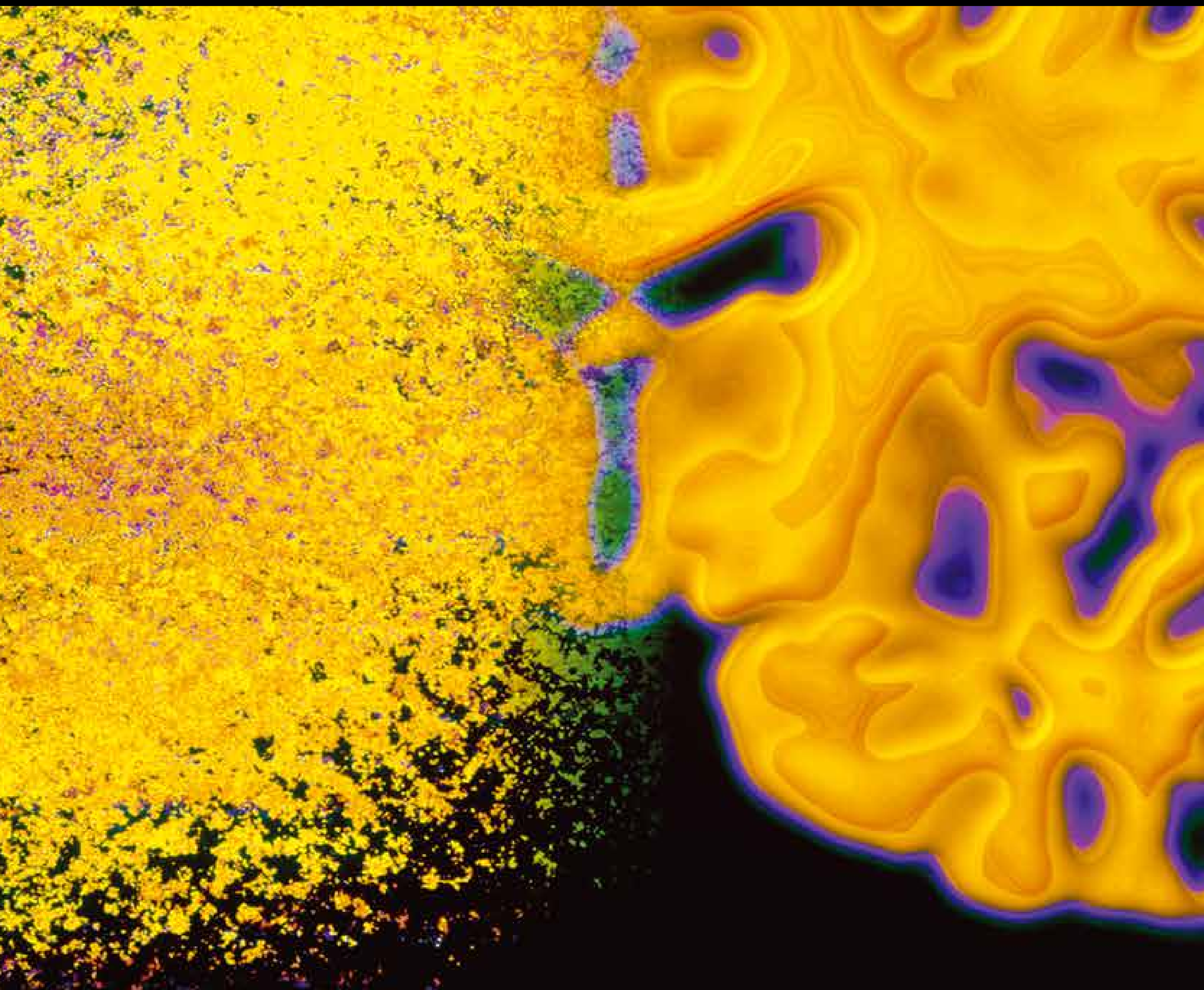
Behavioural Neurology

The Cognitive Neurology of Bilingualism in the Age of Globalization

Guest Editors: Jubin Abutalebi and Brendan S. Weekes



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Editorial Board

Contents

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Editorial

The Cognitive Neurology of Bilingualism in the Age of Globalization

Jubin Abutalebi[1,2] and Brendan S. Weekes[1]

[1] *Department of Speech and Hearing Sciences, The University of Hong Kong, Hong Kong*
[2] *Faculty of Psychology, University San Raffaele, Via Olgettina 58, 20132 Milan, Italy*

Correspondence should be addressed to Jubin Abutalebi; abutalebi.jubin@hsr.it

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As globalization advances, more people become bilingual or multilingual. Indeed, in the age of globalization, where people can connect through Internet to someone else across the globe, where the mass media provides information from around the globe, and where migration means multilingual and multicultural societies, the necessity of speaking more than a single language becomes more evident as never before. Some languages like English, French, and Spanish for cultural and political reasons are widespread because of their international use for communication, tourism, and trade. Some languages like Mandarin are emergent and are most likely about to substitute one or two of the aforementioned world languages in the future. As a matter of fact, modern world is becoming more bilingual and modern behavioural neurology and neuroscience must be prepared to deal with challenging research questions originating from the study of the bilingual brain.

In general, a bilingual speaker may be someone with different levels of proficiency in the two languages, using the two languages in different contexts or learning a new language due to educational requirements, immigration, or other business and life demands. By this definition, a bilingual individual is not only necessarily someone who has acquired both languages from birth, or early in life, but also that one who learns a second language (L2) later in life. The different contexts and circumstances of L2 acquisition have important effects upon the cerebral organization of multiple languages. Moreover, having acquired more than one language, the bilingual or multilingual speaker may eventually encounter potential conflicts between languages, such as how to speak in one language while avoiding potential intrusions from the other. Problems like these are resolved by the intervention of a neurocognitive mechanism unique to bilinguals, that is, language control [1].

In the past, a lot of misleading information has circulated about the eventual cognitive effects of bilingualism such as bilingualism as being detrimental to the development of cognitive skills in children and that infants exposed simultaneously to two languages would suffer from an incomplete language acquisition. Nowadays, scientists have proven the contrary to be true. Researchers have clearly demonstrated that early bilingualism (i.e., if both languages are learned from early on in life) leads to cognitive advantages over lifespan. Bilinguals when compared to monolinguals are faster in information processing and conflict resolution in nonverbal tasks [2, 3]. Strikingly, these effects are already present in bilingual infants. Seven-month-old bilingual infants are able to more efficiently switch their attention in a nonlinguistic task than monolinguals [4], and, at 18 months old, they appear to have a more developed memory generalization processes [5].

