of P similarity. This showed that a fine-grained continuous measure of P similarity was predictive of responses even when the items were restricted in terms of their P similarity (i.e., all items were rated between *similar* and *very similar*). However, this finding was not replicated in Chapter 7, where all items were cognate. Here there was no effect of P similarity in L2 lexical decision. This was true for items that were preceded by related and unrelated primes, revealing no notable effect of P similarity in lexical decision regardless of prime type. For translation prime-target pairs, the P activation created by the L1 prime likely mitigated any observable P similarity effect of L2 targets, as cross-linguistic activation had already been achieved by way of the L1 primes. For unrelated prime-target pairs, the activation of unrelated lexical items prior to processing the targets may have created competition between the prime and target items, meaning that the fine-grained effects of P similarity for cognates as observed in the non-primed lexical decision task were not observed when primes were present. Future studies may test this idea by including a baseline in which null primes (i.e., a blank prime or sequence of non-linguistic symbols) are included in the stimulus list. In contrast to the L1-L2 task, L2 translation primes were completely ineffective at facilitating responses to L1 targets, meaning that P similarity is unlikely to have been implicated in the initial processing of the prime. This is in line with previous research showing that L1 tasks are rarely affected by L2 cross-linguistic similarity when participants are dominant in the L1 (Basnight-Brown and Altarriba, 2007; Duñabeitia et al., 2010, 2011; but see Duyck & Warlop, 2012).

Another factor determining the role of formal (O/P) similarity effects in L2 reading is the availability of linguistic and semantic context (Duyck et al., 2007; Scwartz & Kroll, 2006; Van Assche et al., 2009, 201l; Van Hell & De Groot, 2008). When a task was used that provided linguistic context, as in the extended L2 reading task in Chapter 9, L1 P similarity effects were not observed. This was hypothesized to be due to the important role of tuning of bottom-up processing mechanisms and also top-down S activation during free reading. Specifically, the linguistic context including the semantic and syntactical dependencies of words in sentence/text context create increased L2 activation relative to single-word L2 tasks such as lexical decision. Thus, the overall L2 activation deriving from the availability of linguistic context reduces any potential influence of bottom-up P similarity with the L1. In sum, when context is provided by the task, processing appears to be more biased to the language that is being used in the task and the L1 exerts only minimal influence on processing of individual words.

Another critical determinant of whether effects of P similarity can be observed is bilingual language proficiency, with such effects being typically observable in the L2 but not in the L1. In L1 picture naming (Chapter 6), P similarity was not predictive of bilinguals' naming processes. This was hypothesized to be due to the language dominance of participants, such that when bilinguals are L1 dominant and have intermediate-high L2 proficiency, an influence of P cross-linguistic similarity is unlikely to be observed. This supports previous research in which L1-dominant bilinguals rarely show L2 similarity effects in L1 tasks (Basnight-Brown & Altarriba, 2007; Duñabeitia et al., 2010, 2011; but see Duyck & Warlop, 2012). In Chapter 9, there was no modulation of P similarity effects by proficiency, even though both balanced and unbalanced bilinguals participated in the study. This was hypothesized to be due, however, to the linguistic context provided by the text. In sum, the role of language dominance or relative language proficiency was also shown to be an important predictor of the effects of cross-linguistic P similarity.

In the L2 tasks, L2 proficiency was not shown to modulate the effects of P similarity. In other words, differences in L2 proficiency for participants did not impact the likelihood of observing or degree of P similarity effects in L2 picture naming, lexical decision, masked priming lexical decision or free reading tasks. In terms of IA models, language proficiency is defined in terms of the subjective frequency of sublexical and lexical representations in each language. When bilinguals have higher proficiency in a language, the subjective frequency of these representations is higher, resulting in faster activation during processing. When bilinguals are dominant in one language, the subjective frequency of words in that language are higher than in the non-dominant language. This suggests that greater cross-linguistic activation may occur in tasks that require use of the non-dominant language, which is what was observed (Chapters 5 and 7). However, gradient effects of language proficiency did not appear to modulate the role of cross-linguistic similarity within the L2 tasks. For proficiency to emerge as a significant predictor of cross-linguistic P similarity, it may be that groups with a greater variety of L2 proficiency (i.e., very high and very low) should be tested. This remains a question for future research.

Taken together, the findings of the experiments within this thesis implicate an important role of P similarity in the processing of cognates by Japanese-English bilinguals but this role is modulated by a number of item, task and participant factors. In terms of bilingual models of processing and representation, most of the findings described above can be explained by IA models (i.e., the BIA+ for word recognition and Costa et al.'s model for picture naming). One recent study (Miwa, 2013) provides a useful visualization of how the BIA+ can be used to explain cross-linguistic effects of P similarity with Japanese-English bilinguals (see Figure 10.1). Arrows indicate facilitatory links between levels of processing and the representations in the two languages, while connections indicated by circles indicate lateral inhibitory connections. These links follow the same pattern as those described for the BIA+ in

Chapter 3. Importantly, in the model depicted in Figure 10.1, as in the present thesis, it is predicted that there is no direct activation of L1 *kana* orthography via the L2 orthography (as indicated by the dotted lines). In this model, sublexical phonological features that overlap in the L1 (Japanese) and L2 (English) become more activated by a visual word stimulus in the L2 (e.g., *interview*) than sublexical phonological features that do not correspond across languages. Correspondingly, lexical P representations become more active in both languages when they share a greater number of P features (or degree of P similarity). Thus, as observed in the present study (Chapter 5), increased P similarity would lead to greater cross-linguistic activation according to this model.

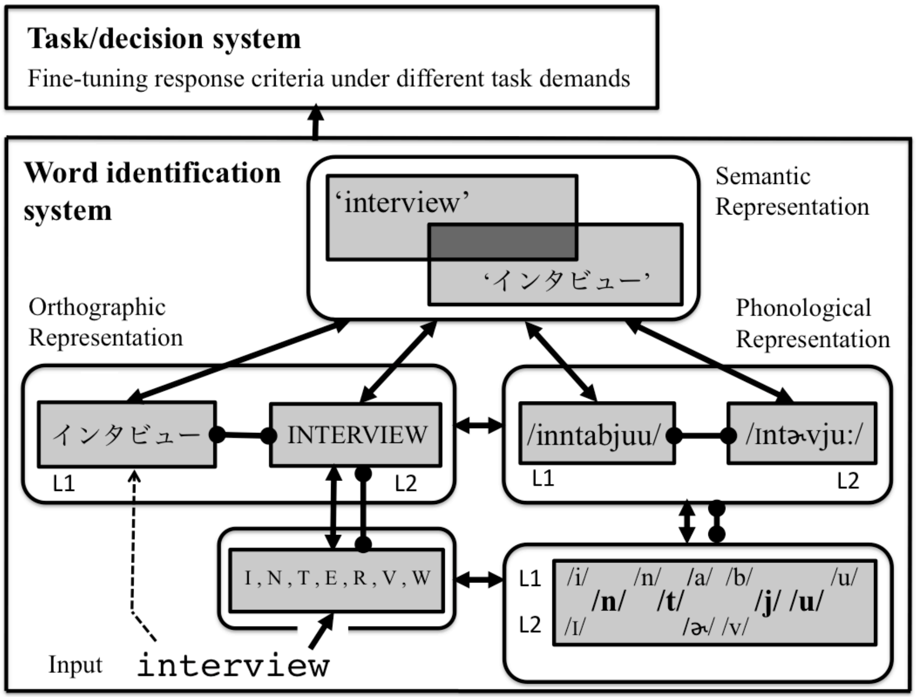

Figure 10.1: The BIA+ adapted for Japanese-English bilingual processing (from Miwa, 2013).

Summary of the role of S similarity

In Chapter 4, Japanese-English bilinguals rated translation pairs in terms of their S overlap. They were instructed to consider the various meanings of the translations in both languages (Japanese and English) and rate the degree of overlap of these meanings. As all word pairs were translations and all items were rated as having S overlap, but the degree of overlap varied depending on the S characteristics of the translations. Previous research has also collected such measures of S similarity for Dutch-English translations (Dijkstra et al., 2010; Tokowicz et al., 2002), but the present research is the first study to collect this data for languages that do not share script and are etymologically unrelated. An important characteristic of S similarity is that it is highly correlated with both concreteness and the number of senses in each language, such that more concrete words and those that have few senses are rated as being more S similar. Concreteness and the number of senses are also highly correlated, such that more concrete words typically have fewer senses than more abstract words. However, whereas concreteness and number of senses measures are typically collected for items in one language, S similarity reflects bilinguals' knowledge of two languages, as opposed to one. Thus, S similarity is inherently a bilingual measure of the S characteristics of translations, while it also reflects concreteness and polysemy of translations in both languages.

In Chapter 5, the combination of both increased P and S similarity led to faster responses in L2 picture naming, but these measures were not predictive by themselves. This somewhat weak effect of S similarity may have been due to the picture naming items all being concrete and thus having few senses in both languages. When abstract words were also included in a subsequent lexical decision task (Chapter 5), it was shown that increased S similarity had the opposite effect, leading to significantly slower responses. In other words, when words overlapped less in S similarity across languages, they were responded to more quickly. This finding was hypothesized to be due to the increased polysemy of S less similar items relative to S more similar items. The facilitatory effects of polysemy in lexical decision have been observed before in monolingual studies (e.g., Chapter 9, this thesis; Hino et al., 2002; Rodd et al., 2002) and the present results appear in line with such findings.

Additional support for this finding was gained in a subsequent L2 masked priming lexical decision experiment (Chapter 7). In this experiment, responses to L2 items were facilitated when items were less S similar (i.e., more polysemous), as in Chapter 5. This finding was also replicated in a monolingual version of this task (see Chapters 7 and 9), indicating that the polysemy effects observed in the L2 task were largely due to the number of senses in English (L2), as opposed to S similarity (overlap of senses in the L1 and L2). Because the monolinguals had no knowledge of Japanese, the speeded responses for more polysemous words could only be due to the number of senses in English, not Japanese.

In contrast, in masked priming lexical decision with Japanese (L1) targets that all had few senses, increased S similarity led to faster responses. Because all items had few senses the role of concreteness was shown to be significant in addition to the number of senses. Thus, words that had fewer senses and were more concrete were responded to more quickly than words that were both abstract and had more senses. The contradictory nature of these findings in the L2 and L1 was suggested to result from the combination of number of senses and concreteness. Tokowicz and Kroll (2007) also found that when items had only one sense, responses were facilitated by increased concreteness in monolingual lexical decision but when items had more than one sense the concreteness advantage was actually reversed. Tokowicz and Kroll's (2007) study is important because it is one of the only studies to look at the roles of both concreteness and polysemy in lexical decision. What we have shown in the present study is that the number of senses and concreteness are important factors that depend on both stimulus list composition (items with few or many senses) and task type (picture naming and lexical decision). The complex interactions between these S characteristics of words warrants further research.

Importantly, when bilinguals are processing words in context, the role of L1 S (and P) overlap with the L2 was not predictive of reading times, while the number of senses in the L2 was (with items that were more polysemous in the L2 being read more quickly). Thus, the role of S similarity in context-dependent tasks appears to be minimal and instead a measure of polysemy in the language of the text may be sufficient to predict the influence of S features on reading performance.

Compared to P similarity ratings, which requires bilinguals to judge the overlap of P features of translations across languages, S similarity is a much more complex measure. It is perhaps due to this complexity that S overlap has received little attention in the literature on cross-linguistic similarity. While many studies have looked at the role of formal overlap (O/P) in bilingual tasks (e.g., Kroll & De Groot, 1997; Van Assche et al., 2009, 2010; Van Hell & De Groot, 1998), many have simply controlled for S similarity by assuming complete overlap, usually by utilizing translations that are almost always translated into one another, meaning that they are very semantically similar. The disadvantage of this approach is that such studies typically have employed only concrete items (e.g., Kroll & De Groot, 1997; Van Hell & De Groot, 1998) because abstract items are usually translated using more than one translation (see Chapter 4), which is due to fact that abstract words tend to have more and different meanings across languages. Other studies have not consider the role of S similarity in their materials selection (e.g., Van Assche et al., 2010, 2011), which is unfortunate because as has been described here, cognate status includes varying degrees of similarity in terms of formal *and* semantic features.

In terms of bilingual models, S overlap has also received relatively little attention. The two IA models, the BIA+ and Multilink, assume localist representations of semantic information. When words have multiple senses, in order to reflect this in these models, additional semantic representations would have to included for each sense in order that the words in each language can be connected to some or all of these semantic representations (e.g., *bat* in English would have different semantic representations for “the animal” and “the hitting device”, while バット/batto/ in Japanese would share only the latter sense with the English word). In the adapted model presented previously (Miwa, 2013; Figure 10.1), the overlapping representations indicate how conceptual features (or senses) are only partially shared across English and Japanese. However, this model also assumes localist representations of senses and thus it is unclear how such overlap could be implemented in a computational model. At present, the IA models cannot sufficiently explain how words can have some overlapping senses across languages but not others, and how these differences may impact word recognition and translation processes. Similarly, concreteness and polysemy effects in word recognition, which are highly related to S similarity, are not explained in such models.

Multilink goes someway to address the issue of S relatedness of words (within languages) by using norms from the S association databases for pairs of words in each of the bilinguals' languages. These measures are used as indicators of the degree of S relatedness of two particular words in terms of how often they are associated with one another by speakers of those languages. The two norms used in Multilink, one for English the other for Dutch, are utilized as though they are mutually exclusive. However, semantic relatedness is likely to be similar regardless of language. For example, whereas *look* and *see* are likely to be semantically associated in English because of their overlap in meaning, the Dutch equivalents *kijken* and *zien* are also likely to be similarly related to one another. Across languages, the translations of *look-kijken* and *see-zien* are also likely to be semantically associated if bilinguals were asked to provide associations across languages (as in Van Hell and De Groot, 1998). In order to specify more precisely how S overlap is represented in the bilingual lexicon and how it influences processing, it may be necessary to create some form of translation association database. This would provide a measure of how semantically related translations are perceived to be. Such a measure would provide an alternative to S similarity, while crucially still being derived from bilinguals' knowledge of word meaning (as opposed to a dictionary/translation approach). In this case, concreteness would also need to be evaluated and controlled for statistically to see if it adds any additional explanatory potential above the cross-linguistic S association measure.

Costa et al.'s (2000/2005) conceptual model of bilingual picture naming has the potential to explain cross-linguistic effects of S overlap, as it assumes distributed S features that can overlap to varying degrees. However, this model was only developed for picture naming, meaning it has restricted applicability to other tasks, especially those for word recognition. Moreover, Costa et al.'s model (2000/2005) has not been computationally implemented, meaning that it is not possible to confirm the role of S overlap.

Another conceptual model, the Distributed Conceptual Feature Model (Van Hell & De Groot, 1998; see Chapter 3, this thesis) attempts to explain overlap of S features across languages while also accounting for the role of concreteness (and formal similarity). Concrete words are believed to share more S features across languages than abstract words. This makes sense when one considers that abstract words tend to be translated using multiple translations and more concrete words being translated using fewer translations. Also, there is the potential for words to share more features if they have more overlapping senses and fewer features if they have few overlapping senses. However, this model is not implemented computationally and thus, while it provides a framework for understanding S overlap and the role of concreteness, it cannot be used as an additional component within the IA models described previously. Future work should attempt to integrate a more developed S level in IA models.

Finally, it is worth mentioning the Sense Model (Finkbeiner et al., 2004), which was described in detail in Chapter 7. The primed lexical decision experiment in that chapter showed that the Sense Model cannot adequately account for cross-linguistic priming asymmetry in lexical decision. This was because the prediction that total activation of the senses is what drives the priming effect was shown to be ineffectual at leading to L2-L1 priming, even when words shared both form and meaning (i.e., cognates). However, the idea that conceptual features are 'bundled' into senses is intuitively appealing, and studies looking at the representation of polysemous words lend support to the idea (e.g., Klein & Murphy, 2001). It is also generally the case that words in different languages overlap only partially and that bilinguals typically know more senses in their L1 (or dominant language). In sum, while the Sense Model built upon the DCFM model, and is useful for understanding the representation of polysemous words in the bilingual lexicon, it also makes false predictions for cross-linguistic priming in lexical decision.

Limitations

A number of limitations mean that further work is necessary to qualify the findings of the present research. In Chapter 5, the picture naming study may have benefitted from the use of a familiarization phase so to eliminate inaccurate responses and hesitations due to deciding what the stimuli were actually depicting (e.g., *penguin* vs. *bird* or *truck* vs. *car*). While the stimuli all had high naming agreement rates (Nishimoto et al., 2005), meaning the targets were generally unambiguous, a familiarization phase would have likely lead to quicker responses overall, which ultimately would have improved the data gained. This is because faster responses have less room for random variance than those that are delayed. Another limitation is the number and range of items used across the studies. Although selecting both concrete and abstract items may lead to findings that are more representative of lexical processing in general (as opposed to restricting the items to simple, concrete nouns), a much greater number of items is necessary for qualifying the present findings across different tasks. Cross-linguistic similarity ratings and number of translations data (Chapter 4) for a
much greater number of items would also prove ultimately more useful as data for other researchers who are interested in conducting studies with Japanese-English bilinguals. Finally, while most of the findings of the present experiments were discussed in terms of IA models, none of the data have currently been used to test whether implemented versions of the models can replicate the findings gained from Japanese-English bilinguals. This is discussed further in the following section on future directions.

