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Language Switch Costs in Urdu-English Bilinguals : A Behavioral Study

Ranjeeta Mahraj

Abstract

This study examines language switch costs, as there is a recent body of work showing that there are behavioral "costs" involved when bilinguals switch between their two languages. A particular point of debate concerns symmetry, regarding whether it is more costly (i.e., takes longer) to switch from one of a bilinguals' languages to the other, or vice versa. In the current study, a partial replication of (Struck & Jiang, 2022), data was collected online from 90 Urdu-English bilinguals living in the US and Pakistan on a language background questionnaire, and a Lexical Decision Task (LDT), designed to measure the effects of language switching. Two moderating variables were investigated in the current study, the role of language environment (i.e., whether subjects were immersed in either an English- or Urdu-speaking environment) and self-rated proficiency. In order to measure switch costs, reaction times (RTs) to responses were recorded during the LDT; data were analyzed through linear mixed-effects models. The study examined the effect of Switching (Urdu-English vs. English-Urdu) and Response, categorized as either repetition (e.g., participants pressed the same button twice) or response change. Results revealed an overall effect of Language, such that subjects showed faster RTs to English words compared to Urdu words. However, we did not replicate previous findings and found no effect of language Switching, with similar RTs observed in both types of switching. Interestingly, when language environment was included as a factor in the LME model, an interaction between Response and Language emerged, such that English RTs were found faster in comparison to the Urdu RTs. In sum, this study provides new insights into language switching, revealing novel results from a new language pair/population, which may contribute to the complex findings.

Keywords: bilingualism, psycholinguistics, language switching, lexical access

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Language Switch Costs in Urdu-English Bilinguals: A Behavioral Study

By

Ranjeeta Mahraj

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Department of Linguistics

Thesis Committee:

[redacted]_

Dr. Lauren Covey

Thesis Sponsor

[redacted]___

Dr. Larissa Goulart

Committee Member

[redacted]____

Dr. Longxing Wei

Committee Member

____

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1. Introduction

Bilingualism has always been the topic of great attention to researchers in the field of linguistics and and cognitive neuroscience. Bilinguals are those who speak two languages and have command over language switching. The experience of bilingualism can vary widely depending on a person's environment, including whether they learned both languages simultaneously from birth or learned a second language later in life through immersion in a new environment. Kroll and Ma (2017) discuss recent counter-intuitive findings in their chapter on the bilingual lexicon that suggest that bilingual speakers keep their both of the languages active even when only one of the languages needs to be activated (Fernández et al., 2018; Kroll & Ma, 2017). This is taken from examining the perspective of two models, first the Bilingual Interactive Model+ (Dijkstra & Van Heuven, 2002) and second the Revised Hierarchical Model (Kroll & Stewart, 1994). The authors note that the similarity between the languages and the activation of two languages together is not dependent on language proficiency. Kroll and Ma (2017) also review studies presenting that production and comprehension are impacted by this simultaneous activation and discuss mechanisms that allow bilingual speakers to inhibit the inactive language when required.

Choosing a particular word from a set of options has a significant impact on the corresponding word in the intended language. This perspective suggests that bilingual individuals engage in comparable processes to monolingual speakers when accessing words, as the target language regulates which options are to be activated and the two languages are not treated as simultaneous entities. Yet words from the non-targeted language may become activated, though they are not considered viable options for selection (Kroll et al., 2008). For example, Words from non-targeted language exhibits when individuals think in one language usually in L1, though the response is not required to be produced in their L1. Yet, they activate cognitive process in L1 even to produce their response to the second language L2. So, this is not considered a viable option for selection.

Examining how bilinguals access their two languages can provide insights into the structure and usage of the mental lexicon, which is particularly interesting given research that has argued for non-selective lexical access (Ong et al., 2019). Early research on bilingual lexical access found cross-linguistic effects, such that bilinguals' first language (L1) could influence performance on a variety of psycholinguistic tasks in their second language (L2) (Issa et al., 2021). This suggests that for bilinguals, both languages remain active, even in monolingual contexts in which only one language is being used.

Bonfieni et al. (2019) define that the ability to control and access language is influenced by various factors in the bilingual experience. Regarding, language switching is also affected by the amount of exposure to the second language L2 based on daily routine, which in turn affects the mixing of languages. Moreover, the age of the individuals at which they started acquiring L2 can predict the overall time it takes to access the L2. These findings highlight the idea that language dominance is not solely determined by proficiency and establish a link between the mechanisms of language control and certain aspects of language experience (e.g., Tao et al., 2021; Bonfieni et al., 2019). This is particularly interesting to examine in highly multilingual countries like Pakistan and India, where there are many regional languages as well as national languages that include Urdu and English (as well as Hindi).

This paper specifically examines language switching, which is at play when bilingual individuals switch from one language to the other. Individuals who live in dual-language communities are often found engaged in language alternation. Although there is a long history of code-switching research (Hui et al., 2022; Khodos et al., 2021; Litcofsky & Van Hell, 2017; Segal et al., 2021), the goal of the present study is to examine the psycholinguistic effects of language switching, examining “costs”, measured as the time required to switch, measured behaviorally (e.g., reaction times). A new line of research investigates whether it is the case that bilinguals experience reduced costs when they switch from their more dominant language (e.g., L1) to their less dominant and/or less proficient language (e.g., L2) (de Bruin et al., 2023; Deibel & Cognition, 2020; Hui et al., 2022; Khodos et al., 2021; Meuter et al., 1999; Mosca et al., 2022; Segal et al., 2021; Shi et al., 2023; Struck & Jiang, 2022; Volmer et al., 2018; Zhu et al., 2022). In contrast, it has been argued that switching from L2 to the more dominant L1 is more costly, making switching costs asymmetric.