Related to these behavioural advantages is also the recent discovery that bilingualism induces neuroplastic changes in the brain. Bilingualism as compared to monolingualism induces experience-related structural changes (i.e., in terms of increased grey or white matter density) in several brain areas such as the frontal lobes [6], left inferior parietal lobule [7, 8], the anterior cingulate cortex (ACC) [9], and the subcortical structures such as the left caudate [10] and putamen [11]. These areas are part of the executive control network and this may explain why bilinguals usually have a cognitive advantage in executive control tasks over monolinguals [2].

As to the reasons behind these neurocognitive advantages, we should consider the following two: First, bilinguals usually get less exposure and use of each of their languages when compared to the single language of monolinguals. Second, bilinguals need to monitor their language production system in order to avoid unwanted intrusion from the language not in use. The consequence of these two factors is a more demanding language processing situation that relies heavily upon the intervention of cognitive control mechanism when speaking. Because of the continuous use of these cognitive control mechanisms, the neural networks subserving cognitive control in bilinguals become more tuned and, hence, may be utilized more efficiently also for nonverbal cognitive conflict such as nonlinguistic information processing and conflict resolution. In other words, the bilingual experience strengthens the executive control network and it is reasonable to believe that bilingual individuals create more connections between the single areas of this network following the rules of Hebbian dynamics. Having more connections, in turn, is the most plausible interpretation for explaining recent and compelling findings that the bilingual brain is more resistant against cognitive decline [12, 13]. Bilingualism as such would accordingly act as a cognitive reserve and as a neuroprotective factor against aging. Indeed, recent studies have shown that elderly bilinguals outperform monolinguals in executive control tasks and appear to have a 4-5-year onset delay of behavioral symptoms associated with neurodegenerative diseases such dementia as compared to monolinguals [13, 14].

As exciting as all these recent discoveries on bilingualism seem, modern globalized societies are also confronted with the management of some pathologies that are unique to bilingual and multilingual speakers such as bilingual aphasia which is the main focus of the present special issue. The reader should keep in mind that the incidence of bilingual aphasia is likely to increase and become a clinical issue of primary importance in the field of cognitive neurology because, as stated above, modern society is becoming more and more bilingual and multilingual and because the average age of the aging population is expected to increase in the future. With this inevitable increase in our bilingual caseloads comes the need to determine effective and efficient assessment and treatment strategies that take into consideration the unique needs and skills of bilingual versus monolingual patients. However, at present, we still lack causal explanations of the many features of recovery patterns and there actually is no consensus about the language in which the patient should receive speech therapy. Further advance requires an understanding of the dynamics of recovery [15].

The first contribution to this special issue aims at providing an explanation for the dynamics of recovery. The contribution is authored by Kong, Abutalebi, Lam, and Weekes, and the authors show that impairments in language control are a key feature in bilingual aphasia. As postulated by Paradis [16], problems in language control may explain the various recovery features of bilingual aphasia. However, in their contribution, Kong et al. underline that impairment of language control (i.e., resulting in pathological switching of languages) is paralleled by impairment of domain-general cognitive control. Among similar lines, also the second contribution to this special issue, authored by Dash and Kar, addressed this interesting research question in individuals with bilingual aphasia. However, contrary to Kong et al., the authors suggest the existence of independent but interactive systems for bilingual language control and domain-general cognitive control.

The third contribution is authored by Kiran, Balachandran, and Lucas and has as its main focus the assessment of lexical access deficits in individuals with bilingual aphasia. As the authors rightly claim up to date, there are no clear guidelines on assessment of lexical access in the two languages in individuals with bilingual aphasia. Fundamental lexical retrieval deficits are reported in bilingual individuals with aphasia as compared to healthy bilingual controls, but, most importantly, lexical access deficits are clearly influenced by the degree of language proficiency. This contribution clearly highlights that, although difficult to assess in brain-damaged individuals, the role of language proficiency assessment is central to explain linguistic deficits in individuals with bilingual aphasia.

Finally, we would like to underline that the clinical management of bilingual patients with aphasia raises still several unanswered questions. For instance, we still do not know whether a bilingual individual with aphasia should be rehabilitated only in one language or in both languages. Moreover, it is also not known whether rehabilitation should take place in L1 or rather in L2. These questions may have an immense practical impact and we should be able to provide the solutions to future generations in the globalized world. The fourth contribution of this special issue attempts to provide some solutions. Indeed, Ansaldo and Ghazi Saidi discuss the literature on bilingual aphasia therapy, with a focus on cross-linguistic therapy effects from the treated language to the untreated language. The authors suggest that degree of structural overlap between languages, type of therapy approach, pre- and postmorbid language proficiency profiles, and the status of the cognitive control circuit play a crucial role in the potential for therapy effects from the treated to the untreated language.

The final contribution to this special issue is by S. Ashaie and L. Obler and the authors investigated the effects of variables such as age, education, and bilingualism on confrontation naming in older illiterate and low-educated populations. Interestingly, this study was carried out in the Kashmir highlands and it is all the more impressive that their results revealed that age-related naming declines in a similar fashion to those reported among higher-educated Western populations.

This final contribution is in line with our suggestion for future directions. Indeed, we would like to invite researchers to perform more cross-linguistic studies such as comparing linguistically distant languages such as Indo-European languages versus Ural-Altaic languages, African languages, and even indigenous and isolated languages spoken in more remote areas of the world (Papua Guinea, Amazonia), and so forth. Such studies, apart from providing us with eventual general rules for the organization of the bilingual brain and the eventual management of bilingual aphasia, may provide also a glimpse on the evolution of the human brain and language interface.

We very much hope that the reader will enjoy the comprehensive coverage of the present special issue treating issues inherent to the field of bilingualism from the perspective of cognitive neurology.