Future directions

A number of future directions have already been articulated at the end of the chapters containing experimental work. Perhaps most importantly, further research is needed in developing models of bilingual word production and recognition that make detailed predictions about how cross-linguistic similarity, particularly S similarity, influence bilingual processing. In the present study it was shown that lower S similarity speeds responses in lexical decision, and this was suggested to be due primarily to the increased number of senses that is typical of low S similarity translations. Such findings have not been reported before in the bilingual literature, though similar results have been reported for monolinguals (Hino et al., 2002). Future work will be needed to further develop the theoretical basis of S similarity and how it impacts processing and representation. Teasing apart the contributions of concreteness, number of senses and bilingual aspects will be critical in such work. Bilingual IA models have yet to implement any measures of cross-linguistic S similarity, though clearly this is an important factor for predicting bilinguals' language behaviour. Additionally, though P similarity was shown to be the crucial measure of cross-linguistic similarity for languages that differ in script, it has received less interest and has been less widely tested in IA models, relative to O similarity. The BIA+ and other IA models may be useful tools for testing the theoretical basis of both P and S cross-linguistic similarity for languages that differ in script. The rating and number of translations data provided in this thesis, as well as the response data from Japanese-English bilinguals, should be useful for researchers wanting to explore such lines of inquiry.

Importance of cognates in language learning

Cognates have long been recognised by applied linguists as a source of potential language transfer (e.g., Odlin, 1989, pp.77–80; Ringbom, 1987, pp.113–14, 119). It is also recognised that the similarities across languages in terms of script, phonology and semantics, play a significant role in the likelihood of transfer. (This is often discussed in terms of *language distance*, where, for example, English and French are closely related while English and Japanese are more distant). Michael Swan

(2008) notes that conceptual similarities (sometimes discussed in terms of *cultural distance*) are also an important factor in language transfer of semantics. Swan (2008) notes that although Spanish and Hungarian share few cognates, there is considerable conceptual overlap of many words due to similarities in the cultures in which the languages developed. As such, some applied linguists have recommended integrating 'systematic study' of cognates into language learning programmes (e.g., Meara, 1993). Cognates are also an important consideration for language testing, as one study showed that French L1 post-secondary school students scored better in a vocabulary test with a number of cognates than one without (Meara, Lightbown and Halter, 1994).

However, there is not widespread agreement amongst teachers/applied linguists about how cognates might support language learning. In the case of Japanese language, in studies with teachers of Japanese as a second language (JSL), the teachers believed that learners (with L1 English) will process Japanese katakana words (i.e., cognates) more easily because of L1 knowledge (Prem, 1991;Tomita, 1991; c.f. Kess & Miyamoto). It is often assumed that *katakana* words provide a 'gateway' for learners of Japanese. For example, in a textbook that introduces the *katakana* script and a set of frequently used loanwords to elementary learners of Japanese (Matsumoto-Stewart, 1993), it is assumed that loanwords present instant-gratification in learning Japanese vocabulary. However, Koda (1993) in her review of the book offers an opinion that loanwords rarely sound similar across English-Japanese and thus learners with English L1 often end up more confused than learners from other L1 backgrounds. Thus, it is clear that teachers/applied linguists' beliefs vary considerable on the benefits of cognates in language learning. However, many such beliefs are rarely based on empirical research on the study of how language users process cognates, which may explain the great divide in opinion on the benefits of cognates.

The present study provides a thorough introduction to previous research investigating the role of cognates in language processing, and provides new empirical evidence on the subject, which may be of interest for teachers and applied linguists. For instance, cognates with greater degrees of P overlap were shown to have a processing advantage in an L2 when single words were presented in isolation (Chapter 5), while the effects of P overlap were not observed during free reading, where the general linguistic context creates increased L2 activation (thus minimizing L1 activation). Thus, when teaching or testing language, the impact of cross-linguistic transfer may be less when tasks utilize context, as in extended reading tasks, relative to tasks that present words in isolation. In practical terms, when teachers and testers are instructing language learners or designing teaching materials, it may be more important to consider the degree of O/P/S cross-linguistic similarity when dealing with words out of context (e.g., lists of vocabulary) as opposed to words presented in meaningful sentence and discourse contexts. In terms of language production, while this thesis showed a minor but significant role of cross-linguistic similarity in picture naming, the accuracy of pronunciation is an additional consideration that educators need to consider. While Japanese-English cognates share P similarity more than noncognates, there are still considerable differences that will impact the ease of pronunciation of words in the L2. Naturally, learning the accurate L2 pronunciation will be paramount in such cases in order to improve communicative ability.

Conclusions

While the present research may be of interest to applied linguists, it is more relevant to the work of psycho- and neuro-linguists, who are interested in how bilinguals process words and how they are represented in the mental lexicon. The findings presented in the present thesis provide the most comprehensive study of Japanese-English cognate processing by bilinguals. Here, it was demonstrated that Japanese-English cognates have a processing advantage relative to noncognates in certain tasks and under certain conditions. The role of P and S similarity does, however, depend on factors related to task type and design as well as the language (L1 or L2) that is used for the task. These findings add to a growing body of research that shows that even distant languages, such as Japanese and English, which do not share script, are activated simultaneously by bilinguals when working in the second language. The gradient nature of P and S similarity was thus shown to be an important consideration for researchers when investigating how bilinguals and second language learners process a second language.

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APPENDICES

APPENDIX 2.1

The kana syllabary

Hiragana items are followed by *katakana* equivalents in brackets, followed by transcriptions in *roomaji* (roman characters; cf. Kess and Miyamoto, 1999, p.85).

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Table 4.1 Total inventory of kana syllabaries.

あ (ア)	a	い (イ)	i	う (ウ)	u	え (エ)	e	お (オ)	o
か (カ)	ka	き (キ)	ki	く (ク)	ku	け (ケ)	ke	こ (コ)	ko
さ (サ)	sa	し (シ)	shi	す (ス)	su	せ (セ)	se	そ (ソ)	so
た (タ)	ta	ち (チ)	chi	つ (ツ)	tsu	て (テ)	te	と (ト)	to
な (ナ)	na	に (ニ)	ni	ぬ (ヌ)	nu	ね (ネ)	ne	の (ノ)	no
は (ハ)	ha	ひ (ヒ)	hi	ふ (フ)	fu	へ (ヘ)	he	ほ (ホ)	ho
ま (マ)	ma	み (ミ)	mi	む (ム)	mu	め (メ)	me	も (モ)	mo
や (ヤ)	ya	い (イ)	i	ゆ (ユ)	yu	え (エ)	e	よ (ヨ)	yo
ら (ラ)	ra	り (リ)	ri	る (ル)	ru	れ (レ)	re	ろ (ロ)	ro
わ (ワ)	wa	ゐ (ヰ)	i	う (ウ)	u	ゑ (ヱ)	e	を (ヲ)	o
ん (ン)	n								
が (ガ)	ga	ぎ (ギ)	gi	ぐ (グ)	gu	げ (ゲ)	ge	ご (ゴ)	go
ざ (ザ)	za	じ (ジ)	ji	ず (ズ)	zu	ぜ (ゼ)	ze	ぞ (ゾ)	zo
だ (ダ)	da	ぢ (ヂ)	ji	づ (ヅ)	zu	で (デ)	de	ど (ド)	do
ば (バ)	ba	び (ビ)	bi	ぶ (ブ)	bu	べ (ベ)	be	ぼ (ボ)	bo
ぱ (パ)	pa	ぴ (ピ)	pi	ぷ (プ)	pu	ぺ (ペ)	pe	ぽ (ポ)	po
きゃ (キャ)	kya			きゅ (キュ)	kyu			きょ (キャ)	kyo
しゃ (シャ)	sha			しゅ (シュ)	shu			しょ (ショ)	sho
ちゃ (チャ)	cha			ちゅ (チュ)	chu			ちょ (チョ)	cho
にゃ (ニャ)	nya			にゅ (ニュ)	nyu			にょ (ニョ)	nyo
ひゃ (ヒャ)	hya			ひゅ (ヒュ)	hyu			ひょ (ヒョ)	hyo
みゃ (ミャ)	mya			みゅ (ミュ)	myu			みょ (ミョ)	myo
りゃ (リャ)	rya			りゅ (リュ)	ryu			りょ (リョ)	ryo
ぎゃ (ギャ)	gya			ぎゅ (ギュ)	gyu			ぎょ (ギョ)	gyo
じゃ (ジャ)	ja			じゅ (ジュ)	ju			じょ (ジョ)	jo
びゃ (ビャ)	bya			びゅ (ビュ)	byu			びょ (ビョ)	byo
ぴゃ (ピャ)	pya			ぴゅ (ピュ)	pyu			ぴょ (ピョ)	pyo

APPENDIX 4.1

Cross-linguistic similarity measures: *English name, Japanese name*, the item pair in English and Japanese; *Transcription*, the roman letter transcription of the Japanese word; *Katakana reading*, the transcription of the Japanese word into katakana for confirming the phonetic reading; *Picture naming*, whether or not the item was selected from Nishimoto et al's (2005) picture naming study, if not, the item was selected from a high-frequency wordlist derived from a large web-corpus (Kilgariff et al., 2004); *Cognate status*, whether the item can be termed a cognate (C) or noncognate (NC), based on its obvious phonological and semantic similarity in English and Japanese; *Japanese (L1) age-of-aquisition*, the mean rating for age-of-acquisition gained from 22 bilinguals using the following scale: 1) 0-2 years, 2) 3-4 years, 3) 5-6 years, 4) 7-8 years, 5) 9-10 years, 6) 11-12 years and 7) 13 years or later; *English (L2) familiarity*, the mean rating gained from 19 bilinguals using a scale of 1-7: response categories ranged from very unfamiliar (1) to very familiar (7); *Concreteness (L1)*, the mean concreteness rating for Japanese words gained from 18 bilinguals using a scale of 1-7: response categories ranged from very abstract (1) to very concrete (7); *No. Trans L1-L2*, the total number of different accurate English translations given for the Japanese word; *No.Trans L2-L1*, the total number of different accurate Japanese translations given for the English word; *NoML1*, the total number of different meanings translated for the L2 (English) word into the L1 (Japanese), i.e., only one meaning of the English word *class* was translated into Japanese; *NoML2*, the total number of different meanings translated for the L1 (Japanese) word into the L2 (English), i.e., only one meaning of the Japanese word クラス /kurasu/ 'class' was translated into English; *Phonological similarity*, the mean phonological similarity rating for item pairs using a scale from 1 (competely different) to 5 (identical); *Semantic similarity*, the mean semantic similarity rating for item pairs using a scale from 1 (competely different) to 5 (identical).

English name	Japanese name	Transcription	Katakana reading	Picture naming	Cognate status	Japanese (L1) age-of-acquisition	English (L2) familiarity	Concreteness (L1)	No. Trans L1-L2	No. Trans L2-L1	NoM L1	NoM L2	Phonological similarity	Semantic similarity
access	アクセス	*akusesu*	アクセス	No	C	4.5	4.8	3.4	1	5	1	1	3	3.9
acid	酸	*san*	サン	No	NC	4.8	3.5	4	1	3	1	1	1.2	4.5
aid	援助	*enjo*	エンジョ	No	NC	4.4	3.3	2.9	5	7	1	2	1.4	4.1
arm	腕	*ude*	ウデ	Yes	NC	4	3.6	5.4	1	2	1	2	1	4.2
arrow	矢印	*yajirushi*	ヤジルシ	Yes	NC	3.4	3.4	4.4	4	1	2	1	1	3.3
ashtray	灰皿	*haizara*	ハイザラ	Yes	NC	4.2	2	5.4	1	2	2	1	1.1	4.1
balloon	風船	*fuusen*	フウセン	Yes	NC	3.6	3.3	5.6	1	2	1	2	1	4.7
banana	バナナ	*banana*	バナナ	Yes	C	3.3	4	5.7	1	1	1	1	3.4	4.9
bed	ベッド	*beddo*	ベッド	Yes	C	3.9	4.8	5.7	1	1	1	1	3.7	4.7
bench	ベンチ	*benchi*	ベンチ	Yes	C	3.7	4.1	5.6	1	2	1	1	4.2	4.1

English name	Japanese name	Transcription	Katakana reading	Picture naming	Cognate status	Japanese (L1) age-of-acquisition	English (L2) familiarity	Concreteness (L1)	No. Trans L1-L2	No. Trans L2-L1	NoM L1	NoM L2	Phonological similarity	Semantic similarity
bicycle	自転車	*jitensha*	ジテンシャ	Yes	NC	4	4.1	5.7	2	1	1	1	1	4.7
blank	空白	*kuuhaku*	クウハク	No	NC	4.6	4.1	4.3	2	3	1	1	1.1	3.7
bone	骨	*hone*	ホネ	Yes	NC	4.1	3.2	4.9	1	1	1	1	1	4.6
bricks	レンガ	*renga*	レンガ	Yes	NC	3.4	2.9	5.7	2	3	2	1	1.1	3.7
broom	ほうき	*houki*	ホウキ	Yes	NC	3.4	2.7	5.5	3	1	1	1	1	2.3
brush	ブラシ	*burashi*	ブラシ	Yes	C	3.5	4	5.4	1	2	1	2	3.1	4.2
bus	バス	*basu*	バス	Yes	C	3.8	3.1	5.8	1	1	1	1	4.1	4.7
bust	胸	*mune*	ムネ	No	NC	4.3	3.2	4.9	2	3	1	1	1.2	4.2
button	ボタン	*botan*	ボタン	Yes	C	3.8	4.1	5.6	1	1	1	1	3	4.2
cake	ケーキ	*keeki*	ケーキ	Yes	C	3.5	4.5	5.4	2	1	1	1	2.6	4.2
call	コール	*kooru*	コール	No	C	4.6	4.7	2.7	1	4	1	2	3	3.6
camel	ラクダ	*rakuda*	ラクダ	Yes	NC	3.2	3.5	5.7	1	2	1	1	1.1	4.1
care	ケア	*kea*	ケア	No	C	4.6	4.1	2.8	1	8	1	2	3.9	4.1
career	キャリア	*kyaria*	キャリア	No	C	4.4	3.7	3.1	1	5	1	2	2.9	3.6
carrot	人参	*ninjin*	ニンジン	Yes	NC	3.6	3.1	6.1	1	1	1	1	1	4.8
case	ケース	*keesu*	ケース	No	C	4.3	4.5	3.7	1	6	1	2	3.3	3.8
caution	注意	*chuui*	チュウイ	No	NC	4.3	3.6	2.5	4	3	2	2	1.1	4.1
cherry	さくらんほ	*sakuranbo*	サクランボ	Yes	NC	2.9	4	5.9	1	2	1	1	1	4.1
chimney	エントツ	*entotsu*	エントツ	Yes	NC	3	2.1	5.3	1	1	1	1	1	3.7
class	クラス	*kurasu*	クラス	No	C	4	4.8	4.3	2	2	1	1	3.5	3.7
classic	クラシック	*kurashikku*	クラシック	No	C	4.4	4.3	4.2	1	2	1	2	3.7	3.7
clear	クリアー	*kuriaa*	クリアー	No	C	4.4	4.2	2.6	1	6	1	3	3.7	3.6

English name	Japanese name	Transcription	Katakana reading	Picture naming	Cognate status	Japanese (L1) age-of-acquisition	English (L2) familiarity	Concreteness (L1)	No. Trans L1-L2	No. Trans L2-L1	NoM L1	NoM L2	Phonological similarity	Semantic similarity
clue	手がかり	*tegakari*	テガカリ	No	NC	4.3	3.6	2.8	3	2	1	1	1.1	3.9
cool	クール	*kuuru*	クール	No	C	4.3	4.6	2.7	1	4	1	2	3.9	3.8
coral	サンゴ	*sango*	サンゴ	No	NC	4.2	2.8	5.3	1	1	1	1	1.2	3.7
core	コア	*koa*	コア	No	C	4.9	3.5	2.6	1	4	1	1	3.7	4.1
course	コース	*koosu*	コース	No	C	4.3	4.5	3.4	1	3	1	2	3.9	4.5
cow	牛	*ushi*	ウシ	Yes	NC	3.8	3.3	5.7	3	2	2	1	1	4.6
crime	犯罪	*hanzai*	ハンザイ	No	NC	4.3	3.5	3.4	3	3	2	1	1.1	4.6
cross	クロス	*kurosu*	クロス	No	C	4.3	3.7	3.2	1	4	1	2	3.5	4.1
cure	治る	*naoru*	ナオル	No	NC	4.2	4	3.3	5	4	1	2	1.1	3.7
curtain	カーテン	*kaaten*	カーテン	Yes	C	3.3	3.9	5.5	1	1	1	1	3.4	4.5
cycle	サイクル	*saikuru*	サイクル	No	C	4.6	4	2.5	1	5	1	2	3.3	4
deer	シカ	*shika*	シカ	Yes	NC	3.5	3.1	5.8	2	1	1	1	1	4.7
demand	要求	*youkyuu*	ヨウキュウ	No	NC	4.6	4	2.9	6	3	2	1	1.1	4.3
desk	机	*tsukue*	ツクエ	No	NC	4.4	4.6	5.7	1	1	1	1	1	4.4
dolphin	イルカ	*iruka*	イルカ	Yes	NC	3	3.4	5.7	1	1	1	1	1	4.9
door	ドア	*doa*	ドア	Yes	C	3.6	5.4	5.4	1	2	1	1	3.6	4.6
dress	ドレス	*doresu*	ドレス	Yes	C	3.8	4.3	5.4	1	4	1	3	3.2	4.1
dresser	たんす	*tansu*	タンス	Yes	NC	3	2.8	5.6	5	3	1	3	1	3.1
eagle	ワシ	*washi*	ワシ	Yes	NC	3.5	3	5.7	3	2	1	1	1.2	4.5
elephant	象	*zou*	ゾウ	Yes	NC	3.4	3.2	5.8	1	1	1	1	1	4.9
exit	出口	*deguchi*	デグチ	No	NC	4.3	4.2	3.9	1	2	1	2	1.1	4.1
fail	失敗	*shippai*	シッパイ	No	NC	4.7	4	2.5	4	2	1	1	1.1	4.1