The goal of the current study is to probe language switching costs in comprehension, examining whether costs are indeed asymmetric when switching from the L1 to the L2 and vice versa. This study extends an active line of research to a new language pair, Urdu-English bilinguals. In addition, unlike most laboratory psycholinguistics studies, this study is carried out online, allowing us to collect data from bilinguals living in English-immersed environments (e.g., US residents/immigrants) as well as participants currently living in Urdu-speaking environments (e.g., Pakistan, India). In what follows, the relevant literature regarding lexical access and language switching is reviewed. Then, details about the methods of the current study are outlined before the results are discussed.

2. Literature Review

2.1 Models of Bilingual Lexical Access

Models of the bilingual mental lexicon primarily are concerned with the mechanisms involved in the interaction of the bilingual's two languages. Given the overwhelming evidence of cross-language activation for bilinguals in both comprehension and production, different models of lexical access hypothesize about the nature and extent of parallel activation. One model that has received a great amount of attention within the last twenty years is the Bilingual Interactive Activation (BIA) model, developed by Grainger and Dijkstra in 1992. It has been further expanded upon in subsequent models such as BIA+ (Dijkstra et al., 2002) and BIA-d (Grainger et al., 2010). The BIA+ Model builds upon the Interactive Activation Model (McLelland & Rumelhart, 1981), which uses a connectionist architecture to explain word recognition, such that concepts and words are represented in a network of nodes, and the activation of one node can spread to other nodes that are associated with it. BIA+ extends this model to bilingual processing by assuming that bilinguals have two separate but interconnected sets of nodes, one for each language. The activation of a node in one language can spread to its translation equivalent in the other language, and vice versa. Under this account, early stages of lexical access involve bottom-up processing of sub-lexical information, such as orthographic and/or phonological information, which are activated in parallel in both of the bilinguals' languages. This results in competition between potential word candidates. At the second stage of processing, words are identified in each language, with language control only available later in the time course of processing.

Evidence for the BIA+ model is largely based on studies on bilingual word recognition. The model predicts that bilinguals should activate both of their languages when processing words in either language and that the level of activation for each language will depend on factors such as the frequency and context of the word. This prediction has been supported by a large body of research using a variety of methods. For example, Kroll and colleagues (2002) conducted a study in which they asked bilinguals to read words presented in their first language (L1) or their second language (L2) while measuring their reaction times. They found that the reaction times were slower for words that were less frequent in the language being processed, suggesting that the activation of each language was influenced by the frequency of the words. This finding is consistent with the BIA+ model's prediction that language activation is determined by the frequency of the words. Another line of evidence for the BIA+ model comes from studies of language switching. The model predicts that language switching should be influenced by various factors, such as the cognitive control demands of the task and the similarity between the two languages. Kroll and colleagues (2010) conducted a study in which they asked bilinguals to perform a language-switching task while measuring their brain activity. They found that language switching was associated with increased activation in brain regions involved in cognitive control. This finding supports the BIA+ model's prediction that language switching is associated with increased cognitive control demands (Kroll et al., 2008; Kroll et al., 2006; Kroll et al., 1994). More recent models, such as BIA-d, propose that inhibition is a crucial top-down control mechanism that suppresses other language items from the non-target language that may have been activated simultaneously during comprehension (Tao et al., 2021).

One key feature of BIA+ is that it takes into account the proficiency level of the bilingual in each language. Nodes that represent words that are more frequent or more important in one language will have higher activation thresholds in the other language, reflecting the fact that bilinguals may be less proficient or less familiar with those words. In a review paper by Van Hell and Tanner (2012), the role of proficiency in bilingual lexical access was examined in detail, and they report that the majority of individuals around the world use multiple languages regularly, with many having learned their second language during their childhood education. However, research has shown that success in learning a new language varies significantly among L2 learners, with only a small proportion achieving a native-like proficiency in their second language. Language proficiency is not a binary measure but rather a complex and continuous construct that encompasses several dimensions, including a bilingual's lexical, morphological, or syntactic knowledge in both languages. As language experience changes, individuals can progress along these continua. The differences in proficiency levels between a bilingual's two languages affect how they activate and use each language. Typically, the stronger language (usually the L1) has a more profound influence on the weaker language (typically the L2), while processing in the first language is only affected by the non-target L2 in bilinguals with high levels of proficiency in the second language (Van Hell & Tanner, 2012). BIA+ has been used to account for a wide range of bilingual phenomena, including code-switching, lexical access, and language comprehension. It has also been extended to account for the processing of more than two languages in multilingual individuals. Overall, BIA+ provides a useful framework for understanding how bilinguals process and access their two languages, taking into account the complexity and dynamic nature of bilingualism.