Jubin Abutalebi
Brendan S. Weekes

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Research Article

Bilingual Language Control and General Purpose Cognitive Control among Individuals with Bilingual Aphasia: Evidence Based on Negative Priming and Flanker Tasks

Tanya Dash and Bhoomika R. Kar

Centre of Behavioural and Cognitive Sciences, Senate Hall Campus, University of Allahabad, Allahabad-211002, India

Correspondence should be addressed to Bhoomika R. Kar; bhoomika@cbcs.ac.in

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Background. Bilingualism results in an added advantage with respect to cognitive control. The interaction between bilingual language control and general purpose cognitive control systems can also be understood by studying executive control among individuals with bilingual aphasia. *Objectives*. The current study examined the subcomponents of cognitive control in bilingual aphasia. A case study approach was used to investigate whether cognitive control and language control are two separate systems and how factors related to bilingualism interact with control processes. *Methods*. Four individuals with bilingual aphasia performed a language background questionnaire, picture description task, and two experimental tasks (nonlinguistic negative priming task and linguistic and nonlinguistic versions of flanker task). *Results*. A descriptive approach was used to analyse the data using reaction time and accuracy measures. The cumulative distribution function plots were used to visualize the variations in performance across conditions. The results highlight the distinction between general purpose cognitive control and bilingual language control mechanisms. *Conclusion*. All participants showed predominant use of the reactive control mechanism to compensate for the limited resources system. Independent yet interactive systems for bilingual language control and general purpose cognitive control were postulated based on the experimental data derived from individuals with bilingual aphasia.

1. Introduction

Bilingualism and cognitive control are two widely studied phenomena. Numerous studies have examined the interaction between bilingualism and cognitive control using different methodologies and paradigms [1–11]. Juggling two or more languages makes our brain more flexible [10]. The bilingual advantage has been well established not only with respect to studies comparing monolingual and bilingual individuals [6, 12–14] but also among different bilingual groups [6–9]. Interestingly, a review by Adesope et al. [15] suggested that different aspects of bilingualism influence distinct levels of cognitive control mechanisms. Moreover, several cognitive outcomes may be attributed to bilingualism, including increased attentional control, working memory, metalinguistic awareness, and abstract and symbolic representational skills. Researchers have differentiated between bilingual language control and domain general cognitive control [2, 16]. Miller and Cohen [17] proposed that to provide top-down support to language control, processes such as attention, working memory, response selection, and inhibition function as different manifestations of domain general cognitive control. Moreover, bilingual language control (bLC) may not be a subsidiary to domain general cognitive control [16]; however, bLC may still show some overlap with domain general control mechanisms [2, 18].

Different frameworks have been suggested to study the interaction between bilingualism and cognitive control. A few studies have examined the interaction between bilingualism and cognitive control in the context of bilingual aphasia [18–20]. Aphasia is a language impairment caused by brain damage. Language-related deficits are well explained in the literature targeting auditory comprehension, naming skills, spontaneous speech, and repetition as well as reading and writing skills. There are lines of evidence supporting the presence of cognitive impairment in individuals with aphasia [19, 21]; however, most of these studies refer to the independence of deficits in language skills and other cognitive processes. In one such study, Helm-Estrabrooks [22] argued that clinicians cannot predict the relative integrity of other domains of cognition on the basis of language deficits observed in aphasic patients. Another group of researchers [23] discussed the implications of different aspects of cognition in language-related treatment approaches. They employed a global aphasic neuropsychological battery (nonlinguistic tests) and a test of auditory comprehension. The battery of tests assessed attention, memory, intelligence, visual recognition, and nonverbal auditory recognition. The authors concluded that the score on this battery was independent of spoken language comprehension.

Communicative success among individuals with aphasia may be dependent on the integrity of the executive functions that allow us to plan, sequence, organise, and monitor goal-directed activities in a flexible manner. While emphasising the role of executive functions in communicative processes, Helm-Estrabrooks and Ratner [24] suggested that deficits in executive functions may result in a failure in the generalisation of skills, which are similar to those learned in therapy sessions to those learned in everyday life situations. Similarly, Purdy [19] conducted a study investigating the efficiency, speed, and accuracy of individuals with aphasia while performing executive function tasks (i.e., Porteus Maze Test, Wisconsin Card Sorting Test, and Tower of London). Their deficits were predominantly related to cognitive flexibility and, to a lesser extent, planning.

Until recently, cognitive impairments in aphasia were studied in isolation; however, this can be well explored through empirical research by examining the underlying mechanisms that manifest as cognitive impairments. A study by Penn et al. [25] supports this notion of bilingual advantage, in which they compared monolingual and bilingual individuals with aphasia. If bilingualism is a cognitive advantage, then bilingual aphasics may demonstrate a faster rate of language recovery compared to monolingual aphasics. However, bilingual aphasics exhibited pathological code switching and code mixing behaviours. In one of their studies, Abutalebi and Green [2] highlighted the need to investigate the performance of bilingual aphasics on a range of control tasks. They suggested that individuals with parallel recovery may demonstrate problems with control without having problems related to language interference.

In addition to the language processing deficits evident among individuals with aphasia, there are subtle cognitive-communicative deficits, which are not due to the faulty language processing system but may be due to general problems in resolving conflict. Green et al. [26] reported that there are two distinct control-related impairments, one for naming and another for control. Green and colleagues compared two bilingual aphasics who demonstrated a parallel form of recovery to a similar extent. However, their performance on three explicit control tasks indicated that different control mechanisms were involved in recovery. One of the patients showed an impaired verbal, but spared nonverbal control, whereas the other patient demonstrated deficits in the selection of the manual response. Thus, two separate circuits may exist for naming and control, and the recovery patterns may be dependent on damage to these control circuits [2].

According to Abutalebi et al. [18], language control and cognitive control mechanisms may act as the primary determinants of cognitive-linguistic recovery in aphasia. This is because the effect of treatment is dependent on the integrity of the naming and control pathways as previously described by Abutalebi and Green [2]. To understand this distinction between naming and control networks, Abutalebi et al. [18] studied the neural correlates of selective language therapy in a Spanish-Italian bilingual aphasic in a longitudinal study consisting of three time points. An improvement in naming performance was evident in the naming network only. Another study [20] emphasised the role of the dorsal anterior cingulate in both language control and while resolving nonverbal conflict. Using a combined functional and structural neuroimaging method, a structural overlap between the two networks (i.e., naming and control) was demonstrated. These studies demonstrated that there was a dissociation as well as an overlap between the mechanisms that were involved while resolving verbal and nonverbal conflict.