English name	Japanese name	Transcription	Katakana reading	Picture naming	Cognate status	Japanese (L1) age-of-acquisition	English (L2) familiarity	Concreteness (L1)	No. Trans L1-L2	No. Trans L2-L1	NoM L1	NoM L2	Phonological similarity	Semantic similarity
find	見つける	*mitsukeru*	ミツケル	No	NC	4	4.6	3.1	3	2	1	2	1.1	4.3
firm	会社	*kaisha*	カイシャ	No	NC	4	3.6	3.8	3	5	1	3	1.2	2.9
fish	魚	*sakana*	サカナ	Yes	NC	4.1	4.6	4.3	1	1	1	1	1	4.6
flag	旗	*hata*	ハタ	Yes	NC	4.3	3.8	5.2	1	1	1	1	1	4.3
flute	フルート	*furuuto*	フルート	Yes	C	3.9	4	5.7	1	1	1	1	3.8	4.1
fool	バカ	*baka*	バカ	No	NC	3.4	3.7	2.7	3	2	1	1	1	4.1
foot	足	*ashi*	アシ	Yes	NC	3.5	4.3	5.6	2	1	2	1	1	3.8
fork	フォーク	*fooku*	フォーク	Yes	C	3.1	3.8	5.6	2	1	2	1	3.9	4.1
fox	キツネ	*kitsune*	キツネ	Yes	NC	3.1	3.5	5.6	1	1	1	1	1	4.6
frog	カエル	*kaeru*	カエル	Yes	NC	3.1	3.1	5.8	1	1	1	1	1	4.6
front	前	*mae*	マエ	No	NC	4	4.4	3.5	4	3	3	2	1.1	4.3
fuel	燃料	*nenryou*	ネンリョウ	No	NC	4.7	3.6	3.7	3	2	2	2	1.1	4.5
fund	資金	*shikin*	シキン	No	NC	4.5	3.5	3.6	5	5	1	1	1.1	4.1
future	将来	*shourai*	ショウライ	No	NC	4.4	4.8	2.4	1	2	1	1	1.1	4.4
genre	ジャンル	*janru*	ジャンル	No	C	4.4	3.2	2.6	3	2	1	1	2.5	4.1
giraffe	キリン	*kirin*	キリン	Yes	NC	3	3	6.1	1	1	1	1	1	4.3
glass	グラス	*gurasu*	グラス	No	C	3.7	4.4	5.3	1	3	1	2	3.7	4.1
goal	ゴール	*gooru*	ゴール	No	C	3.7	4.6	3.9	1	4	1	2	3.6	4.6
goat	ヤギ	*yagi*	ヤギ	Yes	NC	2.8	2.6	5.8	1	3	1	1	1	4.5
gorilla	ゴリラ	*gorira*	ゴリラ	Yes	C	2.8	3.6	5.9	1	1	1	1	3.3	4.7
grapes	ブドウ	*budou*	ブドウ	Yes	NC	3	3.4	5.8	1	1	1	1	1	4.6
guitar	ギター	*gitaa*	ギター	Yes	C	3.7	4.3	5.6	1	1	1	1	3.1	4.9

English name	Japanese name	Transcription	Katakana reading	Picture naming	Cognate status	Japanese (L1) age-of-acquisition	English (L2) familiarity	Concreteness (L1)	No. Trans L1-L2	No. Trans L2-L1	NoM L1	NoM L2	Phonological similarity	Semantic similarity
hammock	ハンモック	*hanmokku*	ハンモック	Yes	C	4	2.6	5.3	1	1	1	1	3.3	5
hanger	ハンガー	*hangaa*	ハンガー	Yes	C	3.1	4.4	5.7	2	1	2	1	3.6	4.1
hate	憎む	*nikumu*	ニクム	No	NC	4.9	4	2.4	1	3	1	1	1.1	4.1
head	頭	*atama*	アタマ	No	NC	3.8	4.7	5.2	1	1	1	1	1.1	4.1
heart	ハート	*haato*	ハート	Yes	C	4.4	4.5	3.3	1	3	1	2	3.2	3.7
helicopter	ヘリコプタ	*herikoputc*	ヘリコプタ	Yes	C	3.6	4	5.8	1	1	1	1	3.4	4.9
helmet	ヘルメット	*herumetto*	ヘルメット	Yes	C	3.4	3.7	5.4	1	1	1	1	3.6	4.9
hope	希望	*kibou*	キボウ	No	NC	4.9	4.9	1.9	1	4	1	2	1.3	4.1
ideal	理想	*risou*	リソウ	No	NC	4.6	3.5	2.2	2	1	1	1	1.2	4.1
iron	アイロン	*airon*	アイロン	Yes	C	3.6	3.6	5.7	1	2	1	2	3.2	2.8
jar	つぼ	*tsubo*	ツボ	No	NC	4.4	2.6	5.2	1	3	3	1	3.6	4.6
joint	関節	*kansetsu*	カンセツ	No	NC	4.4	3	4.5	1	5	1	2	1.1	3.1
joke	ジョーク	*jooku*	ジョーク	No	C	4.5	4.5	3.4	1	2	1	1	3.3	4.6
jury	陪審	*baishin*	バイシン	No	NC	5.4	2.6	4.1	1	2	1	1	1.1	4
kangaroo	カンガルー	*kangaruu*	カンガルー	Yes	C	3.3	3.6	5.9	1	1	1	1	3.5	4.9
kick	キック	*kikku*	キック	No	C	3.4	4.5	4.4	1	2	1	1	3.9	4.6
kiss	キス	*kisu*	キス	No	C	4	4.3	4.4	1	2	1	1	3.6	4.7
ladder	はしご	*hashigo*	ハシゴ	Yes	NC	3.2	2.8	5.2	1	3	1	1	1	4.1
learn	習う	*narau*	ナラウ	No	NC	3.9	4.5	3.1	1	2	1	1	1.1	4.4
left	左	*hidari*	ヒダリ	No	NC	3.6	4.3	4.3	1	2	1	2	1.1	4.4
lemon	レモン	*remon*	レモン	Yes	C	3.1	4.2	5.8	1	1	1	2	3.4	4.9
lesson	レッスン	*ressun*	レッスン	No	C	4.2	5.1	3.8	1	5	1	1	3.5	4.3

English name	Japanese name	Transcription	Katakana reading	Picture naming	Cognate status	Japanese (L1) age-of-acquisition	English (L2) familiarity	Concreteness (L1)	No. Trans L1-L2	No. Trans L2-L1	NoM L1	NoM L2	Phonological similarity	Semantic similarity
lion	ライオン	*raion*	ライオン	Yes	C	3	3.8	5.6	1	2	1	2	3.7	4.9
lips	唇	*kuchibiru*	クチビル	Yes	NC	3.6	3.7	5.5	1	1	1	1	1	4.7
loan	ローン	*roon*	ローン	No	C	4.9	3.7	3.7	1	6	2	1	4	3.9
lobster	ザリガニ	*zarigani*	ザリガニ	Yes	NC	3	3.1	5.8	2	5	1	1	1	3.5
local	ローカル	*rookaru*	ローカル	No	C	4.3	4.8	3.4	1	3	1	1	3.4	3.9
loose	緩い	*yurui*	ユルイ	No	NC	4.4	3.8	2.8	3	6	1	1	1.2	3.9
lucky	ラッキー	*rakkii*	ラッキー	No	C	4	5.1	2.4	1	3	1	2	3.8	4.3
matter	物事	*monogoto*	モノゴト	No	NC	4.6	4.1	3	4	3	2	1	1.1	3.6
maze	迷路	*meiro*	メイロ	No	NC	3.9	2.2	4.6	2	2	1	2	1.1	2.9
morale	モラル	*moraru*	モラル	No	C	4.6	3.2	2.7	1	5	1	1	2.9	4.1
naked	裸	*hadaka*	ハダカ	No	NC	3.4	3.1	4.9	2	3	1	1	1	4.3
necklace	ネクレス	*nekuresu*	ネクレス	Yes	C	3.9	4.5	5.5	1	3	1	1	3.6	4.8
normal	普通	*futsuu*	フツウ	No	NC	4.1	4.4	2.1	4	2	1	1	1.1	4.4
nose	鼻	*hana*	ハナ	Yes	NC	3.9	4.1	5.5	1	1	1	1	1.1	4.9
past	過去	*kako*	カコ	No	NC	4.6	4.1	2.2	2	2	1	1	1	4.3
peanut	ピーナツ	*piinatsu*	ピーナツ	Yes	C	3.3	4	5.8	1	2	1	1	3.3	4.9
pelican	ペリカン	*perikan*	ペリカン	Yes	C	3.3	2.7	5.8	1	1	1	1	3.4	4.8
pencil	鉛筆	*enpitsu*	エンピツ	Yes	NC	3.6	3.9	5.5	1	1	1	1	1.1	4.8
penguin	ペンギン	*pengin*	ペンギン	Yes	C	3.1	3.7	5.8	1	1	1	1	3.3	5
pig	豚	*buta*	ブタ	Yes	NC	3.6	3.5	5.7	1	1	1	1	1.1	4.6
pipe	パイプ	*paipu*	パイプ	Yes	C	4	3.1	5	1	4	1	1	3.7	4.4
place	場所	*basho*	バショ	No	NC	4.2	4.6	3.3	5	1	1	2	1	4.3

English name	Japanese name	Transcription	Katakana reading	Picture naming	Cognate status	Japanese (L1) age-of-acquisition	English (L2) familiarity	Concreteness (L1)	No. Trans L1-L2	No. Trans L2-L1	NoM L1	NoM L2	Phonological similarity	Semantic similarity
plain	明白	*meihaku*	メイハク	No	NC	4.9	3.6	2.4	3	12	2	1	1	3.3
pool	プール	*puuru*	プール	Yes	C	3.8	3.6	5.5	1	3	1	3	3.6	4.3
prison	刑務所	*keimusho*	ケイムショ	No	NC	4.4	3.1	5.4	2	3	1	2	1.2	4.5
profit	利益	*rieki*	リエキ	No	NC	4.5	3.3	2.9	4	2	2	1	1	4.5
pyramid	ピラミッド	*piramiddo*	ピラミッド	Yes	C	3.7	3.2	5.3	1	3	1	1	3.4	4.6
rabbit	ウサギ	*usagi*	ウサギ	Yes	NC	3	3.7	6.1	1	2	1	1	1	5
race	レース	*reesu*	レース	No	C	4.5	4.2	4.4	1	3	1	1	3.2	3.8
radio	ラジオ	*rajio*	ラジオ	Yes	C	3.9	4.2	5.4	1	1	1	2	2.5	4.6
rain	雨	*ame*	アメ	No	NC	3.6	4.5	5.1	1	2	1	1	1.3	4.1
rank	ランク	*ranku*	ランク	No	C	4.1	4.4	3.2	1	7	1	1	3.7	4.1
real	リアル	*riaru*	リアル	No	C	4.5	4.3	2.5	1	4	1	2	3.3	4.2
regular	レギュラー	*regyuraa*	レギュラー	No	C	4.2	4.6	3.2	1	5	1	2	3.3	3.7
release	リリース	*ririisu*	リリース	No	C	4.6	3.7	3.1	1	7	1	1	3.7	3.9
rental	レンタル	*rentaru*	レンタル	No	C	4.2	4.5	3.9	1	8	1	2	3.3	4.4
return	リターン	*ritaan*	リターン	No	C	4.3	4.2	3.2	1	8	1	1	3.4	4.3
ring	指輪	*yubiwa*	ユビワ	Yes	NC	3.9	4	5.3	1	5	1	2	1.1	4
rocket	ロケット	*roketto*	ロケット	Yes	C	3.8	3.5	5.2	1	1	1	3	3.6	4.5
roll	ロール	*rooru*	ロール	No	C	3.9	3.6	3.1	2	6	2	1	3.2	4
rule	ルール	*ruuru*	ルール	No	C	4.1	4.5	3.1	1	7	1	1	3.5	4.3
sailor	水兵	*suihei*	スイヘイ	No	NC	5.3	2.7	5.2	2	9	1	2	1.1	4.1
scale	スケール	*sukeeru*	スケール	No	C	4.5	3.6	2.8	1	5	1	1	3.3	4
scissors	はさみ	*hasami*	ハサミ	Yes	NC	3.3	2.7	5.7	1	1	1	4	1.1	4.7

English name	Japanese name	Transcription	Katakana reading	Picture naming	Cognate status	Japanese (L1) age-of-acquisition	English (L2) familiarity	Concreteness (L1)	No. Trans L1-L2	No. Trans L2-L1	NoM L1	NoM L2	Phonological similarity	Semantic similarity
score	スコア	*sukoa*	スコア	No	C	4.5	4.2	3.4	1	4	1	1	3.7	4.3
screen	スクリーン	*sukuriin*	スクリーン	No	C	4.3	4.5	4.9	1	2	1	2	3.8	4.4
screw	ネジ	*neji*	ネジ	Yes	NC	3.2	3.1	3	1	4	1	1	1	3.5
sense	センス	*sensu*	センス	No	C	4.3	4.8	2.7	1	4	1	2	3.8	3.8
share	シェア	*shea*	シェア	No	C	4.4	4.7	5.4	1	4	1	2	3.9	4
shark	サメ	*same*	サメ	Yes	NC	3.1	3.1	5.2	2	2	1	1	1.1	4.9
shirt	ワイシャツ	*waishatsu*	ワイシャツ	Yes	C	3.8	4.4	2.7	2	1	1	2	1.7	3.4
shock	ショック	*shokku*	ショック	No	C	4.4	4.4	5.4	1	5	1	1	3.7	4.3
show	ショー	*shoo*	ショー	No	C	4.2	4.4	3.6	1	5	1	1	3.4	4
shower	シャワー	*shawaa*	シャワー	No	C	3.6	4.5	5.3	1	2	1	2	3.6	4.1
sign	サイン	*sain*	サイン	No	C	4.4	4.6	4	2	8	2	2	4	3.3
single	シングル	*shinguru*	シングル	No	C	4.3	4.3	3.1	1	6	1	2	3.2	4.1
size	サイズ	*saizu*	サイズ	No	C	4	4.7	3.3	1	2	1	2	3.7	4.3
ski	スキー	*sukii*	スキー	Yes	C	4	4.1	5.6	1	1	1	1	4.1	4.6
skill	スキル	*sukiru*	スキル	No	C	4.6	4.5	3.2	1	4	1	1	3.5	4.3
skirt	スカート	*sukaato*	スカート	Yes	C	3.5	4	5.6	1	1	1	1	3.2	4.8
slipper	スリッパ	*surippa*	スリッパ	Yes	C	3.3	3.5	5.6	1	2	1	2	3.4	4.2
slow	スロー	*suroo*	スロー	No	C	4.2	4.3	2.7	1	2	1	1	3.6	4.1
smell	香り	*kaori*	カオリ	No	NC	4.2	3.7	2.9	4	2	2	1	1	4
snake	ヘビ	*hebi*	ヘビ	Yes	NC	3.2	3.4	5.6	1	1	1	2	1.1	4.9
snowman	雪だるま	*yukidarum*	ユキダルマ	Yes	NC	2.8	3	5.2	1	3	1	1	1	4.6
sock	靴下	*kutsushita*	クツシタ	Yes	NC	3.5	3	5.8	1	2	1	2	1	4.6

English name	Japanese name	Transcription	Katakana reading	Picture naming	Cognate status	Japanese (L1) age-of-acquisition	English (L2) familiarity	Concreteness (L1)	No. Trans L1-L2	No. Trans L2-L1	NoM L1	NoM L2	Phonological similarity	Semantic similarity
solid	固体	*kotai*	コタイ	No	NC	4.7	3	3.2	3	4	1	1	1.2	4.1
spoon	スプーン	*supuun*	スプーン	Yes	C	2.8	4.4	5.9	1	3	1	2	4.3	4.8
stroke	なでる	*naderu*	ナデル	No	NC	3.5	3.2	4.2	2	7	1	1	1	2.3
style	スタイル	*sutairu*	スタイル	No	C	4.5	4.5	2.3	1	8	1	4	3.5	3.9
swan	白鳥	*hakuchou*	ハクチョウ	Yes	NC	3.7	3.1	5.6	1	1	1	1	1	4.6
tank	戦車	*sensha*	センシャ	Yes	NC	4.1	3.6	5.5	3	4	2	1	1	3.4
task	タスク	*tasku*	タスク	No	C	4.6	4.1	2.9	1	4	1	2	3.9	3.9
telephone	電話	*denwa*	デンワ	Yes	NC	4	4.3	5.1	4	1	2	2	1	4.9
television	テレビ	*terebi*	テレビ	Yes	C	3.6	4.4	5.7	1	1	1	1	2.4	4.9
tent	テント	*tento*	テント	Yes	C	3.7	3.4	5.2	1	1	1	1	3.9	4.8
tiger	トラ	*tora*	トラ	Yes	NC	3.2	3.4	5.7	1	1	1	1	1.7	4.8
toaster	トースター	*toosutaa*	トースター	Yes	C	3.5	3.6	5.8	1	1	1	1	3.5	4.7
tomato	トマト	*tomato*	トマト	Yes	C	3.8	4.2	5.9	1	1	1	1	2.8	4.9
tractor	トラクター	*torakutaa*	トラクター	Yes	C	3.7	2.7	5.2	1	1	1	1	3.6	4.8
trap	ワナ	*wana*	ワナ	No	NC	4	3.5	3.9	1	1	1	1	1	4.3
truck	トラック	*torakku*	トラック	Yes	C	4.1	3.6	5.6	1	1	2	1	3.5	3.9
trumpet	トランペッ	*toranpetto*	トランペッ	Yes	C	3.6	3.5	5.8	1	2	1	1	3.7	5
turtle	カメ	*kame*	カメ	Yes	NC	3.4	3.3	5.7	1	1	1	1	1	4.8
umbrella	傘	*kasa*	カサ	Yes	NC	3.3	3.7	5.6	1	1	1	1	1	4.9
vest	ベスト	*besuto*	ベスト	Yes	C	3.8	3.4	3.6	1	2	2	1	3.4	4.2
view	眺め	*nagame*	ナガメ	No	NC	4.6	4.2	3.2	3	11	2	1	1	4.1
violin	バイオリン	*bairorin*	バイオリン	Yes	C	3.7	3.7	5.7	1	1	1	2	3.3	4.8