The second model of bilingual lexical access is the Revised Hierarchical Model (RHM; Kroll & Stewart, 1994). The RHM takes a different approach, focusing on form-to-meaning mapping, with emphasis on how L2 words are initially learned. Evidence for the RHM initially focused on words that were translation equivalents in the L1 and L2, resting on the assumption that early word learning of L2 vocabulary is mediated by access to the L1 translation equivalent. Thus, there is an important role for transfer under this model, and a clear role for language development, such that as learners become more proficient in the L2, reliance on L1 translation equivalents decreases until speakers can directly access the meaning of L2 words without the L1. Early evidence for the RHM came from tasks involving translation equivalents (Kroll & Stewart, 1994; Talamas, Kroll, & Dufour, 1999; see Kroll et al., 2010 for a review). Of relevance is that the RHM makes specific claims for early stages of L2 learning, although L1 translation effects have been observed for highly proficient bilinguals (e.g., Guo et al., 2012; Thierry & Wu, 2007), leaving open the question of whether L2 words are accessed via their L1 translations.

2.2 Language Switching Costs

Although language switching can sometimes occur unintentionally in emotionally charged situations, proficient bilingual speakers are generally skilled at selecting and keeping their languages separate. This makes it possible for bilingauls to listen to one language while speaking another. Professional simultaneous interpreters can even speak one language while listening to another for up to 75% of the time. Consistently, switching from the weaker L2 language to the dominant L1 language resulted in a larger cost than the opposite direction, meaning that when participants switched languages, their responses were slower in L1 than in L2 (Meuter et al., 1999).

More recent psycholinguistic approaches to language switching investigate the behavioral costs involved in switching, which can be measured in tasks targeting production or comprehension. Much of this research has reported asymmetrical costs. For example, in their seminal study, Meuter and Allport (1999) measured the latency of picture naming in a mixed language task, finding that language switching leads to slower latency for picture naming. This behavioral cost differed depending on the direction of switching, with greater costs observed for L2-to-L1 switches, which they termed backward switches, as compared to L1-to-L2 switches, referred to as forward switches. This asymmetry has been theorized to be linked to the cognitive resource 'inhibitory control' which is an attentional mechanism that is involved in executive functions (Struck & Jiang, 2022). Although backward switches require a great deal of inhibitory control to suppress the dominant L1, forward switches are more costly because the high level of inhibitory control has to be overcome to reactivate the L1, with this "reactivation cost" leading to slower performance. This proposal is largely in line with expectations of the BIA+ model (Dijikstra & van Heuven, 2002), which attributes switch costs to language control mechanisms. However, as Struys et al. (2019) point out, the BIA+ model associates domain-specific control mechanisms with language production, which arguably involves inhibitory control when multiple competitors are activated in the early stages of processing.

Two new studies have attempted to investigate language switching in comprehension rather than production. This is an interesting test case because recognition tasks (e.g., lexical decision tasks) have been argued to recruit different mechanisms. In production studies utilizing picture naming tasks, a given stimuli (picture) can elicit two responses, one in each language. Thus, inhibitory control becomes important given the competition between the two different responses. In contrast, recognition tasks typically utilize stimuli (e.g., a word) that are "univalent," such that they are coded to represent a specific language. It has been argued that switch asymmetries emerge in production tasks due to the involvement of inhibitory control which is not necessarily recruited in recognition tasks (Reynolds et al., 2016).

Over the past decade, there has been significant research conducted on how bilingual individuals manage their two language systems during daily interactions (Kroll & Bialystok, 2013). The findings of numerous studies indicate that bilingual language management involves the use of cognitive control. Such cognitive control can enhance the bilinguals' performance on tasks that involve interference with conflict trials, such as the Simon task (Bobb et al., 2013; Zhou et al., 2016). To investigate the role of language control in language switching, a recent study by Struys et al. (2019) employed a categorization task involving 32 young adults fluent in both Dutch and French. Their study builds on the assumption that language-switching experience in bilinguals has an impact on domain-general cognitive control abilities. Domain-general cognitive resources refer to general intelligence abilities that engage information processing; this is also related to the level of proficiency of bilinguals in one or both of their languages. They examined the relationship between L1 Dutch L2 French bilinguals' language switching and their domain-general cognitive control skills. Findings exhibited that domain-general monitoring is effectively involved in language-switching performance while exposure to language contributes to controlling certain language. Struys et al. argued that individuals with higher proficiency or longer exposure to L2 may show more assistance in language switching than individuals with low proficiency and shorter exposure to L2.

Moreover, a recent study by Struck and Jiang (2022) investigates the symmetry of language switch costs in a lexical decision task (LDT). The relationship between language switching and cognitive processes is examined with English-Chinese bilinguals. The study aims to answer the research question of whether the language switch costs are symmetrical for both languages and whether the cognitive processes are associated with successful language switching. The experiment involved 100 English-Chinese bilinguals who were asked to perform a lexical decision task in which they had to decide whether a presented string of letters was a real word or not in either English or Chinese. They found larger switching costs asymmetrical during language switching, they observed greater switching costs from L1 Chinese to L2 English as opposed to the opposite direction, from English to Chinese. In addition, the article by Struys et al.

(2019) aims to provide a domain-general monitoring account of language switching in recognition tasks by examining the behavioral and neural mechanisms of language switching. The study investigates the research question: How do bilinguals monitor and control their language selection in recognition tasks? The experiment involved 32 Dutch-French bilinguals who performed a semantic categorization task in which they had to decide whether a presented word belonged to a particular semantic category in either Dutch or French. The study found that bilinguals can monitor and control their language selection in recognition tasks by engaging in domain-general cognitive processes. Specifically, the study found that bilinguals exhibit adaptive control mechanisms, which allow them to switch between languages efficiently. These mechanisms involve the activation of a domain-general monitoring system that evaluates the language context and adjusts the cognitive control settings accordingly. In summary, both studies provide valuable insights into the cognitive processes involved in language switching. The study by Struck and Jiang highlights the importance of the symmetry of switch costs during language switching. The study by Struys et al. contributes to our understanding of the neural and behavioral mechanisms of language switching and provides a domain-general monitoring account of language switching in recognition tasks.