Conflict resolution tasks involve two modes of control mechanisms, namely, proactive and reactive controls. The proactive mode of control is prospective or future-oriented, helping to prepare the cognitive system for upcoming events via the predictive use of context. Reactive control is retrospective, responding to the presence of salient events by engaging control only when it is needed, via the reactivation of previously stored information [27]. In the context of bilingualism, these two modes of control might be operating in cases of conflict and during increasing demand on the inhibitory control system while using activation-suppression mechanisms. Thus, this study aimed to address the relationship between language control and general purpose cognitive control with respect to the recruitment of proactive and reactive control mechanisms among bilingual aphasics.

The current study was designed to test patients on a range of executive function tasks that bear on the circuits implicated in language control and general purpose cognitive control. The specific objective was to examine differences in performance across executive control tasks with linguistic and nonlinguistic stimuli. Flanker and negative priming paradigms were employed to show the distinction in performances with different cognitive outcomes between the two paradigms. One way to understand how control mechanisms are recruited by bilingual aphasics is to examine the slow and fast trials, which indicate the use of reactive and proactive control mechanisms, respectively. Special emphasis was placed on accuracy, efficiency, and speed-related measures, unlike previous studies, which focused on one of the three aspects of performance. Predominant involvement of reactive control compared to proactive control mechanisms in the context of both linguistic and nonlinguistic stimuli was expected. Differences in performance were expected with respect to negative priming and flanker effects in the two paradigms, indicating variability in different control processes. Thus, the present study helps to understand the interactive yet independent control mechanisms in the clinical population, particularly in language disorders, such as aphasia, which provide the appropriate context to examine the relationship between bilingualism and cognitive control. In addition, such an investigation also helps to understand the broad cognitive-linguistic mechanisms that underlie a disease process and its recovery patterns.

2. Method

2.1. Screening Measures

2.1.1. Language Background Questionnaire [28]. This questionnaire was employed to collect information on the languages in use, frequency of use, self-reported proficiency, and the linguistic environment at home, work, and so forth. Domains assessed in the questionnaire included acquisition history (age of acquisition and at what age the subject became fluent), contexts of acquisition (modality: oral/written/both; environment of acquisition: informal/formal/both), language use (%), language preference (1–3 rating scale; where 1 = never, 2 = sometimes, 3 = most of the time), and the proficiency rating on different tasks (a 0–10 rating scale was provided for each descriptive task, for example, asking for directions, counting up to 100 in both languages, and so forth, which resulted in a composite score for proficiency). Apart from these questions, a contribution of various other factors, such as the use of language with family, friends, extended family, and neighbours was assessed by asking the participants to name the language predominantly used in different contexts. The participants also indicated the medium of instruction and self-reported proficiency level in the domains of speaking, understanding, reading, and writing (1–5 point rating) (see Table 1 for language background information for all the participants).

2.1.2. Picture Description Task. This test is a subtest of the language proficiency test [29]. In this task, the participants were instructed to carefully describe a picture by focusing on the overall theme of the picture along with the individual items in that particular picture. A grand rubric score was calculated by summing the scores on the following aspects: overall impact and achievement of purpose (whether the participant establishes the main idea), organisation and techniques (coherence and cohesion, method of organisation), and mechanics (focusing on grammar, pronunciation, presence of pause). Pictures were selected from the Western Aphasia Battery [30] and Boston Diagnostic Aphasia Examination [31] for L1 and L2, respectively. A total score of 18 could be achieved by each participant (Table 5 presents the scoring method).

2.1.3. Western Aphasia Battery [30]. WAB is a tool used to assess language functions in adults and discerns the presence and type of aphasia. Four major components of the aphasia quotient are spontaneous speech, auditory verbal comprehension, repetition, and naming. Table 3 presents the scores obtained on each of the subtasks in WAB for the four participants.

2.1.4. Aphasia Severity Rating Scale [31]. This is a severity rating scale that is often used in clinical routine as well as in scientific studies. Administration of this scale takes 5–15 minutes and is very simple to perform. It is a 5-point rating scale where the communication profile is described and based on the clinical observation that one can make a judgment about severity. Table 2 presents the ratings indicating the severity of aphasia for each of the four participants.

2.2. Participants. We report data from four male bilingual right-handed individuals with aphasia. English was the second language for all the participants. L1 was Telugu for two participants and Hindi for the other two participants. All four participants were considered for the current study based on the following inclusion criteria: (a) diagnosis of aphasia based on the Western Aphasia Battery [30], (b) above chance level performance on the experimental tasks, (c) average level of intellectual functions on Raven's Coloured Progressive Matrices test (as a subtask in WAB), (d) being able to perform the picture description task from the test of language proficiency, which provides a composite rubric score [29], (e) similar degree of impairment in L1 and L2, and (f) postmorbid daily usage of both languages in the speaking/understanding domain as well as in the reading/writing domain. These criteria were met using the subjective and objective measures mentioned above as well as the clinician's report.

All participants showed parallel recovery based on their performance on the language skills tasks as well as the self-reported information on the language background questionnaire [28]. All four participants were highly educated and were able to perform the activities of daily living. The experimental and language proficiency tasks were performed on the same day with many rest pauses (see Table 2 for a summary of the demographic information of all the participants).

2.2.1. Participant 1. CR was a 33-year-old, right-handed Telugu-English bilingual male, who was a banker prior to his illness. He had resumed his work on a part-time basis a few days from the time of his current evaluation. CR reported a complaint of a loss of speech due to a postmeningitis squeal. It had resulted in diffuse damage to the left frontal and parietal regions as per the clinician's report. CR was initially diagnosed with Broca's aphasia and is currently diagnosed with anomic aphasia. CR had been undergoing speech and language therapy for 15 months prior to the time of his current evaluation on a regular basis. On the WAB subtests, his language skills were affected in all four WAB subtasks; namely, spontaneous speech, auditory verbal comprehension, repetition, and naming. His repetition subtask score was below the 50th percentile, and his naming subtask score was at the 50th percentile level. His auditory verbal comprehension skills were better than the rest of his skills. Performance on the picture description task in both languages showed an impairment at the discourse level with rubric scores of 11 and 9 for L1 and L2, respectively (maximum score of 18). His spontaneous speech showed the presence of both circumlocutions and paraphasic errors (semantic). Language switching or mixing was neither observed nor reported.