English name	Japanese name	Transcription	Katakana reading	Picture naming	Cognate status	Japanese (L1) age-of-acquisition	English (L2) familiarity	Concreteness (L1)	No. Trans L1-L2	No. Trans L2-L1	NoM L1	NoM L2	Phonological similarity	Semantic similarity
wake	覚める	*sameru*	サメル	No	NC	4.2	3.6	2.8	2	3	1	1	1	4.1
warm	暖かい	*atatakai*	アタタカイ	No	NC	4.1	4	3.3	2	3	1	1	1	4.6
waste	浪費	*rouhi*	ロウヒ	No	NC	5	3.6	3.2	2	5	2	2	1	4
wolf	オオカミ	*ookami*	オオカミ	Yes	NC	3.8	3	5.4	1	1	1	2	1.1	4.9
work	ワーク	*waaku*	ワーク	No	C	4.7	4.8	3.1	1	2	1	1	3.6	4
youth	ユース	*yuusu*	ユース	No	C	4.9	3.5	3.4	2	3	2	1	3.4	3.9
zebra	シマウマ	*shimauma*	シマウマ	Yes	NC	2.9	3.1	5.7	1	1	1	2	1	4.7

APPENDIX 4.2

Additional measures. *English name, Japanese name,* the item pair in English and Japanese; *SBTLWF,* the word frequency per million of the English item taken from the SUBTLEX corpus (Brysbaert & New, 2009); *logSBTLWF*, the log-transformed SBTLWF word frequency; *AK*, the raw word frequency of the Japanese item taken from a corpus of Japanese newspaper articles (Amano & Kondo, 2000); *logAK*, the log-transformed AK word frequency; *UkWac*, the raw word frequency of the English item taken from thea 1-billion word web-corpus (Kilgariff et al., 2004); *logUK*, the log-transformed UkWac word frequency; *JpWac*, the raw word frequency of the Japanese item taken from a 300-million word web-corpus (Kilgariff et al., 2004); *logJP*, the log-transformed JpWac word frequency; *Length*, the number of letters in the English word; *Syll*, the number of syllables in the English word; *Mora*, the number of mora in the Japanese word; *ENoS*, the total number of senses of the English word taken from WordNet (Princeton, 1990);

English name	Japanese name	SUBTLWF	log SBTLWF	AK	logAK	UkWac	logUK	JpWac	logJP	Length	Syll	Mora	ENoS	JNoS
access	アクセス	31.7	3.46	1901	7.55	424272	12.96	29653	10.3	6	2	4	8	2
acid	酸	10	2.3	431	6.07	32830	10.4	4218	8.35	4	2	2	5	4
aid	援助	13.9	2.63	35098	10.47	87524	11.38	18824	9.84	3	1	3	6	1
arm	腕	65.4	4.18	5656	8.64	41717	10.64	11039	9.31	3	1	2	8	5
arrow	矢印	7.8	2.06	213	5.36	9330	9.14	1239	7.12	5	2	4	2	1
ashtray	灰皿	3.3	1.18	364	5.9	564	6.34	560	6.33	7	2	4	1	1
balloon	風船	8.7	2.16	804	6.69	8837	9.09	427	6.06	7	2	4	4	2
banana	バナナ	10.7	2.37	1264	7.14	5774	8.66	2770	7.93	6	3	3	2	1
bed	ベッド	187.1	5.23	4571	8.43	91169	11.42	9427	9.15	3	1	3	13	2
bench	ベンチ	9.7	2.27	2940	7.99	15246	9.63	2817	7.94	5	1	3	9	1
bicycle	自転車	6.6	1.89	7809	8.96	9351	9.14	14077	9.55	7	3	4	2	1
blank	空白	9.7	2.27	2627	7.87	18551	9.83	1894	7.55	5	1	4	8	2
bone	骨	26.1	3.26	6312	8.75	32268	10.38	8365	9.03	4	1	2	6	6
bricks	レンガ	3.9	1.37	1488	7.31	9020	9.11	1095	7	6	1	3	2	1
broom	ほうき	4.8	1.56	394	5.98	1691	7.43	524	6.26	5	1	3	5	1
brush	ブラシ	14.2	2.65	385	5.95	12780	9.46	988	6.9	5	1	3	14	1
bus	バス	74.2	4.31	11801	9.38	94182	11.45	29002	10.28	3	1	2	7	1
bust	胸	27.6	3.32	113755	11.64	5510	8.61	15323	9.64	4	1	2	10	7

English name	Japanese name	SUBTLWF	log SBTLWF	AK	logAK	UkWac	logUK	JpWac	logJP	Length	Syll	Mora	ENoS	JNoS
button	ボタン	28.3	3.34	2558	7.85	72516	11.19	11724	9.37	6	2	3	9	2
cake	ケーキ	45.1	3.81	942	6.85	18535	9.83	7745	8.95	4	1	3	4	1
call	コール	861.4	6.76	3021	8.01	269805	12.51	4161	8.33	4	1	3	41	4
camel	ラクダ	5	1.61	542	6.3	2837	7.95	362	5.89	5	2	3	1	2
care	ケア	485.3	6.18	1730	7.46	365146	12.81	8244	9.02	4	1	2	11	2
career	キャリア	45.2	3.81	1525	7.33	135195	11.81	8783	9.08	6	2	4	3	3
carrot	人参	3.8	1.34	1812	7.5	3902	8.27	936	6.84	6	2	4	4	2
case	ケース	282.4	5.64	22587	10.03	495699	13.11	27323	10.22	4	1	3	22	2
caution	注意	5.2	1.64	12308	9.42	13690	9.52	34338	10.44	7	2	3	5	3
cherry	さくらんぼ	13.6	2.61	708	6.56	4301	8.37	15	2.71	6	2	5	5	1
chimney	エントツ	4.2	1.43	635	6.45	7924	8.98	687	6.53	7	2	4	2	1
class	クラス	117.4	4.77	9927	9.2	234399	12.36	24518	10.11	5	1	3	9	2
classic	クラシック	16.2	2.78	1729	7.46	60857	11.02	5237	8.56	7	2	5	5	2
clear	クリアー	171.8	5.15	954	6.86	295974	12.6	814	6.7	5	1	4	45	4
clue	手がかり	17.6	2.87	1316	7.18	10913	9.3	1960	7.58	4	1	4	3	2
cool	クール	195.9	5.28	193	5.26	53108	10.88	4169	8.34	4	1	3	11	2
coral	サンゴ	2.4	0.86	1078	6.98	6962	8.85	378	5.93	5	2	3	5	2
core	コア	9.8	2.28	195	5.27	82620	11.32	5098	8.54	4	1	2	11	5
course	コース	487.2	6.19	10728	9.28	620418	13.34	23421	10.06	6	1	3	13	4
cow	牛	25.5	3.24	4585	8.43	11145	9.32	11445	9.35	3	1	2	4	1
crime	犯罪	71.2	4.27	12694	9.45	100196	11.51	26146	10.17	5	1	4	2	1
cross	クロス	55	4.01	258	5.55	84840	11.35	4570	8.43	5	1	3	16	3
cure	治る	20.8	3.04	2035	7.62	17772	9.79	1574	7.36	4	1	3	5	8
curtain	カーテン	10.3	2.33	962	6.87	7198	8.88	2513	7.83	7	2	4	3	2

English name	Japanese name	SUBTLWF	log SBTLWF	AK	logAK	UkWac	logUK	JpWac	logJP	Length	Syll	Mora	ENoS	JNoS
cycle	サイクル	5.9	1.77	1396	7.24	69463	11.15	4319	8.37	5	2	4	11	3
deer	シカ	8.7	2.16	248	5.51	13747	9.53	2482	7.82	4	1	2	1	1
demand	要求	17.1	2.84	47607	10.77	105817	11.57	31351	10.35	6	2	5	11	1
desk	机	43.9	3.78	4091	8.32	27593	10.23	6507	8.78	4	1	3	1	2
dolphin	イルカ	2.8	1.02	891	6.79	3386	8.13	1755	7.47	7	2	3	2	1
door	ドア	292.1	5.68	4557	8.42	119227	11.69	18755	9.84	4	1	2	5	1
dress	ドレス	87.2	4.47	586	6.37	30358	10.32	3037	8.02	5	1	3	21	1
dresser	たんす	3.6	1.27	869	6.77	1081	6.99	436	6.08	7	2	3	7	1
eagle	ワシ	11.5	2.44	1304	7.17	4151	8.33	1540	7.34	5	2	2	6	1
elephant	象	11.4	2.43	1732	7.46	7564	8.93	2431	7.8	8	3	2	2	1
exit	出口	15.6	2.75	2061	7.63	28353	10.25	3997	8.29	4	2	3	5	1
fail	失敗	24.6	3.2	14314	9.57	46844	10.75	22422	10.02	4	1	4	11	1
find	見つける	831	6.72	12877	9.46	669574	13.41	6568	8.79	4	1	4	18	2
firm	会社	35.3	3.56	121162	11.7	93876	11.45	124291	11.73	4	1	3	14	1
fish	魚	83.5	4.42	7205	8.88	100302	11.52	14341	9.57	4	1	3	6	1
flag	旗	17.5	2.86	3398	8.13	26318	10.18	307	5.73	4	1	2	13	4
flute	フルート	2.1	0.75	610	6.41	5704	8.65	1063	6.97	5	1	4	4	1
fool	バカ	89.3	4.49	1727	7.45	9773	9.19	8887	9.09	4	1	2	7	7
foot	足	64.9	4.17	19920	9.9	72861	11.2	34179	10.44	4	1	2	14	10
fork	フォーク	8.8	2.18	1406	7.25	8845	9.09	2010	7.61	4	1	3	9	2
fox	キツネ	21.6	3.07	867	6.77	8476	9.04	701	6.55	3	1	3	10	2
frog	カエル	11.8	2.47	794	6.68	3595	8.19	2234	7.71	4	1	3	4	1
front	前	181.6	5.2	156283	11.96	203471	12.22	240980	12.39	5	1	2	13	15
fuel	燃料	17.2	2.84	7782	8.96	68646	11.14	11055	9.31	4	1	4	5	1

English name	Japanese name	SUBTLWF	log SBTLWF	AK	logAK	UkWac	logUK	JpWac	logJP	Length	Syll	Mora	ENoS	JNoS
fund	資金	10.6	2.36	59829	11	72473	11.19	30818	10.34	4	1	3	9	1
future	将来	103.5	4.64	35007	10.46	383038	12.86	35828	10.49	6	2	4	7	2
genre	ジャンル	1.1	0.06	1599	7.38	20766	9.94	9316	9.14	5	2	3	4	1
giraffe	キリン	1.5	0.4	891	6.79	975	6.88	893	6.79	7	2	3	1	2
glass	グラス	60.7	4.11	670	6.51	75896	11.24	3578	8.18	5	1	3	12	3
goal	ゴール	16.8	2.82	6455	8.77	98872	11.5	9685	9.18	4	1	3	4	3
goat	ヤギ	10.5	2.35	414	6.03	4710	8.46	889	6.79	4	1	2	4	1
gorilla	ゴリラ	5.6	1.71	348	5.85	1249	7.13	553	6.32	7	3	3	1	1
grapes	ブドウ	3.9	1.37	1281	7.16	4655	8.45	844	6.74	6	1	3	2	1
guitar	ギター	15.6	2.75	1317	7.18	48378	10.79	8290	9.02	6	2	3	1	1
hammock	ハンモック	1.4	0.33	51	3.93	939	6.84	136	4.91	7	2	5	2	1
hanger	ハンガー	1.4	0.3	225	5.42	1138	7.04	464	6.14	6	2	4	2	1
hate	憎む	214.6	5.37	648	6.47	28358	10.25	581	6.36	4	1	3	2	1
head	頭	371.5	5.92	21291	9.97	236151	12.37	57859	10.97	4	1	3	42	9
heart	ハート	244.2	5.5	424	6.05	188643	12.15	3927	8.28	5	1	3	10	3
helicopter	ヘリコプター	15.8	2.76	4902	8.5	10646	9.27	1498	7.31	10	4	6	1	1
helmet	ヘルメット	9.5	2.25	1135	7.03	9128	9.12	1127	7.03	6	2	5	2	2
hope	希望	320.6	5.77	23915	10.08	215310	12.28	31622	10.36	4	1	3	9	2
ideal	理想	7.3	1.99	4744	8.46	91640	11.43	13474	9.51	5	2	3	5	1
iron	アイロン	17.9	2.89	406	6.01	42295	10.65	791	6.67	4	2	4	6	1
jar	つぼ	8.3	2.12	730	6.59	6000	8.7	703	6.56	6	2	4	7	6
joint	関節	27.6	3.32	1374	7.23	85612	11.36	5100	8.54	5	1	4	13	1
joke	ジョーク	73	4.29	584	6.37	15061	9.62	2129	7.66	4	1	4	6	1
jury	陪審	42.8	3.76	921	6.83	13815	9.53	1917	7.56	4	2	4	2	1

English name	Japanese name	SUBTLWF	log SBTLWF	AK	logAK	UkWac	logUK	JpWac	logJP	Length	Syll	Mora	ENoS	JNoS
kangaroo	カンガルー	2.3	0.84	106	4.66	1065	6.97	453	6.12	8	3	5	1	1
kick	キック	73.4	4.3	394	5.98	28820	10.27	2206	7.7	4	1	3	14	2
kiss	キス	121.2	4.8	647	6.47	8097	9	3627	8.2	4	1	2	6	1
ladder	はしご	9.3	2.22	609	6.41	13413	9.5	614	6.42	6	2	3	4	2
learn	習う	118.6	4.78	2022	7.61	164507	12.01	1022	6.93	5	1	3	6	1
left	左	484.5	6.18	13434	9.51	456491	13.03	21651	9.98	4	1	3	24	6
lemon	レモン	12	2.49	84	4.43	8657	9.07	1896	7.55	5	2	3	5	1
lesson	レッスン	32.2	3.47	773	6.65	34865	10.46	7638	8.94	6	2	4	4	2
lion	ライオン	15.4	2.73	757	6.63	8053	8.99	2365	7.77	4	2	4	4	1
lips	唇	31.2	3.44	868	6.77	12390	9.42	3214	8.08	4	1	4	5	1
loan	ローン	19.9	2.99	4079	8.31	64240	11.07	9567	9.17	4	1	3	3	1
lobster	ザリガニ	7.3	1.99	128	4.85	2446	7.8	358	5.88	7	2	4	2	2
local	ローカル	41.7	3.73	477	6.17	807598	13.6	4432	8.4	5	2	4	5	1
loose	緩い	41.8	3.73	874	6.77	29939	10.31	466	6.14	5	1	3	18	6
lucky	ラッキー	143.5	4.97	317	5.76	37067	10.52	3772	8.24	5	2	4	3	1
matter	物事	370.6	5.92	1252	7.13	199009	12.2	6597	8.79	6	2	4	7	1
maze	迷路	2.6	0.94	509	6.23	6095	8.72	951	6.86	4	1	3	2	1
morale	モラル	4.1	1.42	1612	7.39	7057	8.86	2857	7.96	6	2	3	2	1
naked	裸	39.3	3.67	1617	7.39	10531	9.26	3419	8.14	5	2	3	5	4
necklace	ネクレス	9.8	2.28	456	6.12	2095	7.65	732	6.6	8	2	5	1	1
normal	普通	70.4	4.25	7667	8.94	136501	11.82	49509	10.81	6	2	3	5	2
nose	鼻	69.8	4.24	2050	7.63	23573	10.07	10735	9.28	4	1	2	10	2
past	過去	123.8	4.82	40726	10.61	288728	12.57	43084	10.67	4	1	2	6	4
peanut	ピーナツ	12.4	2.51	181	5.2	1963	7.58	120	4.79	6	2	5	5	1