Together, Keeping the difficulty of Urdu-English bilinguals in language switching in view, the study of Stuck and Jiang also addresses the same problem, but the pair of languages was change. Therefore, this study needs to be conducted to replicate their paper and extend the methods to a new language population as Urdu-English bilinguals in order to build a comprehensive picture of the cognitive processes involved in language switching.

3. Current Study

This study aims to investigate the impact of language environment and language dominance on language and switch costs in English-Urdu bilingual speakers, an understudied population, and as one of only a handful of studies examining switching using a receptive language task. In a partial replication study, we extend the work by Struck and Jiang (2022). We created a lexical decision task with 400 items (words and non-words), 200 items in Urdu, and 200 items in English. We analyzed data from this project, intending to compare language switch costs measured via recording reaction times (RTs) from Urdu to English, as well as English to Urdu.

In Pakistan, a country with over 50 local languages, one national language (Urdu), and one official language (English), residents regularly engage in switching between two or three of their languages, often within the same conversation. Therefore, this study's interest centers on language switching with respect to switch "costs," measured as the time taken to switch from one language to another. The existing literature on receptive switch costs has two limitations that limit a complete understanding of the phenomenon. Firstly, there is a lack of research on the symmetry of switch costs in receptive tasks, and the available studies have used a wide range of methods, making it difficult to identify the factors that affect the magnitude of switch costs. Additionally, because many studies have focused on production, less is known about the switching costs potentially involved in comprehension. These reasons may hinder the synthesis of findings and a comprehensive understanding of switch costs in receptive tasks.

This study aims to examine the nature of switch costs in receptive language tasks, and it is divided into two research questions. The first question builds directly on the Struck and Jiang (2022) study, investigating whether switch costs are symmetrical. The second question is exploratory, concerning whether there is an impact of language environment and language dominance on LDT performance (i.e., switch costs). Even though both questions aim to understand switch costs in receptive language tasks, they have different focuses. The second question aims to relate the theoretical discussion of the role of language dominance as well as the role of living within an English-speaking environment. Therefore, it is important to distinguish between receptive and productive tasks when studying switch costs.

The study aimed to overcome the limitations of previous research by directly addressing two questions related to switch costs. To address the first question about switch cost symmetry, we administered a controlled lexical decision task. We controlled for the variable of response sequence (repetition or change) in the design and included it in the model.

3.1 Linguistic Background

English and Urdu are the two predominant languages used in Pakistan and are highly valued in the country's linguistic market, or "linguistic capital" (Bourdieu, 1991; Simons & Charles, 2018). While Urdu is commonly used as a lingua franca across the country, English is the official language and is privileged in elite institutions like the military and bureaucracy (Rehman, 2004). As a result, fluency in English is often necessary for access to prestigious higher education and well-paying jobs. Although Pakistan's National Education Policy acknowledges the importance of English and Urdu languages besides the regional languages (NEP, 2009), these languages are typically lower in the language hierarchy and mainly used informally among family and friends (Manan & David, 2014; Rahman, 2003). Overall, both Urdu and English are commonly used for oral and written communication in various contexts in Pakistan.

Pakistan has a diverse range of languages, with 77 languages spoken by its people. Despite this, Urdu and English are the only two official languages. After gaining independence from British colonial rule in 1947, the country underwent a significant shift in language policy. The policy, which was previously monolingual, oriented towards Urdu, with English being reserved for elite institutions. However, in 2009, the country made a promising shift towards the educational policy regarding multilingual language, responding to the growing social demand for the inclusion of English in the curriculum. Despite this change, Urdu still dominates the present language policy, neglecting the inclusion of dynamic and unstable regional non-dominant languages that are continually restructured due to the country's multilingual and plurilingual repertoire (Ashraf, 2022).

Urdu is a combination of Arabic, Persian, Turkish, and Hindi languages, and it has 39 letters that are written from right to left (Zaidi, 2020). Although the spoken style of Hindi and Urdu languages are similar, which can be compared to the parallel differences between British and American English (Bhatia & Ritchie, 2014), Urdu is written with a different script (Perso-Arabic).

In a 2013 survey, Gallup Pakistan estimated that 53% of the population speaks Urdu at home. According to the Census Pakistan Bureau of Statistics (2017), Pakistan is a multilingual country with many also proficient in regional languages such as Punjabi (44.15%), Pashto (15.42%), Sindhi (14.1%), Saraiki (10.53%), Balochi (3.57%, and others (4.66%) (Statistics, 2017). English is widely used as a second language in education, government, and business, whereas Urdu is popular in national media, such as television, radio, and newspapers as well as in business and education. In this context, bilingualism often involves using Urdu and English interchangeably in various domains, such as code-switching between the two languages in conversation.

For Urdu speakers living in the US, English is the dominant language in the environment. Bilingualism in the US often involves the use of English and Urdu in different contexts, such as immigrants from Urdu-speaking countries speaking Urdu at home and English in school or work. Immigrant communities may also use a combination of languages in daily life, with children growing up with exposure to both their home language and English.