Table 1: Language background information based on current state (poststroke aphasia data).

Participants	CR	MMH	SC	MU
Languages exposed at home	Telugu (sometimes Kannada)	Urdu/Hindi	Telugu (sometimes Tamil with extended family)	Hindi/Urdu
Languages exposed at office/workplace/college	English, Kannada, Hindi	English, Hindi, Kannada	English, Telugu, Hindi	English, Hindi
Age of acquisition:	L1 (Telugu): since birth	L1 (Hindi/Urdu): since birth	L1 (Telugu): since birth	L1 (Hindi/Urdu): since birth
	L2 (English): 10th standard	L2 (English): 3.5 years	L2 (Tamil): exposed since birth	L2 (English): since school that is 1st standard
	L3 (Kannada): after arriving at Kannada speaking state due to occupational needs in 2008	L3 (Kannada): after arriving at Kannada speaking state (10 years)	L3 (English): since school that is 1st standard	
Order of dominance (premorbid):				
L1	Telugu (60%)	Hindi/Urdu (70%)	Telugu (50%)	Hindi (50%)
L2	English (40%)	English (30%)	English (50%)	English (50%)
Order of dominance (postmorbid):				
L1	Telugu (30%)	Hindi/Urdu (85%)	Telugu (60%)	Hindi (90%)
L2	English (70%)	English (15%)	English (40%)	English (10%)
	Sporadic usage of Kannada and Hindi	Sporadic usage of Kannada	Sporadic usage of Tamil and Hindi	
Modality of language acquisition:				
L1	both (oral/written and formal/informal)	both (oral/written and formal/informal)	both (oral/written and formal/informal)	both (oral/written and formal/informal)
L2	both (oral/written and formal/informal)	both (oral/written and formal/informal)	both (oral/written and formal/informal)	both (oral/written and formal/informal)
Family members uses following languages:				
Grandparents, parents, siblings-	Telugu	Hindi/Urdu	Telugu/Tamil	Hindi
Neighbours/children-	Kannada	Kannada	Hindi/Telugu	Hindi
Language use choice: 3 point rating (composite scores)	(can perform 3/10 tasks)	(can perform 6/10 tasks)	(can perform 6/10 tasks)	(can perform 5/10 tasks)
L1	3	1	1	2.7
L2	2	2.7	3	2
Language proficiency 5 point rating (composite scores)	(can perform 5/15 tasks)	(can perform 7/15 tasks)	(can perform 6/15 tasks)	(can perform 10/15 tasks)
L1	2.25	2.53	3.1	4.25
L2	4.25	3.25	2.83	2.25
Self-reported proficiency (5-point rating)				
Reading (L1 L2)	4 4	4 4	2 2	2 3
Writing (L1 L2)	3 4	3 4	1 2	2 2
Speaking (L1 L2)	3 4	3 4	2 2	3 2
Understanding (L1 L2)	4 4	4 4	4 3	4 4

Table 2: Demographic information.

Participants	CR	MMH	SC	MU
Age	33 years	34 years	35 years	59 years
Etiology	Bacterial meningitis	CVA	Trauma	CVA
Time post stroke	17 months	26 months	15 months	20 months
Native language	Telugu	Hindi/Urdu	Telugu	Hindi
Educational and work background	MBA and currently employed as a banker	Postgraduate and currently unemployed	B. Tech and own a construction business	Retired as assistant controller of examination for an university
Languages known (in order of dominance)	Telugu, English, Hindi	Hindi, English, Urdu	Telugu, English, Tamil, Hindi	Hindi, English, Urdu
Aphasia type	Anomic aphasia	Anomic aphasia	Broca's aphasia	Anomic aphasia
Rehabilitation period	15 months	20 months	3 months	17 months
Aphasia severity	2	3	1	3
Language for therapy	L2	Both L1 and L2	Both L1 and L2, more emphasis L1.	L1

Table 3: Scores on the Western Aphasia battery.

Participants WAB task (maximum scores)	CR	MMH	SC	MU
Spontaneous speech				
Information content (10)	7	9	4	8
Fluency (10)	4	9	5	9
Auditory verbal comprehension				
Yes/no question (60)	48	60	20	58
Auditory word recognition (60)	60	58	53	48
Sequential commands (80)	40	72	21	74
Repetition (100)	45	81	26	79
Naming				
Object naming (60)	40	59	4	45
Word fluency (20)	3	12	2	15
Sentence completion (10)	4	7	2	8
Responsive speech (10)	3	10	5	9

2.2.2. Participant 2. MMH was a 34-year-old right-handed male and presented with a history of cerebrovascular disease. He was diagnosed with aphasia and was undergoing therapy. He was initially diagnosed with global aphasia and is currently diagnosed with anomic aphasia. He had a lesion in the left cerebral hemisphere involving the insular cortex, frontal, and frontoparietal region, which was suggestive of an infarct in the left middle cerebral artery territory. MMH had been undergoing speech and language therapy for 17 months prior to the time of his current evaluation. He was unemployed at the time of his current evaluation and had been undergoing speech and language therapy as well as physiotherapy and occupational therapy due to right hemiparesis. On the WAB, his spontaneous speech was greatly affected, with a score in the 70th percentile, whereas his scores were greater than the 80th percentile on rest of the tasks, namely, the auditory verbal comprehension, repetition, and naming subtasks. His spontaneous speech showed problems in fluency as well as in speech initiation. Performance on the picture description task in both languages resulted in a composite rubric score of 14 and 12 in Hindi and English, respectively. No significant problems were observed in language selection.

2.2.3. Participant 3. SC was a 35-year-old right-handed male who presented with a history of head trauma, which resulted in a subdural hematoma in the left hemisphere involving the frontal regions. At the time of the current evaluation, SC was actively participating in the family business. His initial diagnosis was global aphasia, and his current diagnosis was Broca's aphasia. He had been regularly attending speech and language therapy sessions for three months since the injury. He demonstrated difficulties in the naming (26%) and repetition (13%) subtasks on the WAB, similar to Participant 1. Circumlocution and paraphasia were also observed more in English than Telugu. His auditory comprehension skills were better than the rest of the subtasks on the WAB with 94% accuracy. There was a difference in his performance between L1 and L2 on the picture description task. He showed a greater impairment in L2 compared to L1 with composite rubric scores of 11 and 6 for L1 and L2, respectively.