English name	Japanese name	SUBTLWF	log SBTLWF	AK	logAK	UkWac	logUK	JpWac	logJP	Length	Syll	Mora	ENoS	JNoS
pelican	ペリカン	1.8	0.56	95	4.55	614	6.42	176	5.17	7	3	4	1	1
pencil	鉛筆	9.9	2.29	1357	7.21	8138	9	1694	7.43	6	2	4	5	1
penguin	ペンギン	2.9	1.06	395	5.98	1597	7.38	1450	7.28	7	2	4	1	1
pig	豚	39.1	3.67	1432	7.27	11464	9.35	5090	8.54	3	1	2	9	2
pipe	パイプ	19.4	2.96	4833	8.48	22290	10.01	2827	7.95	4	1	4	10	4
place	場所	602.7	6.4	26951	10.2	711596	13.48	67227	11.12	5	1	2	30	3
plain	明白	21.8	3.08	515	6.24	38613	10.56	3613	8.19	5	1	4	11	1
pool	プール	47	3.85	3298	8.1	65923	11.1	5905	8.68	4	1	3	7	4
prison	刑務所	66	4.19	2762	7.92	47075	10.76	4255	8.36	6	2	4	2	1
profit	利益	11	2.39	35064	10.46	45239	10.72	32021	10.37	6	2	3	4	2
pyramid	ピラミッド	4	1.39	713	6.57	4171	8.34	2057	7.63	7	3	5	7	1
rabbit	ウサギ	20.9	3.04	1535	7.34	10445	9.25	2175	7.68	6	2	3	4	1
race	レース	61.9	4.13	8147	9.01	132707	11.8	10294	9.24	4	1	3	10	2
radio	ラジオ	77.2	4.35	8696	9.07	95220	11.46	13013	9.47	5	3	3	5	1
rain	雨	48.9	3.89	12241	9.41	50650	10.83	24566	10.11	4	1	2	4	3
rank	ランク	8.5	2.14	2963	7.99	20069	9.91	4716	8.46	4	1	3	13	1
real	リアル	442.8	6.09	205	5.32	310064	12.64	7644	8.94	4	1	3	13	1
regular	レギュラー	33.9	3.52	867	6.77	141490	11.86	2115	7.66	7	3	5	17	3
release	リリース	36.3	3.59	72	4.28	126790	11.75	10788	9.29	7	2	4	22	2
rental	レンタル	4.8	1.57	1324	7.19	20916	9.95	4584	8.43	6	2	4	4	1
return	リターン	91.7	4.52	185	5.22	243755	12.4	2153	7.67	6	2	4	29	**3**
ring	指輪	92.8	4.53	1076	6.98	55053	10.92	2219	7.7	4	1	3	15	4
rocket	ロケット	11.8	2.47	3714	8.22	8802	9.08	4432	8.4	6	2	4	7	1
roll	ロール	63.3	4.15	183	5.21	36851	10.51	3265	8.09	4	1	3	33	4

English name	Japanese name	SUBTLWF	log SBTLWF	AK	logAK	UkWac	logUK	JpWac	logJP	Length	Syll	Mora	ENoS	JNoS
rule	ルール	48.1	3.87	9481	9.16	81760	11.31	19419	9.87	4	1	3	5	1
sailor	水兵	12.4	2.52	239	5.48	3869	8.26	249	5.52	6	2	4	3	1
scale	スケール	9.5	2.25	1023	6.93	100719	11.52	3747	8.23	5	1	4	18	3
scissors	はさみ	6.7	1.9	1369	7.22	2986	8	753	6.62	8	2	3	4	3
score	スコア	30.4	3.42	1257	7.14	59974	11	4810	8.48	5	1	3	18	2
screen	スクリーン	23.4	3.15	1305	7.17	117693	11.68	5172	8.55	6	1	5	16	4
screw	ネジ	37.5	3.62	576	6.36	8785	9.08	1384	7.23	5	1	2	10	2
sense	センス	131.8	4.88	1057	6.96	200193	12.21	5735	8.65	5	1	3	9	2
share	シェア	69.5	4.24	0	NA	165513	12.02	5722	8.65	5	1	2	10	1
shark	サメ	15	2.71	457	6.12	4491	8.41	760	6.63	5	1	2	5	1
shirt	ワイシャツ	46.4	3.84	697	6.55	14529	9.58	378	5.93	5	1	4	2	1
shock	ショック	28.8	3.36	5825	8.67	30052	10.31	8844	9.09	5	1	3	17	3
show	ショー	488.4	6.19	2643	7.88	375088	12.83	8899	9.09	4	1	3	16	2
shower	シャワー	41.1	3.72	903	6.81	33304	10.41	3608	8.19	6	1	3	11	1
sign	サイン	133.3	4.89	2956	7.99	110620	11.61	7017	8.86	4	1	3	20	2
single	シングル	72.1	4.28	1196	7.09	267442	12.5	4476	8.41	6	2	4	10	9
size	サイズ	46.1	3.83	2164	7.68	190529	12.16	16925	9.74	4	1	3	9	1
ski	スキー	8.1	2.09	5444	8.6	19514	9.88	6912	8.84	3	1	3	2	2
skill	スキル	7.9	2.07	23	3.14	43361	10.68	9451	9.15	5	1	3	2	7
skirt	スカート	10	2.3	1124	7.02	4414	8.39	2375	7.77	5	1	4	7	2
slipper	スリッパ	2.2	0.8	191	5.25	660	6.49	31	3.43	7	2	4	2	1
slow	スロー	76	4.33	107	4.67	62118	11.04	3386	8.13	4	1	3	11	1
smell	香り	83.1	4.42	3540	8.17	19164	9.86	8796	9.08	5	1	3	10	2
snake	ヘビ	22.4	3.11	1211	7.1	6661	8.8	2462	7.81	5	1	2	8	1

English name	Japanese name	SUBTLWF	log SBTLWF	AK	logAK	UkWac	logUK	JpWac	logJP	Length	Syll	Mora	ENoS	JNoS
snowman	雪だるま	1.9	0.64	357	5.88	469	6.15	382	5.95	7	2	5	1	1
sock	靴下	9	2.19	645	6.47	1793	7.49	872	6.77	4	1	4	3	1
solid	固体	19.6	2.97	364	5.9	52114	10.86	4135	8.33	5	2	3	18	1
spoon	スプーン	7.6	2.03	420	6.04	5199	8.56	1426	7.26	5	1	4	5	2
stroke	なでる	13.1	2.57	592	6.38	25763	10.16	174	5.16	6	1	3	16	3
style	スタイル	30.1	3.4	3962	8.28	160463	11.99	16291	9.7	5	1	4	12	3
swan	白鳥	6.8	1.92	793	6.68	2265	7.73	1223	7.11	4	1	4	4	1
tank	戦車	25.6	3.24	3495	8.16	29573	10.29	2679	7.89	4	1	3	7	1
task	タスク	12.7	2.54	12	2.48	94278	11.45	2342	7.76	4	1	3	4	2
telephone	電話	32.4	3.48	61289	11.02	108445	11.59	72126	11.19	9	3	3	2	2

APPENDIX 4.3

Number of translations and number of meanings data (L2-L1). *L2-L1,* word to be translated from second language (L2, English) to first language (L1, Japanese); *Error*, number of errors made by bilinguals when translating, as determined by two professional Japanese-English translators; *NoAns*, number of times that a bilingual skipped the word; *Total INACC*, total number of times that an item was mistakenly translated or skipped; *% INACC*, the percentage of responses in which the item was erronously translated or skipped; *Accurate Trans*, the number of accurate translations for each item; *% ACC*, the percentage of accurate translations per item; *Expected Trans*, the number of times that the item was translated as the item selected in the word pair (e.g., the number of times that *class* was tranlsated as クラス /kurasu/; note that this the 'expected' translation is not necessarily the 'best' translation, but was the translation selected apriori for the word pair based on the necessity to include cognate and noncognate concrete and abstract items); *Alternative Trans*, the number of alternative translations given (i.e., the number of translations given that were not the 'expected' translation); *NoT*, the total number of different correct tranlsations given for each item; *NoM*, the total number of different meanings that were translated, as determined by two professional translators.

L2 to L1 Translation Task

L2-L1	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
access	0	0	0	0.0	17	100	10	7	5	1
acid	2	0	2	11.8	15	88	8	7	3	1
aid	4	0	4	23.5	13	76	2	11	7	2
arm	0	0	0	0.0	17	100	16	1	2	2
arrow	7	1	8	47.1	9	53	9	0	1	1
ashtray	3	7	10	58.8	7	41	5	2	2	1
balloon	0	0	0	0.0	17	100	16	1	2	2
banana	0	0	0	0.0	17	100	17	0	1	1
bed	1	0	1	5.9	16	94	16	0	1	1
bench	0	1	1	5.9	16	94	14	2	2	1
bicycle	0	0	0	0.0	17	100	17	0	1	1
blank	0	0	0	0.0	17	100	10	7	3	1
bone	0	0	0	0.0	17	100	17	0	1	1
bricks	1	5	6	35.3	11	65	7	4	3	1
broom	12	3	15	88.2	2	12	2	0	1	1
brush	1	1	2	11.8	15	88	3	12	2	2
bus	0	0	0	0.0	17	100	17	0	1	1
bust	1	1	2	11.8	15	88	5	10	3	1

L2 to L1 Translation Task

L2-L1	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
button	1	0	1	5.9	16	94	16	0	1	1
cake	0	0	0	0.0	17	100	17	0	1	1
call	0	0	0	0.0	17	100	1	16	4	2
camel	0	3	3	18.8	13	81	8	5	2	1
care	0	0	0	0.0	17	100	4	13	8	2
career	1	0	1	5.9	16	94	8	8	5	2
carrot	1	0	1	5.9	16	94	16	0	1	1
case	0	0	0	0.0	17	100	6	11	6	2
caution	2	0	2	11.8	15	88	9	6	3	2
cherry	2	0	2	11.8	15	88	14	1	2	1
chimney	5	3	8	47.1	9	53	9	0	1	1
class	2	0	2	11.8	15	88	8	7	2	1
classic	0	0	0	0.0	17	100	4	13	2	2
clear	0	0	0	0.0	17	100	0	17	6	3
clue	10	0	10	58.8	7	41	6	1	2	1
cool	0	0	0	0.0	17	100	3	14	4	2
coral	9	3	12	70.6	5	29	4	1	1	1
core	0	0	0	0.0	17	100	1	16	4	1
course	1		1	5.9	16	94	14	2	3	2
cow	0	0	0	0.0	17	100	16	1	2	1
crime	1	0	1	5.9	16	94	9	7	3	1
cross	0	0	0	0.0	17	100	0	17	4	2
cure	2	1	3	16.7	15	83	1	14	4	2
curtain	2	1	3	17.6	14	82	14	0	1	1
cycle	1	0	1	5.9	16	94	6	10	5	2
deer	3	1	4	23.5	13	76	13	0	1	1
demand	2	1	3	16.7	15	83	10	5	3	1
desk	0	0	0	0.0	17	100	17	0	1	1
dolphin	0	0	0	0.0	17	100	17	0	1	1

L2 to L1 Translation Task

L2-L1	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
door	0	0	0	0.0	17	100	12	5	2	1
dress	0	0	0	0.0	17	100	12	5	4	3
dresser	3	1	4	22.2	14	78	8	6	3	3
eagle	0	0	0	0.0	17	100	13	4	2	1
elephant	0	0	0	0.0	17	100	17	0	1	1
exit	0	0	0	0.0	16	100	16	0	2	2
fail	3	1	4	23.5	13	76	10	3	2	1
find	0	0	0	0.0	17	100	13	4	2	2
firm	7	1	8	47.1	9	53	5	4	5	3
fish	0	0	0	0.0	17	100	17	0	1	1
flag	0	0	0	0.0	17	100	17	0	1	1
flute	1	0	1	5.9	16	94	16	0	1	1
fool	0	1	1	5.6	17	94	10	7	2	1
foot	0	0	0	0.0	17	100	17	0	1	1
fork	5	1	6	35.3	11	65	11	0	1	1
fox	0	0	0	0.0	17	100	17	0	1	1
frog	2	2	4	23.5	13	76	13	0	1	1
front	0	0	0	0.0	17	100	9	8	3	2
fuel	0	0	0	0.0	17	100	13	4	2	2
fund	1	1	2	11.8	15	88	4	11	5	1
future	0	0	0	0.0	17	100	4	13	2	1
genre	1	5	6	35.3	11	65	10	1	2	1
giraffe	1	5	6	35.3	11	65	11	0	1	1
glass	1	0	1	5.9	16	94	12	4	3	2
goal	0	0	0	0.0	17	100	11	6	4	2
goat	4	2	6	35.3	11	65	6	5	3	1
gorilla	0	0	0	0.0	17	100	17	0	1	1
grapes	1	1	2	11.8	15	88	14	1	1	1
guitar	0	0	0	0.0	17	100	17	0	1	1

L2 to L1 Translation Task

L2-L1	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
hammock	1	0	1	5.9	16	94	16	0	1	1
hanger	1	0	1	5.9	16	94	16	0	1	1
hate	1	0	1	5.9	16	94	2	14	3	1
head	0	0	0	0.0	17	100	17	0	1	1
heart	1		1	5.9	16	94	3	13	3	2
helicopter	0	1	1	6.3	15	94	15	0	1	1
helmet	0	0	0	0.0	17	100	17	0	1	1
hope	0	0	0	0.0	17	100	8	9	4	2
ideal	1	0	1	5.9	16	94	8	8	1	1
iron	0	0	0	0.0	17	100	3	14	2	2
jar	4	5	9	52.9	8	47	0	8	3	1
joint	6	2	8	47.1	9	53	1	8	5	2
joke	0	0	0	0.0	15	100	2	13	2	1
jury	11	3	14	82.4	3	18	2	1	2	1
kangaroo	0	0	0	0.0	17	100	17	0	1	1
kick	0	0	0	0.0	17	100	5	12	2	1
kiss	0	0	0	0.0	17	100	15	2	2	1
ladder	2	5	7	41.2	10	59	8	2	3	1
learn	0	0	0	0.0	17	100	2	15	2	1
left	0	0	0	0.0	21	100	21	0	2	2
lemon	1	0	1	4.8	20	95	20	0	1	2
lesson	0	0	0	0.0	21	100	7	14	5	1
lion	0	0	0	0.0	21	100	20	1	2	2
lips	0	0	0	0.0	21	100	21	0	1	1
loan	0	0	0	0.0	21	100	11	10	6	1
lobster	0	0	0	0.0	21	100	5	16	5	1
local	2	0	2	9.5	19	90	0	19	3	1
loose	5	0	5	23.8	16	76	6	10	6	1
lucky	0	0	0	0.0	21	100	0	21	3	2

L2 to L1 Translation Task

L2-L1	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
matter	0	0	0	0.0	21	100	0	21	3	1
maze	6	4	10	47.6	11	52	4	7	2	2
morale	2	1	3	14.3	18	86	6	12	5	1
naked	0	0	0	0.0	21	100	19	2	3	1
necklace	1	1	2	9.5	19	90	15	4	3	1
normal	0	0	0	0.0	21	100	17	4	2	1
nose	2	0	2	9.5	19	90	19	0	1	1
past	0	0	0	0.0	21	100	20	1	2	1
peanut	0	0	0	0.0	21	100	17	4	2	1
pelican	0	0	0	0.0	21	100	21	0	1	1
pencil	0	0	0	0.0	21	100	21	0	1	1
penguin	0	0	0	0.0	21	100	20	1	1	1
pig	0	0	0	0.0	21	100	20	1	1	1
pipe	0	0	0	0.0	21	100	14	7	4	1
place	0	0	0	0.0	21	100	21	0	1	2
plain	2	1	3	14.3	18	86	2	16	12	1
pool	0	0	0	0.0	21	100	19	2	3	3
prison	2	1	3	14.3	18	86	7	11	3	2
profit	0	0	0	0.0	21	100	20	1	2	1
pyramid	0	1	1	4.8	20	95	18	2	3	1
rabbit	0	0	0	0.0	21	100	21	0	2	1
race	0	0	0	0.0	21	100	3	18	3	1
radio	0	0	0	0.0	21	100	21	0	1	2
rain	0	0	0	0.0	21	100	19	2	2	1
rank	0	0	0	0.0	21	100	7	14	7	1
real	0	0	0	0.0	21	100	1	20	4	2
regular	1	0	1	4.8	20	95	1	19	5	2
release	1	0	1	4.8	20	95	2	18	7	1
rental	0	0	0	0.0	21	100	4	17	8	2

L2 to L1 Translation Task

L2-L1	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
return	0	0	0	0.0	21	100	1	20	8	1
ring	0	0	0	0.0	21	100	9	12	5	2
rocket	0	0	0	0.0	21	100	21	0	1	3
roll	5	0	5	19.2	21	81	2	19	6	1
rule	0	0	0	0.0	21	100	4	17	7	1
sailor	0	3	3	14.3	18	86	2	16	9	2
scale	0	0	0	0.0	20	100	6	14	5	1
scissors	0	0	0	0.0	21	100	21	0	1	4
score	0	0	0	0.0	21	100	1	20	4	1
screen	0	0	0	0.0	21	100	9	12	2	2
screw	3	1	4	19.0	17	81	3	14	4	1
sense	0	0	0	0.0	21	100	16	5	4	2
share	0	0	0	0.0	21	100	0	21	4	2
shark	1	0	1	4.8	20	95	19	1	2	1
shirt	6	0	6	35.3	11	65	11	0	1	2
shock	0	0	0	0.0	21	100	3	18	5	1
show	0	0	0	0.0	21	100	3	18	5	1
shower	1	0	1	4.8	20	95	17	3	2	2
sign	0	0	0	0.0	21	100	5	16	8	2
single	1	0	1	4.8	20	95	0	20	6	2
size	0	0	0	0.0	21	100	5	16	2	2
ski	0	0	0	0.0	21	100	21	0	1	1
skill	0	0	0	0.0	21	100	1	20	4	1
skirt	1	0	1	4.8	20	95	20	0	1	1
slipper	2	1	3	15.0	17	85	16	1	2	2
slow	0	0	0	0.0	21	100	0	21	2	1
smell	0	0	0	0.0	21	100	14	7	2	1
snake	0	0	0	0.0	21	100	21	0	1	2
snowman	1	0	1	4.5	21	95	17	4	3	1