3.2 Method

3.2.1 Participants

Subjects were recruited through email advertisements, social media, and word-of-mouth contacts. An eligibility survey was used, and participants were invited to participate if they identified as bilingual in Urdu and English, and additionally indicated that they were literate in both languages. 90 individuals participated in the study on a volunteer basis, 82 of which were retained for analysis after matching responses on the language history questionnaire and Testable LDT (49 males, 33 females). Demographic information for participants was collected from a language history questionnaire, represented in Table 1.

Table 1.

Demographic information for participants

Age	*M*=31.2, *SD*=6.0, Range=21-63
Level of Education	High school: 2 Undergraduate: 12 Master's degree: 58 Doctorate: 9 NA: 1
Length of Residence in the US (n=48)	Less than 1 year: 2 1-2 years: 38 2-5 years: 1 More than 5 years: 7

The United States Census Bureau conducted the American Community Survey (ACS) and states that the number of Urdu speakers in the USA was approximately 709,000 in 2019, of those approximately 61,000 people spoke Urdu at home in the USA (tables, 2019). In our study, Most of the Urdu-English bilinguals belong to Asian countries like especially Pakistan and India, and have been living in the USA for more than a year in the capacity of being Fulbright scholars.

3.2.2 Task and Stimuli

Following Struck and Jiang (2022), the lexical decision task was employed as the main experimental task. In the lexical decision task, participants are required to visually process character strings displayed on the screen of a computer and make binary decisions about them. The participants need to determine whether the presented item is a real word or not a real word. Participants respond "yes" if the item is a real word in either English or Urdu, otherwise "no" if it is not a real word. The experiment was implemented online via Testable.org, and individuals were directed to press the number key “1” with their left index finger for a non-word, the number key “0” was to be pressed with their right index finger when a real word was identified.

There were 400 trials in the task, divided into 200 Urdu items and 200 English items. In each language, half of the items were real words and half were non-words. The English items were taken directly from Struck and Jiang (2022), disyllabic nouns of five to eight letters. Frequency statistics were derived from the Corpus of Contemporary American English (Davies, 2008). Non-words were sourced from the English Lexicon Project (Balota et al., 2007), with one or two letters changed from existing words. The Urdu items comprised four to eight characters of Urdu disyllabic nouns. The frequency of Urdu words measured from Sketch Engine - Urdu Web 2018 (urTenTen2018) available size of the corpora 245,656,128. Non-words were created from real words through replacing one letter to be phonologically pronounceable in Urdu, involving combinations of four to eight characters. Non-words were reviewed by native speakers to ensure that they were not colloquialisms or existing words. After Urdu items were created, items were cross-checked across languages to ensure there were no cognate words or translations.

Table 2.
Example stimuli

Language	**Lexical Status**	**Item**
English	Word	guffaw
English	Non-word	snaze
Urdu	Word	زنجیر(chain)
Urdu	Non-word	پرنکا

The LDT employed a within-subject design, crossing the factors of Language (English/Urdu), Lexicality (word/non-word), Switch (switch/non-switch), and Response (change/repetition). The condition Response concerns the lexicality of the previous item; for example, if two subsequent trials were words (in either language), participants would be required to press "1" on two sequential trials. The second word in this example would be labeled response-repetition. When a non-word trial followed a word trial, participants were required to press "0" after having pressed "1" on the previous trial, and these were coded as response-change. Following Struck and Jiang (2022), only words were analyzed; non-words were included for task-design purposes and were excluded from the analysis.

3.3.3 Procedure

Participants who met the criteria were invited to participate in an online experiment session that took about 20 minutes. Participants provided written informed consent prior to beginning the tasks. First, participants completed a language history questionnaire on Qualtrics. After the survey was completed, participants were automatically redirected to the lexical decision task, which was hosted on the website Testable.org. A randomly generated code was used to link data from both websites. Before the main experiment, participants saw four practice trials, which included words and non-words in both languages. During the experiment, participants were provided with three breaks, after 100 trials each, and participants could take as much time as they needed.

4. Results

Following Struck and Jiang's (2022) procedures, the data were cleaned before analysis. Only correct trials were analyzed, and non-word trials were also not included in the analysis. Then, to calculate within-subject RT cutoffs, conditional means and SDs were calculated for each participant within each condition (e.g., language, switch, response, etc.). Conditional means were used to replace RTs that were under 300 ms, and RTs that were greater than one conditional mean plus three conditional SDs. One participant was eliminated after this procedure for having incorrect responses to all Urdu words. A remaining 82 individuals were included in the final data analysis.