Table 4: Mean reaction time and standard deviations on control tasks.

Participants	CR	MMH	SC	MU
Flanker task (nonlinguistic)				
Congruent	964.42 (556.89)	608.85 (153.17)	737.2 (181.92)	911.98 (140.86)
Incongruent	1183 (767.47)	580.62 (158.50)	877.63 (269.85)	915.65 (183.13)
Neutral	1221.61 (597.01)	672.70 (186.53)	708.56 (153.81)	941.3 (217.62)
Flanker task (linguistic)				
L1 congruent	1488.6 (450.91)	1003.08 (178.79)	1269.2 (270.48)	1467 (381.61)
L1 incongruent within	1319.52 (476.38)	999.71 (231.41)	1136.62 (229.28)	1406.38 (342.35)
L1 incongruent across	1318.94 (423.27)	1023.84 (154.55)	1303.63 (296.71)	1639.66 (387.03)
L2 congruent	1439.38 (503.12)	896.9 (143.40)	1218.21 (283.56)	1336.71 (380.55)
L2 incongruent within	1578.68 (569.45)	910.13 (149.55)	1171.92 (256.05)	1130.87 (252.92)
L2 incongruent across	1476.91 (526.39)	903.64 (173.09)	1208.93 (292.72)	1312.33 (340.48)
Negative priming task				
Attended repetition	1651.69 (769.31)	607.45 (117.23)	648.08 (301.44)	832.27 (284.72)
Control	1939.81 (681.08)	933.05 (131.70)	791.27 (334.3)	1626.32 (269.32)
Ignored repetition	1751.57 (732.14)	807.33 (201.76)	1091.83 (554.43)	1232.01 (434.35)

Table 5: Rubric for picture description: for spoken discourse analysis.

Strong: 3 points	Average: 2 points	Weak: 1 point
	Overall impact and achievement of purpose	
3 Presents a vivid, memorable picture of a person, place or things	**2** Presents a clear picture of a person, place, or thing	**1** Presents an unclear or confusing picture of a person, place and thing
3 Establishes a dominant, or main, impression of the picture	**2** Focuses on important characteristic(s) of the picture	**1** Presents an unfocused array of characteristics of the picture
3 Conveys a clear sense of purpose	**2** Suggests the speakers purpose	**1** Unclear or inadequate indication of speakers' purpose
	Organization and techniques	
3 Uses a clear, consistent method of organization of event	**2** Method of organization is usually clear and consistent	**1** Method of organization is difficult to identify or follow
3 Coherence and cohesion demonstrated through some appropriate use of devices (transitions, pronouns, causal linkage, etc.)	**2** Coherence and cohesion (sentence to sentence) evident; may depend on holistic structure, most transitions are appropriate	**1** Evidence of coherence may depend on sequence. If present, transitions may be simplistic or even redundant
	Mechanics	
3 Very few, if any errors in grammar and pronunciation and presence of few pauses (filled and unfilled)	**2** Small number of errors in grammar and pronunciation and presence of indefinable pauses (filled and unfilled)	**1** Numerous errors in grammar and pronunciation and presence of pauses (filled and unfilled)

Note: a composite score on the picture description task is the sum of ratings across the three aspects of discourse analysis.

2.2.4. Participant 4. MU, a 59-year-old right-handed male was working at a higher administrative position at an academic institution prior to his stroke. He had experienced an ischemic stroke involving the MCA territory, which caused a typical lesion in the left frontal areas as well as white matter lesions. He presented with hemiparesis and an inability to speak. His initial diagnosis was global aphasia, and his current diagnosis was anomic aphasia. He had undergone therapy for a period of 20 months. On the auditory verbal comprehension subtask, his score was more than 90% similar to the scores of Participants 2 and 3. However, his WAB profile matched more with Participant 2. He showed a similar performance in L1 and L2 on the picture description task with scores of 14 and 12, respectively (see Table 3 for scores on the WAB for all participants).

2.3. Control Tasks

2.3.1. Nonlinguistic Negative Priming Task. Negative priming describes the phenomenon of a prolonged reaction time (RT) and/or a greater number of errors when the participants have to respond to a target that was ignored in the preceding trial [32, 33]. In this task, the participants were required to process pairs of trials that were structured according to a prime-probe schema. Two picture stimuli (line drawings of animate or inanimate objects) were displayed in the form of overlapping pictures in shades of grey on both trials: one picture was the target in which the participants must respond and the other was the distracter, which must be ignored. In the present experiment, the participants were required to respond to one of the shades of grey (dark grey with the RGB coordinates 60, 60, 60, or light grey with the RGB coordinates 157, 157, 157) by suggesting the identity of the picture as being animate or inanimate.

The stimuli were presented on a 17″ monitor in a quiet dimly lit room. The stimuli appeared at the centre of the screen, which measured within the frame of 106 pixels $*$ 52 pixels. The horizontal and vertical resolutions were fixed at 71 dpi. The participants were seated comfortably at a distance of 60 cm from the computer monitor. The experiment was programmed using E prime version 2.0 to record the reaction time and accuracy of each trial. Each trial began with a fixation point for a duration of 400 milliseconds (ms) followed by a prime-probe stimuli, which was presented on a white background for a duration of 500 ms. These stimuli were each separated by a 300 ms blank screen. During the probe trial, the blank screen remained until the response or 3000 ms, whichever came first, and then the next trial began with a fixation point. The participants were required to press the right arrow key for animate and left arrow key for inanimate targets using the first and second fingers of their dominant hand. They were instructed to respond as quickly and as accurately as possible.

The experiment consisted of a total of 180 trials with 60 trials for the attended repetition condition, 60 trials for the ignored repetition condition, and 60 trials for the control condition. The attended repetition measured the facilitation effect in performance. In such a condition, the picture being attended in the prime trial was attended again on the probe trial, resulting in faster reaction times compared to the control and ignored repetition conditions. The ignored repetition measured the inhibitory effect on performance. In such a condition, the picture being ignored in the previous trial was attended in the probe/current trial, resulting in an increase in reaction time (slowing of the response) compared to the other two conditions.Thecontrol condition acts as a baseline measure for the experiment in which the pictures (two overlapping pictures) in the prime trial were different from the probe trial. Thus, there was no effect of priming, whether positive or negative priming. The accuracy and reaction times were recorded for each condition for all four participants. The analysis was performed based on these three conditions. A linguistic counterpart of the negative priming task with a similar design could not be performed because it involved perceptually complex stimuli with overlapping words, and these stimuli appeared to be difficult for individuals with aphasia during the pilot phase of the study.