L2 to L1 Translation Task

L2-L1	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
sock	3	1	4	18.2	18	82	16	2	2	2
solid	2	1	3	14.3	18	86	6	12	4	1
spoon	0	0	0	0.0	21	100	19	2	3	2
stroke	4	2	6	33.3	12	67	1	11	7	1
style	0	0	0	0.0	21	100	11	10	8	4
swan	0	0	0	0.0	21	100	21	0	1	1
tank	0	0	0	0.0	21	100	4	17	4	1
task	0	0	0	0.0	21	100	0	21	4	2
telephone	0	0	0	0.0	21	100	21	0	1	2
television	0	0	0	0.0	21	100	21	0	1	1
tent	1	0	1	4.8	20	95	20	0	1	1
tiger	0	0	0	0.0	21	100	21	0	1	1
toaster	0	0	0	0.0	21	100	21	0	1	1
tomato	0	0	0	0.0	21	100	21	0	1	1
tractor	2	0	2	10.5	17	89	17	0	1	1
trap	0	0	0	0.0	21	100	20	1	1	1
truck	3	0	3	13.0	20	87	18	2	1	1
trumpet	0	0	0	0.0	21	100	19	2	2	1
turtle	0	0	0	0.0	21	100	21	0	1	1
umbrella	0	0	0	0.0	21	100	21	0	1	1
vest	3	2	5	23.8	16	76	15	1	2	1
view	0	0	0	0.0	21	100	2	19	11	1
violin	0	0	0	0.0	21	100	21	0	1	2
wake	1	0	1	4.5	21	95	4	17	3	1
warm	1	0	1	4.8	20	95	19	1	3	1
waste	1	0	1	4.8	20	95	2	18	5	2
wolf	0	0	0	0.0	21	100	21	0	1	2
work	0	0	0	0.0	21	100	0	21	2	1
youth	0	0	0	0.0	21	100	0	21	3	1

L2 to L1 Translation Task

L2-L1	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
zebra	1	0	1	4.8	20	95	20	0	1	2

APPENDIX 4.4

Number of translations and number of meanings data (L1-L2). *L1-L2*, word to be translated from first language (L1, Japanese) to second language (L2, English); *Error*, number of errors made by bilinguals when translating, as determined by two professional Japanese-English translators; *NoAns*, number of times that a bilingual skipped the word; *Total INACC*, total number of times that an item was mistakenly translated or skipped; *% INACC*, the percentage of responses in which the item was erronously translated or skipped; *Accurate Trans*, the number of accurate translations for each item; *% ACC*, the percentage of accurate translations per item; *Expected Trans*, the number of times that the item was translated as the item selected in the word pair (e.g.,the number of times that class was tranlsated as クラス /kurasu/; note that this the 'expected' translation is not necessarily the 'best' translation, but was the translation selected apriori for the word pair based on the necessity to include cognate and noncognate concrete and abstract items); *Alternative Trans*, the number of alternative translations given (i.e., the number of translations given that were not the 'expected' translation); *NoT*, the total number of different correct tranlsations given for each item; *NoM*, the total number of different meanings that were translated, as determined by two professional translators.

L1 to L2 Translation Task

L1-L2	Transcription	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
アクセス	*akusesu*	0	0	0	0.0	21	100	21	0	1	1
酸	*san*	3	4	7	33.3	14	67	14	0	1	1
援助	*enjo*	0	0	0	0.0	21	100	5	16	5	1
腕	*ude*	0	1	1	4.5	21	95	21	0	1	1
矢印	*yajirushi*	1	6	7	33.3	14	67	10	4	4	2
灰皿	*haizara*	5	9	14	66.7	7	33	6	1	1	2
バルーン	*fuusen*	0	1	1	4.8	20	95	20	0	1	1
バナナ	*banana*	0	0	0	0.0	22	100	22	0	1	1
ベッド	*beddo*	0	0	0	0.0	21	100	21	0	1	1
ベンチ	*benchi*	1	0	1	4.8	20	95	20	0	1	1
自転車	*jitensha*	1	0	1	4.8	20	95	10	10	2	1
空欄	*kuuhaku*	1	1	2	9.5	19	90	14	5	2	1
骨	*hone*	0	0	0	0.0	21	100	21	0	1	1
レンガ	*renga*	6	6	12	57.1	9	43	5	4	2	2
箒	*houki*	5	4	9	42.9	12	57	10	2	3	1

L1 to L2 Translation Task

L1-L2	Transcription	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
ブラシ	*burashi*	0	0	0	0.0	21	100	21	0	1	1
バス	*basu*	0	0	0	0.0	21	100	21	0	1	1
胸	*mune*	1	1	2	9.5	19	90	3	16	2	1
ボタン	*botan*	0	1	1	4.8	20	95	20	0	1	1
ケーキ	*keeki*	0	0	0	0.0	21	100	21	0	2	1
コール	*kooru*	1	1	2	9.5	19	90	19	0	1	1
ラクダ	*rakuda*	3	6	9	42.9	12	57	12	0	1	1
ケア	*kea*	0	0	0	0.0	21	100	21	0	1	1
キャリア	*kyaria*	0	0	0	0.0	21	100	21	0	1	1
人参	*ninjin*	0	0	0	0.0	21	100	21	0	1	1
ケース	*keesu*	0	0	0	0.0	21	100	21	0	1	1
注意	*chuui*	0	0	0	0.0	21	100	7	14	4	2
サクランボ	*sakuranbo*	0	0	0	0.0	21	100	21	0	1	1
エントツ	*entotsu*	3	6	9	42.9	12	57	12	0	1	1
クラス	*kurasu*	1	0	1	4.8	20	95	19	1	2	1
クラシック	*kurashikku*	0	0	0	0.0	21	100	20	1	1	1
クリアー	*kuriaa*	0	0	0	0.0	21	100	21	0	1	1
手がかり	*tegakari*	4	1	5	23.8	16	76	6	10	3	1
クール	*kuuru*	0	0	0	0.0	21	100	21	0	1	1
珊瑚	*sango*	6	4	10	47.6	11	52	11	0	1	1
コア	*koa*	0	1	1	4.8	20	95	20	0	1	1
コース	*koosu*	1	0	1	4.8	20	95	20	0	1	1
牛	*ushi*	0	0	0	0.0	21	100	17	4	3	2
犯罪	*hanzai*	0	1	1	4.8	20	95	16	4	3	2

L1 to L2 Translation Task

L1-L2	Transcription	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
クロス	*kurosu*	0	0	0	0.0	21	100	21	0	1	1
治る	*naoru*	0	0	0	0.0	21	100	9	12	5	1
カーテン	*kaaten*	0	0	0	0.0	21	100	21	0	1	1
サイクル	*saikuru*	0	0	0	0.0	21	100	21	0	1	1
鹿	*shika*	1	2	3	14.3	18	86	17	1	2	1
要求	*youkyuu*	1	0	1	4.8	20	95	7	13	6	2
デスク	*tsukue*	0	0	0	0.0	21	100	21	0	1	1
イルカ	*iruka*	0	1	1	4.8	20	95	20	0	1	1
ドア	*doa*	0	0	0	0.0	21	100	21	0	1	1
ドレス	*doresu*	0	0	0	0.0	21	100	21	0	1	1
たんす	*tansu*	3	6	9	33.3	18	67	2	16	5	1
鷲	*washi*	1	5	6	28.6	15	71	11	4	3	1
象	*zou*	0	0	0	0.0	21	100	21	0	1	1
出口	*deguchi*	1	0	1	4.8	20	95	20	0	1	1
失敗	*shippai*	0	0	0	0.0	21	100	6	15	4	1
見つける	*mitsukeru*	0	0	0	0.0	21	100	19	2	3	1
会社	*kaisha*	2	0	2	9.5	19	90	1	18	3	1
魚	*sakana*	0	0	0	0.0	21	100	21	0	1	1
フラッグ	*hata*	0	0	0	0.0	21	100	21	0	1	1
フルート	*furuuto*	9	1	10	47.6	11	52	11	0	1	1
バカ	*baka*	1	0	1	9.1	10	91	12	-2	3	1
足	*ashi*	0	0	0	0.0	21	100	14	7	2	2
フォーク	*fooku*	1	2	3	14.3	18	86	9	9	2	2
狐	*kitsune*	0	3	3	14.3	18	86	18	0	1	1

L1 to L2 Translation Task

L1-L2	Transcription	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
蛙	*kaeru*	1	0	1	4.8	20	95	20	0	1	1
前	*mae*	0	0	0	0.0	21	100	15	6	4	3
燃料	*nenryou*	1	1	2	9.5	19	90	17	2	3	2
資金	*shikin*	1	4	5	22.7	17	77	12	5	5	1
将来	*shourai*	0	0	0	0.0	21	100	21	0	1	1
ジャンル	*janru*	10	0	10	47.6	11	52	9	2	3	1
キリン	*kirin*	0	2	2	9.5	19	90	19	0	1	1
グラス	*gurasu*	0	0	0	0.0	21	100	21	0	1	1
ゴール	*gooru*	0	0	0	0.0	21	100	21	0	1	1
ヤギ	*yagi*	2	5	7	33.3	14	67	14	0	1	1
ゴリラ	*gorira*	0	2	2	9.5	19	90	19	0	1	1
葡萄	*budou*	0	1	1	4.8	20	95	20	0	1	1
ギター	*gitaa*	0	0	0	0.0	21	100	21	0	1	1
ハンモック	*hanmokku*	0	1	1	4.8	20	95	20	0	1	1
ハンガー	*hangaa*	0	1	1	5.9	16	94	8	8	2	2
憎む	*nikumu*	0	2	2	9.5	19	90	19	0	1	1
頭	*atama*	0	0	0	0.0	21	100	21	0	1	1
ハート	*haato*	1	0	1	4.8	20	95	20	0	1	1
ヘリコプター	*herikoputaa*	0	0	0	0.0	21	100	20	1	1	1
ヘルメット	*herumetto*	1	1	2	9.5	19	90	19	0	1	1
希望	*kibou*	1	1	2	9.5	19	90	18	1	1	1
理想	*risou*	3	4	7	33.3	14	67	12	2	2	1
アイロン	*airon*	1	0	1	4.8	20	95	20	0	1	1
つぼ	*tsubo*	6	4	10	47.6	11	52	0	11	1	3

L1 to L2 Translation Task

L1-L2	Transcription	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
関節	*kansetsu*	2	8	10	47.6	11	52	11	0	1	1
ジョーク	*jooku*	0	0	0	0.0	21	100	21	0	1	1
陪審	*baishin*	7	4	11	52.4	10	48	10	0	1	1
カンガルー	*kangaruu*	0	3	3	14.3	18	86	18	0	1	1
キック	*kikku*	0	0	0	0.0	21	100	21	0	1	1
キス	*kisu*	0	0	0	0.0	21	100	21	0	1	1
はしご	*hashigo*	0	6	6	28.6	15	71	15	0	1	1
習う	*narau*	0	0	0	0.0	21	100	20	1	1	1
左	*hidari*	0	0	0	0.0	17	100	17	0	1	1
レモン	*remon*	0	0	0	0.0	17	100	17	0	1	1
レッスン	*ressun*	0	0	0	0.0	17	100	17	0	1	1
ライオン	*raion*	1	0	1	5.9	16	94	16	0	1	1
唇	*kuchibiru*	1	1	2	11.8	15	88	15	0	1	1
ローン	*roon*	1	0	1	5.9	16	94	11	5	1	2
ザリガニ	*zarigani*	3	11	14	82.4	3	18	1	2	2	1
ローカル	*rookaru*	0	0	0	0.0	17	100	17	0	1	1
緩い	*yurui*	5	3	8	47.1	9	53	7	2	3	1
ラッキー	*rakkii*	0	0	0	0.0	17	100	17	0	1	1
物事	*monogoto*	1	1	2	11.8	15	88	12	3	4	2
迷路	*meiro*	2	7	9	52.9	8	47	4	4	2	1
モラル	*moraru*	0	0	0	0.0	17	100	17	0	1	1
裸	*hadaka*	2	1	3	17.6	14	82	11	3	2	1
ネックレス	*nekuresu*	1	0	1	5.9	16	94	16	0	1	1
普通	*futsuu*	0	0	0	0.0	17	100	8	9	4	1

L1 to L2 Translation Task

L1-L2	Transcription	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
鼻	*hana*	0	1	1	5.9	16	94	16	0	1	1
過去	*kako*	2	0	2	11.8	15	88	15	0	2	1
ピーナッツ	*piinatsu*	0	3	3	17.6	14	82	12	2	1	1
ペリカン	*perikan*	1	6	7	41.2	10	59	10	0	1	1
鉛筆	*enpitsu*	1	0	1	5.9	16	94	16	0	1	1
ペンギン	*pengin*	0	0	0	0.0	17	100	17	0	1	1
豚	*buta*	0	0	0	0.0	17	100	17	0	1	1
パイプ	*paipu*	0	0	0	0.0	17	100	17	0	1	1
場所	*basho*	1	0	1	5.9	16	94	12	4	5	1
明白	*meihaku*	3	0	3	17.6	14	82	12	2	3	2
プール	*puuru*	0	0	0	0.0	17	100	17	0	1	1
刑務所	*keimusho*	2	4	6	35.3	11	65	8	3	2	1
利益	*rieki*	2	4	6	35.3	11	65	7	4	4	2
ピラミッド	*piramiddo*	0	2	2	11.8	15	88	15	0	1	1
ウサギ	*usagi*	2	0	2	11.8	15	88	15	0	1	1
レース	*reesu*	0	0	0	0.0	17	100	17	0	1	1
ラジオ	*rajio*	0	0	0	0.0	17	100	17	0	1	1
雨	*ame*	0	0	0	0.0	17	100	17	0	1	1
ランク	*ranku*	0	0	0	0.0	17	100	17	0	1	1
リアル	*riaru*	0	0	0	0.0	17	100	17	0	1	1
レギュラー	*regyuraa*	0	0	0	0.0	17	100	17	0	1	1
リリース	*ririisu*	1	0	1	5.9	16	94	16	0	1	1
レンタル	*rentaru*	0	0	0	0.0	17	100	17	0	1	1
リターン	*ritaan*	0	0	0	0.0	17	100	17	0	1	1

L1 to L2 Translation Task

L1-L2	Transcription	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
リング	*yubiwa*	0	0	0	0.0	17	100	17	0	1	1
ロケット	*roketto*	1	0	1	5.9	16	94	16	0	1	1
ロール	*rooru*	0	0	0	0.0	17	100	9	8	2	2
ルール	*ruuru*	0	0	0	0.0	17	100	17	0	1	1
水兵	*suihei*	4	5	9	52.9	8	47	4	4	2	1
スケール	*sukeeru*	0	0	0	0.0	17	100	17	0	1	1
鋏	*hasami*	6	6	12	70.6	5	29	5	0	1	1
スコア	*sukoa*	0	0	0	0.0	17	100	17	0	1	1
スクリーン	*sukuriin*	0	0	0	0.0	17	100	17	0	1	1
ネジ	*neji*	6	6	12	70.6	5	29	0	5	1	1
センス	*sensu*	0	0	0	0.0	17	100	17	0	1	1
シェア	*shea*	0	0	0	0.0	17	100	17	0	1	1
サメ	*same*	0	1	1	6.3	15	94	15	0	2	1
ワイシャッツ	*waishatsu*	8	1	9	52.9	8	47	0	8	2	1
ショック	*shokku*	0	0	0	0.0	17	100	17	0	1	1
ショー	*shoo*	0	0	0	0.0	17	100	17	0	1	1
シャワー	*shawaa*	0	0	0	0.0	17	100	17	0	1	1
サイン	*sain*	0	0	0	0.0	17	100	15	2	2	2
シングル	*shinguru*	0	0	0	0.0	17	100	17	0	1	1
サイズ	*saizu*	0	0	0	0.0	17	100	17	0	1	1
スキー	*sukii*	0	0	0	0.0	17	100	17	0	1	1
スキル	*sukiru*	1	0	1	5.9	16	94	16	0	1	1