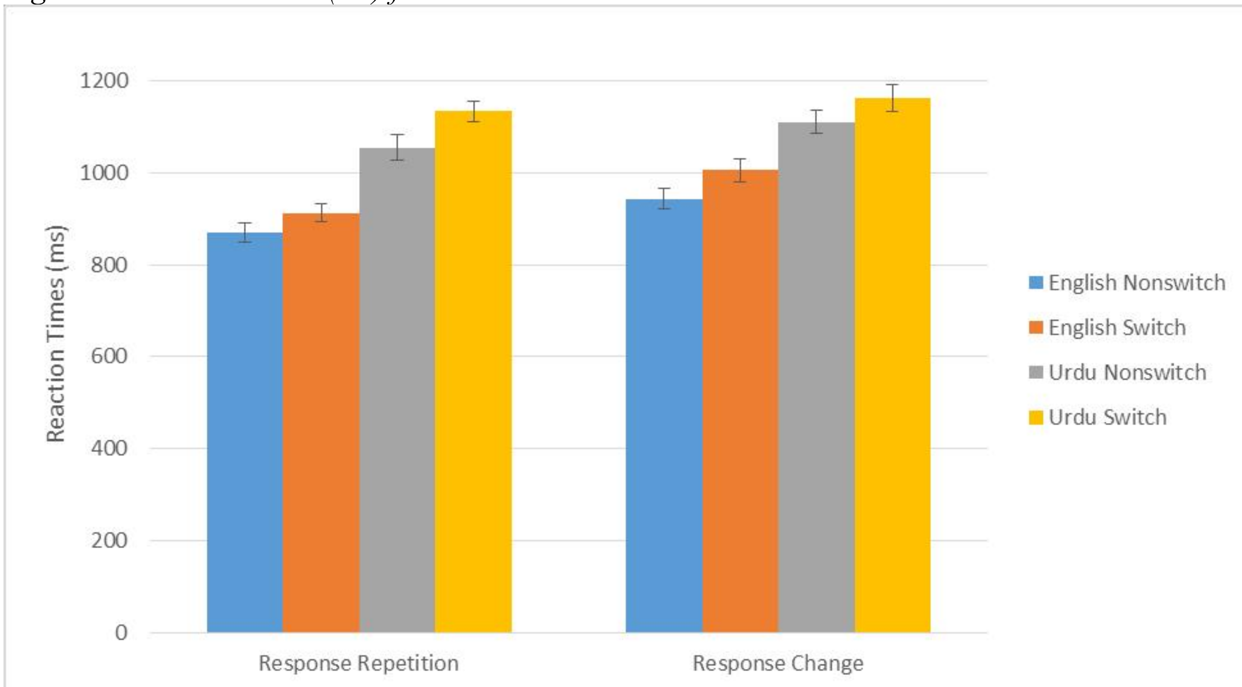
Raw RTs and error rates are reported in Table 1. One initial observation that should be pointed out are the descriptive differences between the RT results in the current study and those in Struck and Jiang (2022). On average, participants in our study shows longer RTs by a magnitude of about 300-400 ms. However, error rates across experiments are more comparable, approximately 1-2% higher in the current dataset. It is unclear why the RT results are much higher in this experiment, but as we speculate in the discussion section, this may be linked to the online modality or to factors related to the multilingual group of participants we tested.

Table 3. Reaction times (RT) and error rates from lexical decision task.

	Non-switch			***Switch***			***Costs***	
	RT	**(SD)**	**ER (%)**	**RT**	**(SD)**	**ER (%)**	**RT**	**ER (%)**
English overall	904.6	(985.0)	3.3	956.1	(1013.8)	3.3	+51.5	-0.04
Response Change	941.8	(1018.8)	4.7	1004.8	(1115.8)	4.0	+63.0	-0.7
Response Repetition	867.6	(949.2)	1.9	910.9	(906.9)	2.6	+43.3	+0.7
Urdu overall	1079.0	(1213.8)	5.4	1142.3	(1170.9)	7.2	+63.3	+1.8
Response Change	1109.5	(1123.4)	6.3	1158.3	(1309.6)	9.1	+48.8	+2.7
Response Repetition	1049.7	(1294.5)	4.5	1127.3	(1023.4)	5.5	+77.6	+1.0

Figure 1 demonstrates the RT results for the eight experimental conditions in the lexical decision task. Overall, this figure demonstrates the relatively small magnitude of RT costs across conditions, which Table 3 reveals, are on the scale of less than 100 ms. To investigate if RTs were influenced by the experimental conditions, a linear mixed-effects model was fit to the data.

Figure 1. Reaction times (ms) for lexical decision task



The model was fit with maximum likelihood estimation in R (3.4.0; R Core Team, 2018) with lme4 (Version 1.1-12; Bates et al., 2015), and *p*-values were obtained via the lmerTest package (Version 3.1; Kuznetsova et al., 2017). We followed the analysis procedures outlined in Struck and Jiang (2022). The model included fixed effects of Language, Switch, and Response, with all of their two- and three-way interactions. For each of the categorical variables, we utilized the following baselines: Language = English; Switch = Non-switch; Response = Change. With respect to random effects, we added random intercepts of participants and trials (i.e., item by list) as a first step. Then using forward likelihood ratio tests, we found that the addition of a random slope of Language by participant accounted for a significant portion of variance, so it was included. The final model utilized a random effects structure that was as maximal as the data and design allowed (Barr et al., 2013). We opted to use raw RT data as the dependent variable in the model (Lo & Andrews, 2015; Skalicky et al., 2019). The final model is reported below:

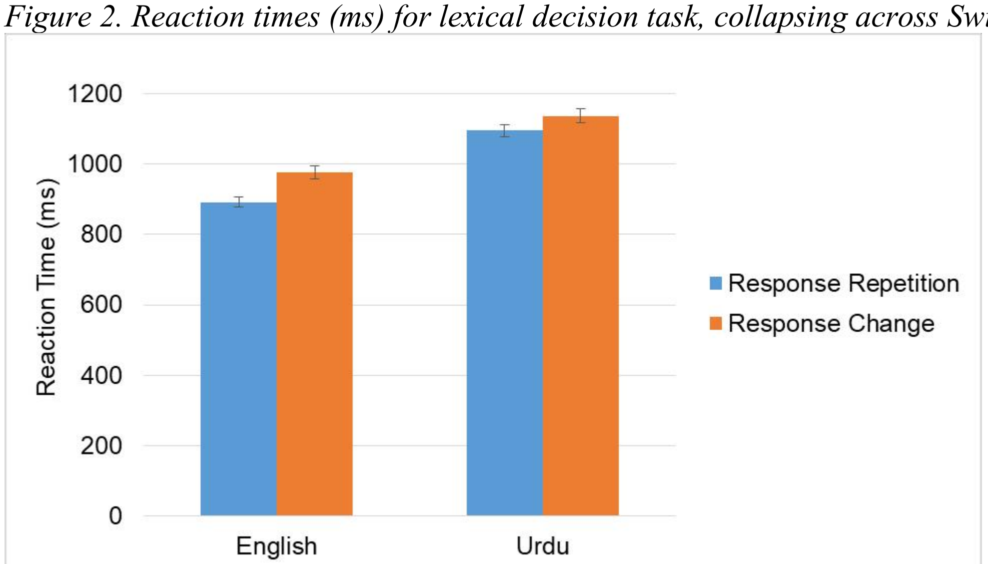
RT ~ Language*Switch*Response + (1+Language|Participant) + (1|Trial)

Results from the model are provided in Table 4. The only experimental effect which was significant was a main effect of Response. The model estimate is negative, which indicates that overall, RTs were faster for trials with response repetition as compared to response change trials. In addition, the main effect of Language was marginally significant (p = .06). This reflects the tendency for English words to be responded to faster than Urdu words. To illustrate this effect, Figure 2 was created, which collapses across the non-significant factor Switch.

Table 4. Results from LME model

	Random	**Variance**	**Std.Dev.**		
	Subject	150255	387.6		
	Language	254092	504.1		
	Trial	38980	197.4		
Fixed	**Estimate**	**SE**	***Df***	***T***	***P***
(Intercept)	967.95	53.46	179.10	18.107	< .001 ***
Language	132.68	70.28	184.60	1.888	0.06062 †
Switch	32.17	44.22	1220.30	0.727	0.47
Response	-127.46	45.37	981.80	-2.810	<0.01**
*Language*Switch*	31.70	62.68	1275.80	0.506	0.62
*Language*Response*	97.27	62.66	1140.00	1.552	0.12
*Switch*Response*	59.06	63.84	977.20	0.925	0.36
*Language*Switch*Response*	-65.50	90.09	1034.60	-0.727	0.47

Figure 2. Reaction times (ms) for lexical decision task, collapsing across Switch



In summary, we found that the Main effect of Language is marginally significant. It is a positive estimate with the baseline as English. This means that when words are in Urdu, RTs are longer (more positive) than in English. The main effect of the Response is significant and negative. The baseline is changed, so when the response is repeated, RTs are significantly faster (more negative) than when the response is changed. No interaction between Language, Switch, or Response emerged.

Although we were unable to include an independent measure of proficiency, in a follow-up analysis we used a self-assessed measure of language dominance as a between-subjects factor. Dominance was dummy coded for the LME model as 0 = English, 1 = Urdu, and it was entered into the model as a fixed effect. The final model syntax was as follows:

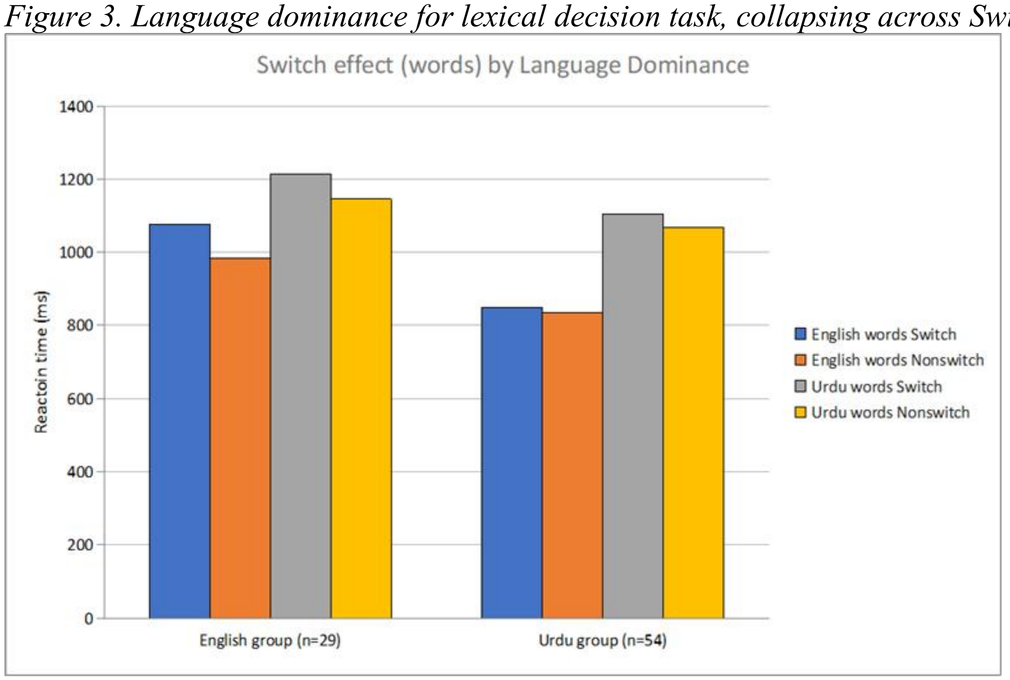
RT ~ Dominance*Language*Switch*Response + (1+Language|Participant) + (1|Trial)

Results from this follow-up model are reported in Table 5. The main effect of Dominance is marginally significant and negative. For participants who are dominant in Urdu, RTs are faster overall (more negative) compared to participants who are English-dominant. The main effect of the Response is significant and negative. This main effect indicates that for trials with response repetition, RTs are faster as compared to response change trials. Finally, a significant interaction of Language*Response emerged. This interaction revealed that there were significant differences in RTs for response repetition trials in English as compared to Urdu. This is largely in line with the pattern shown in Figure 2 above, where there was a greater RT slowdown for response change trials in English as compared to Urdu. To demonstrate the role of language dominance in this model, Figure 3 below provides comparisons across the two groups (English- vs. Urdu-dominant participants).