2.3.2. Flanker Task with Linguistic and Nonlinguistic Stimuli. The flanker task is a response inhibition task that is used to assess the ability to suppress responses that are inappropriate in a particular context. The flanker paradigm was originally introduced as a way to study the cognitive processes involved in the detection and recognition of targets in the presence of distracting information or noise [34]. In the present study, Eriksen's Flanker task [34] was employed to measure executive control to examine conflict resolution with two comparable tasks using linguistic and nonlinguistic stimuli. To introduce a conflict resolution component, the central arrow is "flanked" by congruent or incongruent stimuli. The target is flanked on either side by two arrows in the same direction (congruent condition) or in the opposite direction (incongruent condition). On some trials, the target is flanked by neutral flankers (neutral condition), which were neither similar to the target nor to the flankers in the incongruent condition. The same conditions were used in the current study. Both the target and flankers appeared simultaneously. The participants were required to respond to the direction of the central target arrow, which could be facing in the same direction as the flankers (congruent condition) or in the opposite direction compared to the flankers (incongruent condition). There was also a neutral condition, which consisted of a central target arrow that faced either left or right with dashes as the flankers on either side of the target, thus resulting in a no conflict condition. Each trial began with a fixation cross for 400 ms followed by the stimuli (target and flankers), which were presented for 500 ms followed by a blank screen that stayed until the response or 3000 ms, whichever came first. The participants were required to respond by pressing the right arrow key on the keyboard if the target was facing towards the right, and the left arrowkeyif the target was facing towards the left. There were 180 trials in total, with 60 trials in each condition. There were approximately 30 practice trials in the beginning of the session prior to starting with the main experimental trials.

The linguistic version of the flanker task in different language pairs was designed with letters from the two languages (L1 and L2) known to each participant (Hindi-English and Telugu-English). This task was based on the standard flanker task, but with two flanker compatibility conditions (congruent and incongruent). It did not include the neutral condition because it would have resulted in an unequal number of incongruent trials for both the languages (because the incongruent condition also had two levels). The number of flankers was the same as the nonlinguistic version. The only addition was the presence of two types of incongruent trials: those with within-language incongruence (HHSHH) and those with across language incongruence (HHतHH).

We determined the appropriateness of the stimuli (letters) in the pilot study using normal healthy participants. Each trial began with a fixation cross for 400 ms followed by the target letter flanked by congruent (flanking letters were the same as the target letter) or incongruent flankers (flanking letters were different from the target letter). The stimuli were presented against a white background for 500 ms followed by a blank screen. The blank screen remained until the response or 3000 ms, whichever came first, and then the next trial began with a fixation cross. The participants were required to press the right arrow key for "H," left arrow key for "S," up arrow key for "म," and down arrow key "त" for the flanker task with stimuli in Hindi and English languages. A similar design was used for the Telugu-English version of this task. A total of 360 trials were presented, with 120 trials in each condition, which were congruent, incongruent within a language, and incongruent across language. These conditions were equally divided for both the languages. The response level inhibition resulted in slowing of the responses on the incongruent trials and varied as a function of language. Eriksen's flanker task has also been reported for linguistic stimuli, but only with one language [34].

In both versions of the flanker task (linguistic and nonlinguistic), the stimuli were presented on a 17″ monitor with a refresh rate of 85 Hz in a quiet and dimly lit room. The participants were comfortably seated at a distance of 60 cm from the computer monitor. In the linguistic version of the task, the array of letters appeared on the centre of the screen within the frame of 140 pixels ∗ 45 pixels, whereas in the nonlinguistic version arrows appeared within the frame of 135 pixels ∗ 25 pixels. The experiment was programmed using E prime version 2.0 to record the reaction time and accuracy for each trial.

3. Results

The current study focused on the performance patterns of each participant on the cognitive control tasks, and the subjective and objective measures of language proficiency. The data obtained with the language background questionnaire and the composite rubric scores on the picture description task are provided in Table 1. Data based on the performance of each participant on the respective cognitive control tasks are shown in Table 4. We discussed the results based on the variations in the performance of each participant on the cognitive control tasks as well as their language background information. Statistical inference was generated via visual analysis of the data (mean RT scores as well as CDF plots of different conditions) for each participant for each specific experiment. Correlation analysis was performed to test the relationship between objective and subjective task performance. The variability in a single case study method was controlled using experimental tasks and tools for language proficiency, which have been well adapted for Indian conditions. Negative priming and the flanker paradigm are well established paradigms employed across populations; thus there is a limited chance of variability because of the measurement instrument. This language history questionnaire has been employed in an Indian population [29, 35] in both qualitative and quantitative bilingual studies.

The cumulative frequency distribution was employed as an important tool for the interpretation of individual data to examine the performance patterns of each task across the four participants. To analyse the reaction time data, the cumulative frequency data were used to gain insight into how often a specific phenomenon was either below or above a specific value. The RT distributions were computed using the cumulative distribution function (CDF) in MATLAB. We examined the RT-based differences at the 5th percentile (fast trials) and 95th percentile (slow trials) across conditions for each participant. In a few instances, a different range of percentiles was used to indicate patterns in the performance of specific experimental conditions. Slow and fast reaction times were used as measures of the proactive and reactive modes of control. Slow trials are known to reflect the involvement of the reactive control mechanisms and fast trials are known to reflect the involvement of proactive control mechanisms [27].

The results are discussed with respect to the patterns in the performance on each experimental task across the four participants. In this study, the primary objective was not to compare the performance of the four participants but to illustrate the variations in each participant's performance across tasks and across conditions (experimental manipulations) within a task.

3.1. Negative Priming Task with Nonlinguistic Stimuli. All four participants performed the negative priming task with a good overall accuracy except for SC who showed a below chance level performance on one of the tasks. However, variations in performance across participants were observed with respect to the engagement of proactive and reactive control mechanisms as revealed by the RT distributions on the 5th and 95th percentiles.