L1 to L2 Translation Task

L1-L2	Transcription	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
スカート	*sukaato*	0	2	2	10.5	17	89	17	0	1	1
スリッパ	*surippa*	0	3	3	17.6	14	82	14	0	1	1
スロー	*suroo*	0	0	0	0.0	17	100	17	0	1	1
香り	*kaori*	1	2	3	17.6	14	82	8	6	4	2
蛇	*hebi*	2	1	3	17.6	14	82	14	0	1	1
雪だるま	*yukidaruma*	3	1	4	25.0	12	75	12	0	1	1
靴下	*kutsushita*	1	1	2	11.8	15	88	10	5	1	1
固体	*kotai*	2	5	7	41.2	10	59	7	3	3	1
スプーン	*supuun*	0	0	0	0.0	17	100	17	0	1	1
なでる	*naderu*	4	6	10	58.8	7	41	3	4	2	1
スタイル	*sutairu*	0	0	0	0.0	17	100	17	0	1	1
白鳥	*hakuchou*	3	2	5	29.4	12	71	12	0	1	1
戦車	*sensha*	5	7	12	70.6	5	29	3	2	3	2
タスク	*tasku*	0	0	0	0.0	17	100	17	0	1	1
電話	*denwa*	0	0	0	0.0	17	100	13	4	4	2
テレビ	*terebi*	0	0	0	0.0	17	100	13	4	1	1
テント	*tento*	0	0	0	0.0	17	100	17	0	1	1
トラ	*tora*	1	0	1	5.9	16	94	16	0	1	1
トースター	*toosutaa*	1	2	3	17.6	14	82	0	14	1	1
トマト	*tomato*	0	0	0	0.0	17	100	17	0	1	1
トラクター	*torakutaa*	1	1	2	9.5	19	90	19	0	1	1
わな	*wana*	1	2	3	17.6	14	82	14	0	1	1

L1 to L2 Translation Task

L1-L2	Transcription	Error	NoAns	Total INACC	% INACC	Accurate Trans	% ACC	Expected Trans	Alternative Trans	NoT	NoM
トラック	*torakku*	0	0	0	0.0	17	100	3	14	1	2
トランペット	*toranpetto*	0	0	0	0.0	17	100	17	0	1	1
亀	*kame*	1	3	4	23.5	13	76	13	0	1	1
傘	*kasa*	0	0	0	0.0	17	100	17	0	1	1
ベスト	*besuto*	1	0	1	5.9	16	94	15	1	1	2
眺め	*nagame*	1	1	2	9.5	19	90	17	2	3	2
バイオリン	*bairorin*	0	0	0	0.0	17	100	17	0	1	1
覚める	*sameru*	2	2	4	23.5	13	76	10	3	2	1
暖かい	*atatakai*	0	0	0	0.0	17	100	15	2	2	1
浪費	*rouhi*	2	2	4	19.0	17	81	12	5	2	2
狼	*ookami*	2	1	3	17.6	14	82	14	0	1	1
ワーク	*waaku*	0	0	0	0.0	17	100	17	0	1	1
ユース	*yuusu*	1	1	2	10.5	17	89	12	5	2	2
シマウマ	*shimauma*	2	2	4	23.5	13	76	13	0	1	1

APPENDIX 5.1

et al., 2005) used in Experiment 1 (27 cognates, 27 noncognates)

English Name	Japanese name	Alphabetic transcription	English Name	Japanese name	Alphabetic transcription
Banana	バナナ	banana	Car	車	kuruma
Bed	ベッド	beddo	Cherry	桜ん坊	sakuranbo
Belt	ベルト	beruto	Church	教会	kyoukai
Bench	ベンチ	benchi	Dog	犬	inu
Brush	ブラシ	burashi	Dolphin	イルカ	iruka
Bus	バス	basu	Elephant	象	zou
Button	ボタン	botan	Finger	人差し指	hitosashiyubi
Cake	ケーキ	keeki	Frog	蛙	kaeru
Door	ドア	doa	Goat	ヤギ	yagi
Dress	ドレス	doresu	Mirror	鏡	kagami
Fork	フォーク	fooku	Moon	月	tsuki
Hanger	ハンガー	hangaa	Mountain	山	yama
Heart	ハート	haato	Mouse	ネズミ	nezumi
Helmet	ヘルメット	herumetto	Pencil	鉛筆	enpitsu
Iron	アイロン	airon	Plate	皿	sara
Kangaroo	カンガルー	kangaruu	Rabbit	ウサギ	usagi
Lion	ライオン	raion	Rose	バラ	bara
Pool	プール	puuru	Shoe	靴	kutsu
Radio	ラジオ	rajio	Snake	蛇	hebi
Spoon	スプーン	supuun	Sun	太陽	taiyou
Television	テレビ	terebi	Swan	白鳥	hakuchou
Tent	テント	tento	Telephone	電話	denwa
Toaster	トースター	toosutaa	Train	電車	densha

English Name	Japanese name	Alphabetic transcription	English Name	Japanese name	Alphabetic transcription
Truck	トラック	torakku	Watch	腕時計	udedokei
Trumpet	トランペット	toranpetto	Wheel	車輪	sharin
Vest	ベスト	besuto	Window	窓	mado
Yacht	ヨット	yotto	Zebra	シマウマ	shimauma

APPENDIX 5.2

Target items and matched nonwords used in English lexical decision (60 cognates, 60 noncognates, 120 nonwords)

English name	Japanese name	Alphabetic transcription	Matched nonword	English name	Japanese name	Alphabetic transcription	Matched nonword
access	アクセス	*akusesu*	hieces	ashtray	灰皿	*haizara*	schiped
banana	バナナ	*banana*	bofied	bicycle	自転車	*jitensha*	theppes
bed	ベッド	*beddo*	tet	bone	骨	*hone*	sart
brush	ブラッシ	*burashi*	tomey	bricks	レンガ	*renga*	grajer
bus	バス	*basu*	zat	bust	胸	*mune*	lole
button	ボタン	*botan*	boofed	carrot	人参	*ninjin*	lelles
cake	ケーキ	*keeki*	mest	caution	注意	*chuui*	pimplos
care	ケア	*kea*	pahe	chimney	エントツ	*entotsu*	clermos
career	キャリア	*kyariaa*	parbed	clue	手がかり	*tegakari*	ners
case	ケース	*keesu*	vare	coral	サンゴ	*saigo*	atolp
classic	クラシック	*kurashikku*	sgrotch	cow	牛	*ushi*	bem
cool	クール	*kuuru*	ceat	crime	犯罪	*hanzai*	halms
core	コア	*koa*	sare	cure	治る	*naoru*	mive
course	コース	*koosu*	haples	deer	シカ	*shika*	luty
cross	クロス	*kurosu*	ewact	demand	要求	*youkyuu*	lehind
curtain	カーテン	*kaaten*	topmyst	dolphin	イルカ	*iruka*	pliffen
cycle	サイクル	*saikuru*	rynic	dresser	たんす	*tansu*	doasted
flute	フルート	*furuuto*	grues	fork	フォーク	*fooku*	tham
tent	テント	*tento*	wast	guitar	ギター	*gitaa*	ellnog
tomato	トマト	*tomato*	ettcup	hammock	ハンモック	*hanmokku*	sioneer
tractor	トラクター	*torakutaa*	partiam	hanger	ハンガー	*hangaa*	dester
trumpet	トランペット	*toranpetto*	sishful	helicopter	ヘリコプター	*herikoputaa*	spleatened
violin	バイオリン	*bairorin*	clomax	iron	アイロン	*airon*	erds

English name	Japanese name	Alphabetic transcription	Matched nonword	English name	Japanese name	Alphabetic transcription	Matched nonword
work	ワーク	*waaku*	dran	joke	ジョーク	*jooku*	vock
acid	酸	*san*	boik	kangaroo	カンガルー	*kangaruu*	speories
arm	腕	*ude*	olb	kick	キック	*kikku*	pome
kiss	キス	*kisu*	yops	pig	豚	*buta*	fot
lion	ライオン	*raion*	jite	plain	明白	*meihaku*	bocer
loan	ローン	*roon*	bood	pool	プール	*puuru*	tove
local	ローカル	*rookaru*	nello	pyramid	ピラミッド	*piramiddo*	pripend
lucky	ラッキー	*rakkii*	sazer	race	レース	*reesu*	runk
necklace	ネクレス	*nekuresu*	flinness	rank	ランク	*ranku*	lage
pelican	ペリカン	*perikan*	blereof	regular	レギュラー	*regyuraa*	shafpud
penguin	ペンギン	*pengin*	pludies	rule	ルール	*ruuru*	lonk
pipe	パイプ	*paipu*	dutt	scale	スケール	*sukeeru*	pords
elephant	象	*zou*	alvisers	score	スコア	*sukoa*	kacks
excited	興奮	*koufun*	truckeb	sense	センス	*sensu*	guels
exit	出口	*deguchi*	flis	show	ショー	*shoo*	goll
fail	失敗	*shippai*	poot	single	シングル	*shinguru*	scacks
find	見つける	*mitsukeru*	dall	size	サイズ	*saizu*	furg
firm	会社	*kaisha*	tuny	ski	スキー	*sukii*	efa
fish	魚	*sakana*	reag	skill	スキル	*sukiru*	shord
front	前	*mae*	cleot	skirt	スカート	*sukaato*	toofs
future	将来	*shourai*	peings	slipper	スリッパ	*surippa*	glayling
giraffe	キリン	*kirin*	blerved	slow	スロー	*suroo*	nent
hate	憎む	*nikumu*	sile	style	スタイル	*sutairu*	ploss
ideal	理想	*risou*	aonta	prison	刑務所	*keimusho*	mailef
joint	関節	*kansetsu*	chost	profit	利益	*rieki*	veware

English name	Japanese name	Alphabetic transcription	Matched nonword	English name	Japanese name	Alphabetic transcription	Matched nonword
jury	陪審	*baishin*	jeed	sailor	水兵	*suihei*	mibing
learn	習う	*narau*	efter	scissors	はさみ	*hasami*	brylized
left	左	*hidari*	gour	smell	香り	*kaori*	freen
lips	唇	*kuchibiru*	tave	snake	ヘビ	*hebi*	forry
lobster	ザリガニ	*zarigani*	ouplaws	snowman	雪だるま	*yukidaruma*	biewers
loose	緩い	*yurui*	cetty	sock	靴下	*kutsushita*	zear
matter	物事	*monogoto*	dacked	solid	固体	*kotai*	afoub
nose	鼻	*hana*	lote	tank	戦車	*sensha*	fime
past	過去	*kako*	gare	tiger	トラ	*tora*	tunch
pencil	鉛筆	*enpitsu*	essigy	trap	ワナ	*wana*	juff
turtle	カメ	*kame*	oubing				
umbrella	傘	*kasa*	sulfido				
view	眺め	*nagame*	haip				
warm	暖かい	*atatakai*	kime				

APPENDIX 6.1

Stimuli used in Japanese Picture Naming

English Name	Japanese Name	Transcription	Cognate Status	English Name	Japanese Name	Transcription	Cognate Status	English Name	Japanese Name	Transcription	Cognate Status
belt	ベルト	*beruto*	cognate	skirt	スカート	*sukaato*	cognate	giraffe	キリン	*kirin*	noncognate
boot	ブーツ	*buutsu*	cognate	slipper	スリッパ	*surippa*	cognate	grapes	ぶどう	*budou*	noncognate
brush	ブラシ	*burashi*	cognate	spoon	スプーン	*supuun*	cognate	mirror	鏡	*kagami*	noncognate
button	ボタン	*botan*	cognate	television	テレビ	*terebi*	cognate	moon	月	*tsuki*	noncognate
cake	ケーキ	*keeki*	cognate	tent	テント	*tento*	cognate	mouse	ネズミ	*nezumi*	noncognate
curtain	カーテン	*kaaten*	cognate	tomato	トマト	*tomato*	cognate	pencil	鉛筆	*enpitsu*	noncognate
door	ドア	*doa*	cognate	violin	バイオリン	*baiorin*	cognate	rabbit	ウサギ	*usagi*	noncognate
fork	フォーク	*fooku*	cognate	yacht	ヨット	*yotto*	cognate	ring	指輪	*yubiwa*	noncognate
gorilla	ゴリラ	*gorira*	cognate	arrow	矢	*ya*	noncognate	scissors	はさみ	*hasami*	noncognate
heart	ハート	*haato*	cognate	ashtray	灰皿	*haizara*	noncognate	snowman	雪だるま	*yukidaruma*	noncognate
iron	アイロン	*airon*	cognate	balloon	風船	*fuusen*	noncognate	sock	靴下	*kutsushita*	noncognate
kangaroo	カンガルー	*kangaruu*	cognate	bat	コウモリ	*koumori*	noncognate	suitcase	カバン	*kaban*	noncognate
lemon	レモン	*remon*	cognate	bicycle	自転車	*jitensha*	noncognate	sun	太陽	*taiyou*	noncognate
melon	メロン	*meron*	cognate	broom	ほうき	*houki*	noncognate	telephone	電話	*denwa*	noncognate
necklace	ネックレス	*nekkuresu*	cognate	carrot	人参	*ninjin*	noncognate	train	電車	*densha*	noncognate
penguin	ペンギン	*pengin*	cognate	desk	机	*tsukue*	noncognate	zebra	シマウマ	*shimauma*	noncognate
pineapple	パイナップル	*painnappuru*	cognate	dolphin	イルカ	*iruka*	noncognate				
pool	プール	*puuru*	cognate	dresser	たんす	*tansu*	noncognate				
radio	ラジオ	*rajio*	cognate	fish	魚	*sakana*	noncognate				

APPENDIX 7.1

Stimuli for cross-language masked priming lexical decision tasks

L1-L2

Related prime	Transcription	Unrelated Prime	Transcription	Target	L2-L1 Semantics	Nonword Prime	Transcription	Nonword Target
バナナ	*banana*	ライヴ	*raibu*	banana	Few-Few	キャラ	*kyara*	bofied
ベッド	*beddo*	ジャンル	*janru*	bed	Few-Few	カン	*kan*	tet
バス	*basu*	カメ	*kame*	bus	Few-Few	エア	*ea*	zat
ボタン	*botan*	スキル	*sukiru*	button	Few-Few	コック	*kokku*	boofed
ケーキ	*keeki*	ペンチ	*penchi*	cake	Few-Few	カレー	*karee*	mest
デスク	*desuku*	サイズ	*saizu*	desk	Few-Few	エリア	*eria*	sout
トースター	*toosutaa*	アイロン	*airon*	toaster	Few-Few	シーア	*shiia*	tockets
フルート	*furuuto*	エントツ	*entotsu*	flute	Few-Few	シルク	*shiruku*	grues
フォーク	*fooku*	レンタル	*rentaru*	fork	Few-Few	ロゴ	*rogo*	tham
ゴリラ	*gorira*	サンゴ	*sango*	gorilla	Few-Few	ウォーター	*uootaa*	dramens
ギター	*gitaa*	ベスト	*besuto*	guitar	Few-Few	ガソリン	*gasorin*	ellnog
ハンガー	*hangaa*	ザリガニ	*zarigani*	hanger	Few-Few	クルーズ	*kuruuzu*	dester
ヘルメット	*herumetto*	ネクレス	*nekuresu*	helmet	Few-Few	サンタ	*santa*	pallir
カンガルー	*kangaruu*	ライセンス	*raisensu*	kangar	Few-Few	サングラス	*sangurasu*	speories
レモン	*remon*	イルカ	*iruka*	lemon	Few-Few	エコ	*eko*	phime
ライオン	*raion*	カーテン	*kaaten*	lion	Few-Few	ゲイ	*gei*	jite
ピーナッツ	*piinatsu*	シマウマ	*shimauma*	peanut	Few-Few	ガール	*gaaru*	clowzy
ペンギン	*pengin*	クリアー	*kuriaa*	pengui	Few-Few	タワー	*tawaa*	pludies
ピラミッド	*piramiddo*	カウンター	*kauntaa*	pyram	Few-Few	グッズ	*guzzu*	pripend
ラジオ	*rajio*	オオカミ	*ookami*	radio	Few-Few	ギャグ	*gyagu*	clees
ロケット	*roketto*	フラッグ	*furaggu*	rocket	Few-Few	カタログ	*katarogu*	aining
スキー	*sukii*	カエル	*kaeru*	ski	Few-Few	ゴー	*goo*	efa

L1-L2								
Related prime	**Transcription**	**Unrelated Prime**	**Transcription**	**Target**	**L2-L1 Semantics**	**Nonword Prime**	**Transcription**	**Nonword Target**
スカート	*sukaato*	ジョーク	*jooku*	skirt	Few-Few	アイス	*aisu*	toofs
スリッパ	*surippa*	ハンモック	*hanmokku*	slippe	Few-Few	カロリー	*karorii*	glaying
スプーン	*supuun*	ペリカン	*perikan*	spoon	Few-Few	グレー	*guree*	frool
テント	*tento*	プール	*puuru*	tent	Few-Few	ワイン	*wain*	wast
トマト	*tomato*	ワナ	*wana*	tomato	Few-Few	モーター	*mootaa*	ettcup
トラクター	*torakutaa*	キャッシュ	*kyasshu*	tracto	Few-Few	アルコール	*arukooru*	partiam
トランペット	*toranpetto*	ヘリコプター	*herikoputaa*	trumpe	Few-Few	エクセル	*ekuseru*	sishful
バイオリン	*baiorin*	リサイクル	*risaikuru*	violin	Few-Few	サイエンス	*saiensu*	clomax
ブラシ	*burashi*	キリン	*kirin*	brush	Many-Few	アタック	*atakku*	tomey
キャンセル	*kyanseru*	セッション	*sesshon*	cancel	Many-Few	ソング	*songu*	gehead
ケーア	*keea*	トラ	*tora*	care	Many-Few	ヨガ	*yoga*	pahe
キャリア	*kyaria*	アクセス	*akusesu*	career	Many-Few	オーロラ	*oorora*	parbed
ケース	*keesu*	ロック	*rokku*	case	Many-Few	オン	*on*	vare
クラス	*kurasu*	テレビ	*terebi*	class	Many-Few	コーン	*koon*	nower
クラシック	*kurashikku*	キャラクター	*kyarakutaa*	classi	Many-Few	リモコン	*rimokon*	sgrotch
クール	*kuuru*	スキー	*sukii*	cool	Many-Few	エイズ	*eizu*	ceat
コア	*koa*	シカ	*shika*	core	Many-Few	セル	*seru*	sare
コース	*koosu*	モラル	*moraru*	course	Many-Few	ロイヤル	*roiyaru*	haples
サイクル	*saikuru*	ラッキー	*rakkii*	cycle	Many-Few	スルー	*suruu*	rynic
ゴール	*gooru*	ドレス	*doresu*	goal	Many-Few	シック	*shikku*	wots
ハート	*haato*	リアル	*riaru*	heart	Many-Few	シューズ	*shuuzu*	driek
レスン	*resun*	サークル	*saakuru*	lesson	Many-Few	インター	*intaa*	sarder
ローン	*roon*	ランク	*ranku*	loan	Many-Few	リスク	*risuku*	bood
パイプ	*paipu*	シャワー	*shawaa*	pipe	Many-Few	ワゴン	*wagon*	dutt