Table 5. Results from LME model that includes Dominance

	Random	Variance	Std.Dev.		
	Subject	143725	379.1		
	Language	254923	504.9		
	Trial	38983	197.4		
Fixed	**Estimate**	**SE**	***Df***	***T***	***P***
(Intercept)	1038.65	67.26	154	15.443	<.001 ***
Dominance	-160.61	94.72	119	-1.696	0.0926 †
Language	73.12	90.16	156	0.811	0.4187
Switch	65.56	52.56	2288	1.247	0.2124
Response	-136.61	53.30	1819	-2.563	0.0105 *
*Dominance*Language*	135.61	128.09	124	1.059	0.2918
*Dominance*Switch*	-76.0	64.24	15747	-1.183	0.2368
*Language*Switch*	29.18	74.38	2397	0.392	0.6948
*Dominance*Response*	20.58	63.54	15746	0.324	0.7461
*Language*Response*	150.39	74.09	2152	2.030	0.0425 *
*Switch*Response*	51.80	75.15	1810	0.689	0.4907
*Dominance*Language*Switch*	5.17	91.26	15749	0.057	0.9549
*Dominance*Language*Response*	-120.45	89.91	15751	-1.340	0.1804
*Dominance*Switch*Response*	16.91	89.89	15748	0.188	0.8507
*Language*Switch*Response*	-104.13	106.07	1922	-0.982	0.3264
*Dominance*Language*Switch*Response*	87.59	127.59	15752	0.686	0.4924

Figure 3. Language dominance for lexical decision task, collapsing across Switch



In summary, results showed an overall effect of Language, with clear differences emerging in RT speed depending on the target language of a given trial. We also found that

Response played an important role, with response change trials showing slower RTs than trials in which the participant repeated their same button press (repetition). These two main effects showed a significant interaction when Language Dominance was included as a moderating factor in a follow-up LME model.

5. Discussion

This study aimed to investigate language switch costs involved in the comprehension of two languages, using a lexical decision task with both English and Urdu words. Building on recent research on Chinese-English bilinguals, this thesis examined whether we would replicate Struck and Jiang's (2022) asymmetrical switch costs in a new bilingual population. Furthermore, we investigated two additional factors that may impact language switching, language dominance, and the current language environment. In what follows, we discuss the results which address each research question in turn.

5.1 Switch Cost Symmetry

The process of alternating two languages involves cognitive resources like attention, cognitive control, and memory. Researchers have attempted to investigate the underlying cognitive abilities involved in language switch costs by measuring the time taken in switching from one language to another. The longer it takes to switch the larger the cognitive "cost" is perceived. Studies have reported that larger switching costs postulate that the participants are not balanced in terms of their RTs (Struck & Jiang, 2022).

The primary focus of the first research question was on whether the switch costs were symmetrical. Our results showed that the switch costs were indeed symmetrical, in contrast to Struck and Jiang's (2022) findings. Surprisingly, in the trials of response change, English L2 is found with a significant switch benefit. Before all, it is necessary to better understand the interaction between the response variable and switch, which can start with the L2 switch benefit. Specifically, it is important to determine why response-repetition trials show switch benefit only for the L2, which can be explained in two ways: either the cause lies in the English L2 being the language environment as they live with English-speaking people, or in the L2 being the dominant language.

5.2 Language Environment and Dominant Language

Language environment does influence the experiences of the bilinguals because individuals there are exposed to their L2 (English) via native speakers. In the case of Urdu speakers living in the United States, on the background survey, these individuals reported that they mostly speak in English outside of their homes, but that they speak English with Urdu at home. The targeted population of our study is the Urdu-English bilinguals living in the USA. This exhibits that they live in an environment where English is the dominant language. The findings of the study revealed that there is a significant relationship between language dominance and language proficiency. Therefore, taking English on account of the dominant language, it is inferred that the living environment as living with English speakers leads individuals to be English their dominant language rather than Urdu.

6. Conclusions

The present study investigates the language switch costs of English-Urdu bilingualism. Study findings showed asymmetric switch costs in Urdu L1 with greater switch costs than in English L2 with smaller costs. Rather it was expected. This shows that switch costs are symmetric for L2 rather than L1. It is observed that English- Urdu bilinguals experience difficulty in switching to their first language L1, possibly because English and Urdu have different writing scripts and they mostly expose to the English script (newspaper, books, magazines, daily products) than Urdu. In addition, language environment and language dominance are found with a significant impact on the language in a way that all the participants have been living with English-speaking people and English becomes their dominant language. Further studies on the switch costs need to be conducted to explore the different dimensions of receptive language switch costs with different pairs of languages with different populations.

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