L1-L2								
Related prime	**Transcription**	**Unrelated Prime**	**Transcription**	**Target**	**L2-L1 Semantics**	**Nonword Prime**	**Transcription**	**Nonword Target**
レギュラー	*regyuraa*	モジュール	*mojuuru*	regula	Many-Few	セールス	*seerusu*	shafpud
リラックス	*rirakkusu*	ギャラリー	*gyararii*	relax	Many-Few	タオル	*taoru*	agink
リング	*ringu*	イヤー	*iyaa*	ring	Many-Few	タンク	*tanku*	dite
ロール	*rooru*	キック	*kikku*	roll	Many-Few	ラック	*rakku*	eall
ルール	*ruuru*	スター	*sutaa*	rule	Many-Few	クイズ	*kuizu*	lonk
スケール	*sukeeru*	リターン	*ritaan*	scale	Many-Few	リレー	*riree*	pords
スコアー	*sukoaa*	ユース	*yuusu*	score	Many-Few	タイヤ	*taiya*	kacks
スクリーン	*sukuriin*	アクション	*akushon*	screen	Many-Few	クッション	*kusshon*	hieces
センス	*sensu*	コール	*kooru*	sense	Many-Few	シリコン	*shirikon*	guels
ショック	*shokku*	ワーク	*waaku*	shock	Many-Few	ウォール	*uooru*	sards
ショー	*shoo*	レース	*reesu*	show	Many-Few	ターン	*taan*	goll
サイン	*sain*	クロス	*kurosu*	sign	Many-Few	オゾン	*ozon*	adok
シングル	*shinguru*	ローカル	*rookaru*	single	Many-Few	クラッシュ	*kurasshu*	scacks
タスク	*tasuku*	スロー	*suroo*	task	Many-Few	ゾーン	*zoon*	pred

L2 - L1

Related Prime	Unrelated Prime	Target	Transcription	L2-L1 Semantics	Nonword Prime	Nonword Target	Transcription
banana	sailor	バナナ	*banana*	Few-Few	chic	オナナ	*onana*
bed	sock	ベッド	*beddo*	Few-Few	coin	ロジリ	*rojiri*
bus	cow	バス	*basu*	Few-Few	lens	キニャ	*kihya*
button	pencil	ボタン	*botan*	Few-Few	rack	サーク	*saaku*
cake	tank	ケーキ	*keeki*	Few-Few	ozone	ハワス	*hausu*
desk	fund	デスク	*desuku*	Few-Few	lazer	ヘワシ	*hewashi*
toaster	giraffe	トースター	*toosutaa*	Few-Few	serial	コンキャク	*koshikyaku*
flute	screw	フルート	*furuuto*	Few-Few	equal	キミサチ	*kimisachi*
fork	deer	フォーク	*fooku*	Few-Few	jazz	ソウチャ	*soucha*
gorilla	dresser	ゴリラ	*gorira*	Few-Few	sky	ヨゲレ	*yogere*
guitar	prison	ギター	*gitaa*	Few-Few	young	トデイ	*todei*
hanger	turtle	ハンガー	*hangaa*	Few-Few	salon	フエソク	*fuesoku*
helmet	ladder	ヘルメット	*herumetto*	Few-Few	season	ステーガス	*suteegasu*
kangar	necklace	カンガルー	*kangaruu*	Few-Few	through	モチカゲル	*mochikageru*
lemon	plain	レモン	*remon*	Few-Few	clerk	オウレ	*oure*
lion	arm	ライオン	*raion*	Few-Few	allergy	カゴテン	*kagoten*
peanut	expect	ピーナッツ	*piinatsu*	Few-Few	senser	オペレッチ	*operecchi*
pengui	chimney	ペンギン	*pengin*	Few-Few	resource	ジョロボロ	*joroboro*
pyram	bicycle	ピラミッド	*piramiddo*	Few-Few	rush	モモヤリ	*momoyari*
radio	joint	ラジオ	*rajio*	Few-Few	engine	ジナス	*jinasu*
rocket	profit	ロケット	*roketto*	Few-Few	leisure	ウウコク	*uukoku*
ski	pig	スキー	*sukii*	Few-Few	queen	ペライ	*perai*
skirt	coral	スカート	*sukaato*	Few-Few	square	エウサイ	*eusai*

L2 - L1

Related Prime	Unrelated Prime	Target	Transcription	L2-L1 Semantics	Nonword Prime	Nonword Target	Transcription
slippe	pelican	スリッパ	*surippa*	Few-Few	studio	カイポイ	*kaipoi*
spoon	tiger	スプーン	*supuun*	Few-Few	godzilla	ゼゼコミ	*zezekomi*
tent	bust	テント	*tento*	Few-Few	leather	カフフ	*kafufu*
tomato	bricks	トマト	*tomato*	Few-Few	cook	ネラブ	*nerabu*
tracto	dolphin	トラクター	*torakutaa*	Few-Few	essence	ザイガシロ	*zaigashiro*
trumpe	lobster	トランペット	*toranpetto*	Few-Few	collection	アイサワラズ	*aisawarazu*
violin	carrot	バイオリン	*baiorin*	Few-Few	karaoke	ヤワシカイ	*yawashikai*
brush	smell	ブラシ	*burashi*	Many-Few	monster	シュウケコ	*shuukeko*
cancel	normal	キャンセル	*kyanseru*	Many-Few	sweater	キンサウ	*kinsau*
care	past	ケーア	*keea*	Many-Few	can	マパ	*maba*
career	demand	キャリア	*kyaria*	Many-Few	sausage	ケレガグ	*keregagu*
case	left	ケース	*keesu*	Many-Few	rail	カーワ	*kaawa*
class	front	クラス	*kurasu*	Many-Few	live	トッフ	*toffu*
classi	caution	クラシック	*kurashikku*	Many-Few	slogan	ポジショショ	*pojishosho*
cool	hate	クール	*kuuru*	Many-Few	song	シゲイ	*shigei*
core	fail	コア	*koa*	Many-Few	skin	ワラリ	*warari*
course	matter	コース	*koosu*	Many-Few	juice	テスヨ	*tesuyo*
cycle	loose	サイクル	*saikuru*	Many-Few	tyre	コイカイ	*koikai*
goal	rain	ゴール	*gooru*	Many-Few	seal	クテツ	*kutetsu*
heart	learn	ハート	*haato*	Many-Few	rose	マパア	*mapaa*
lesson	stroke	レスン	*resun*	Many-Few	cookie	イキカヤ	*ikikaya*
loan	clue	ローン	*roon*	Many-Few	axle	バハヤ	*pahaya*

L2 - L1

Related Prime	Unrelated Prime	Target	Transcription	L2-L1 Semantics	Nonword Prime	Nonword Target	Transcription
pipe	bone	パイプ	*paipu*	Many-Few	taxi	カララケ	*kararake*
regula	excited	レギュラー	*regyuraa*	Many-Few	chorous	アザヤヤ	*azayaya*
relax	surge	リラックス	*rirakkusu*	Many-Few	arrangement	モシナシテ	*moshinashite*
ring	nose	リング	*ringu*	Many-Few	casual	フバパ	*fupapa*
roll	wake	ロール	*rooru*	Many-Few	angel	ワワイ	*wawai*
rule	fish	ルール	*ruuru*	Many-Few	wall	ナオブ	*naobu*
scale	crime	スケール	*sukeeru*	Many-Few	shutter	レッコシ	*rekkoshi*
score	youth	スコアー	*sukoaa*	Many-Few	water	アドン	*adon*
screen	waste	スクリーン	*sukuriin*	Many-Few	crystal	メラニズム	*meranizumu*
sense	ideal	センス	*sensu*	Many-Few	gallery	ブヤス	*buyasu*
shock	argue	ショック	*shokku*	Many-Few	yellow	コエエイ	*koeei*
show	acid	ショー	*shoo*	Many-Few	law	シポ	*shipo*
sign	race	サイン	*sain*	Many-Few	swing	キャガテ	*kyagate*
single	future	シングル	*shinguru*	Many-Few	concensus	ナリアゲ	*nariage*
task	firm	タスク	*tasuku*	Many-Few	stance	ターポ	*taapo*

APPENDIX 9.1

Text used in eye-tracking study

A day out in London

We had lived in London for many years but never had much time to do any sightseeing. So, one Sunday morning when I opened the curtains and found it was a bright, clear day without a cloud in the sky, I suggested to my wife, Leanne, that we visit the zoo and then take in some other sights as well. My wife, who was lying in bed at the time, happily agreed and immediately went to take a shower and get ready.

I put on a shirt while Leanne was drying her hair. Then, I got on the Internet and searched for any discount tickets available for the zoo, and also to check that the zoo was actually open (I had heard they were renovating sometime last year). I was browsing on a particular website and happened to find a buy-one-get-one-free deal for the zoo, that meant free zoo tickets if we also purchased tickets for a film being shown at a local cinema.

In fact, the film was a new release by one of my wife's favourite directors, so I was pretty sure she'd agree to it. Well, isn't that lucky, I thought. I was starting to feel quite excited about the day – it might turn out to be quite special indeed.

Eventually, Leanne settled not on the skirt or the trousers but on a nice summery dress accompanied by a matching necklace, meaning that we could finally make a move. The question was whether to go by bus, taxi, car or train; living in the centre of London gives you a lot of options, especially when the destinations are reasonably close. We thought that we'd treat ourselves and go by taxi to the zoo then decide later how to get to the cinema. Our goal was to enjoy the day, regardless of expense (especially seeing as I'd saved us money on the tickets!)

In the zoo and beneath the beautiful midday sun we saw a multitude of different animals. We saw pelicans that were floating around in a huge pool made of plastic and carefully molded into the shape of South America. Close by were the penguins doing their funny little walk across to the buckets of fish that had been prepared for them. Some children were trying to feed peanuts to them - who had ever heard of penguins eating peanuts! Surely the rules state 'no feeding the animals', but hey, whoever works here should be enforcing them, not us.

There were monkeys who had made hammocks out of tree branches and were literally just hanging around. I wondered who had perfected the art of relaxation the most: humans or monkeys. The Australian section had kangaroos that looked dangerous when they demonstrated their powerful kick to each other. The biggest animals, like the gorillas, giraffes, elephants but also the lions, were very impressive to see close up. The gorillas nonchalantly gulped down bananas one after the other, while giraffes were fed carrots by zookeepers.

The elephants seemed too big for their housing, and their ears appeared to be attacked incessantly by insects. The lions appeared really quite gentle, rolling around and chewing on large bones, until unexpectedly one of them let out a ferocious growl, shocking the crowd. We also saw tigers, zebras and snakes, which certainly left us satisfied with our visit.

We took a seat on a bench in front of the bandstand and prepared to enjoy the free show that was provided each afternoon. On the stage, there was a pair of musicians who were apparently quite famous, having appeared on both the radio and television a number of times. One was a tall, blonde woman who played the violin with incredible dexterity; accompanying her was a man playing the trumpet, which by the way is a very difficult instrument to master.

I once tried to learn the trumpet but breathing through my nose is not one of my strong points, and my lips always seemed to get too stiff meaning I couldn't control the airflow. Spotting a huge diamond ring on the violinist's finger, I realised that she was married but not noticing one on his, I guessed that he was single, though one can never reliably guess these things. Yet one thing was certain though: I could never afford to buy my wife a ring like that. I'd have to take out another bank loan to be able to afford one of those!

The music they played was not only beautiful but very interesting as it seemed to cross many different genres and wasn't limited to simply classical music, as we had expected. Another couple came on afterwards with guitars and a flute, but we decided not to stay any longer and instead headed to the zoo's "Animal Cafe" just across the concourse.

Inside the cafe we ordered a coffee and a piece of cake that was decorated with characters from Disney's Jungle Book. These places never seem to put much effort into providing quality food - I don't think I'd ever tried a cake that was so dry. We both had to ask for an additional glass of water to wash it down. We’ve joked about that experience ever since.

On our way out we passed the information centre where one of the zoo's staff appeared to be giving a talk. It happened to be the head zookeeper so we decided to pop in for five minutes. The head zookeeper was an old man who smoked regularly on his pipe as he talked in a slow, intriguing tone. He was extremely knowledgeable about the animals, their habits and their natural habitats, indicating that his career had been a long one.

He mentioned the importance of regular exercise, a balanced diet and careful grooming. The brush that they used for grooming the larger animals was half a metre long! All in all, the free lesson in zoo keeping was enjoyable, though I doubt I'll ever get to put that knowledge to use.

We were both pretty exhausted after the zoo but managed to make it to the cinema on time. The man at the front desk gave us our tickets and we went in. The screen brightened and the commercials began. I don't actually remember seeing the film because I dozed off straight away. Leanne informed me afterwards that it was, as she expected, a cool, modern interpretation of youth in multi-cultural London; the style and quality was consistent with the director's reputation. I guess the zoo had taken all of my energy - I'd have to see the film another day.

APPENDIX 9.2

Cognate and noncognate targets used in eye-tracking study

Cognate Targets					Noncognate Targets				
English	**Japanese**	**Phonological Transcription**	**Phonological Similarity**	**Semantic Similarity**	**English**	**Japanese**	**Phonological Transcription**	**Phonological Similarity**	**Semantic Similarity**
bananas	バナナ	*banana*	3.4	4.9	beautiful	美しい	*utusukushii*	1	4.4
bed	ベッド	*beddo*	4.2	4.1	bones	骨	*hone*	1	4.6
bench	ベンチ	*benchi*	3.7	4.7	carrots	人参	*ninjin*	1	4.8
brush	ブラシ	*burashi*	3.1	4.2	cloud	雲	*kumo*	1	4.1
bus	バス	*basu*	4.1	4.7	dangerous	危険な	*kikenna*	1	4.2
classical	クラシック	*kurashikku*	3.7	3.7	destination	目的地	*mokutekichi*	1	3.5
coffee	コーヒー	*koohii*	3	4.5	ears	耳	*mimi*	1	4.8
curtains	カーテン	*kaaten*	3.4	4.5	effort	努力	*douryoku*	1	4
diamond	ダイアモンド	*daiamondo*	3.5	4.7	enforcing	(決まりを)守らせる	*(kimariwo) mamoraseru*	1	3.4
flute	フルート	*furuuto*	3.8	4.1	famous	有名な	*yuumeina*	1.2	4.3
gorilla	ゴリラ	*gorira*	3.3	4.7	favourite	好きな	*sukina*	1	3.6
guitars	ギター	*gitaa*	3.1	4.9	finger	指	*yubi*	1	4.6
hammock	ハンモック	*hanmokku*	3.3	5	five	五	*go*	1	4.3
kangaroo	カンガルー	*kangaruu*	3.5	4.9	gentle	大人しい	*otonashii*	1	2.5
lions	ライオン	*raion*	3.7	4.9	habits	習性	*shusei*	1	3
pelican	ペリカン	*perikan*	3.4	4.8	impressive	印象的	*inshouteki*	1.1	3.6
penguin	ペンギン	*pengin*	3.3	5	learn	学ぶ	*manabu*	1.1	4.4
pipe	パイプ	*paipu*	3.7	4.4	lips	唇	*kuchibiru*	1	4.7
plastic	プラスチック	*purasuchikku*	3.2	4.1	married	結婚している	*kekkonshiteiru*	1	4.3
pool	プール	*puuru*	3.6	4.3	nose	鼻	*hana*	1.1	4.9
radio	ラジオ	*rajio*	2.5	4.6	places	場所	*basho*	1	4.3

Cognate Targets					Noncognate Targets				
English	**Japanese**	**Phonological Transcription**	**Phonological Similarity**	**Semantic Similarity**	**English**	**Japanese**	**Phonological Transcription**	**Phonological Similarity**	**Semantic Similarity**
shirt	シャーシ	*shaatsu*	1.7	3.4	purchased	買う	*kau*	1	4
shower	シャワー	*shawaa*	3.6	3.7	snakes	蛇	*hebi*	1.1	4.9
skirt	スカート	*sukaato*	3.2	4.8	sun	太陽	*taiyou*	1.1	4.8
taxi	タクシー	*takushii*	3.5	4.5	tree	木	*ki*	1	4
television	テレビ	*terebi*	2.4	4.9	trousers	ズボン	*zubon*	1.1	3.8
trumpet	トランペット	*toranpetto*	3.7	5	zebra	シマウマ	*shimauma*	1	4.7
violin	バイオリン	*baiorin*	3.3	4.8	zoo	動物園	*doubutsuen*	1	4.4