CR's performance on the negative priming task with superimposed line drawings of objects (with reaction times as a measure of performance) suggests the presence of a facilitation effect in the absence of a negative priming effect (see Figure 1(a)). However, error analysis showed a greater number of errors for the ignored repetition trials compared to the control condition, suggesting the presence of a negative priming effect (see Figure 1(b)). In addition, CDF plots further supported these results. CDF curves showed facilitation or a positive priming effect more prominently in the fast trials (i.e., 5th percentile) (see Figure 1(c)). This effect was persistent throughout the distribution except at the 95th percentile level (i.e., slow trials) where the distribution appeared to be very similar across conditions. These results indicated that

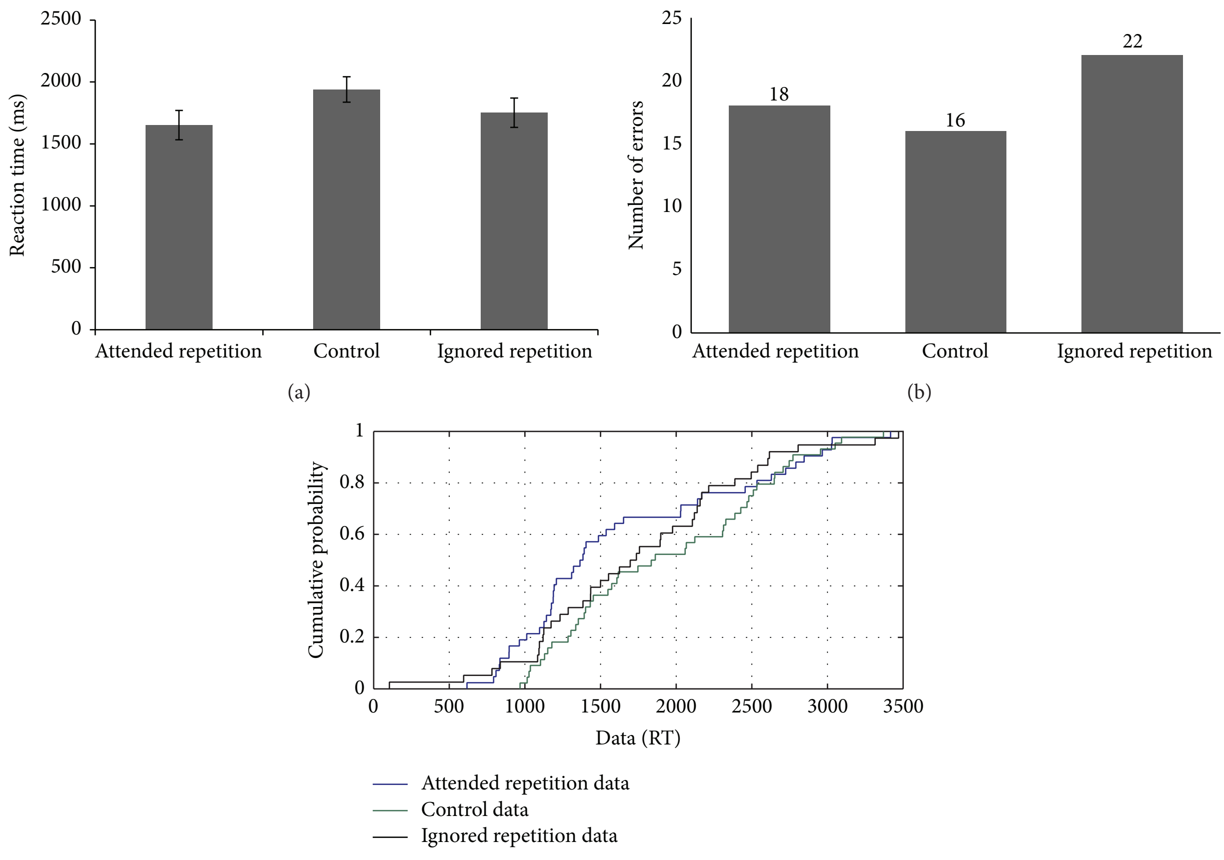

Figure 1: (a–c): Reaction time data, error analysis, and CDF plot based on the performance of CR on the negative priming task.

when the time to respond to a target is less, then the facilitation effect is greater compared to when the time available is more. These results indicated the presence of proactive control in a minimal conflict condition (i.e., attended repetition condition). Similarly, ignored repetition reaction times were faster compared to the control condition throughout the distribution except for the 95th percentile level.

Taken together, these results indicated that although the overall mean RTs showed an absence of a negative priming effect, the negative priming or persistent inhibitory effect surfaced only on the slow trials, when the time available was more, indicating a dependence on the reactive control mechanism. The proactive control mechanisms appeared to be compromised. However, because the error analysis showed a negative priming effect with a greater number of errors on the ignored repetition trials compared to the control trials, this in itself may be the reason why fast trials did not show a negative priming effect. Thus, when the participant takes less time during a more demanding condition (i.e., ignored repetition), it may result in a greater number of errors.

MMH's performance on the negative priming task showed facilitation or a positive priming effect, and a negative priming effect was not observed (see Figure 2(a)). CDF analysis only showed the presence of a facilitation effect and the absence of a negative priming effect based on the observation that there was no difference between the RT distributions for the ignored repetition condition and control condition (see Figure 2(b)). Furthermore, the facilitation effect was greater on the slow trials compared to the fast trials. An absence of an inhibitory effect was observed in both the fast and slow trials. The results based on MMH's performance indicated a potential dependence on reactive control mechanisms and showed a partial correspondence with the RT distributions observed on the nonlinguistic flanker task, as discussed later in this section.

The third participant, SC, performed at a below chance level on the negative priming task. However, interestingly, his performance (RTs) indicated both facilitation and inhibitory effects (see Figure 3(a)). Error analysis suggested the presence of an inhibitory effect with a greater number of errors on the ignored repetition condition compared to the control and attended repetition conditions, and an absence of the facilitation effect (no difference in errors between the attended repetition condition and control condition) (see Figure 3(b)). CDF plots also showed a uniform distribution for all three conditions (attended repetition < control < ignored repetition) showing no variations in performance with respect to the fast and slow trials across conditions (see Figure 3(c)). However, visual inspection of the CDF plots suggested a greater inhibition on the slow trials compared to the fast trials.

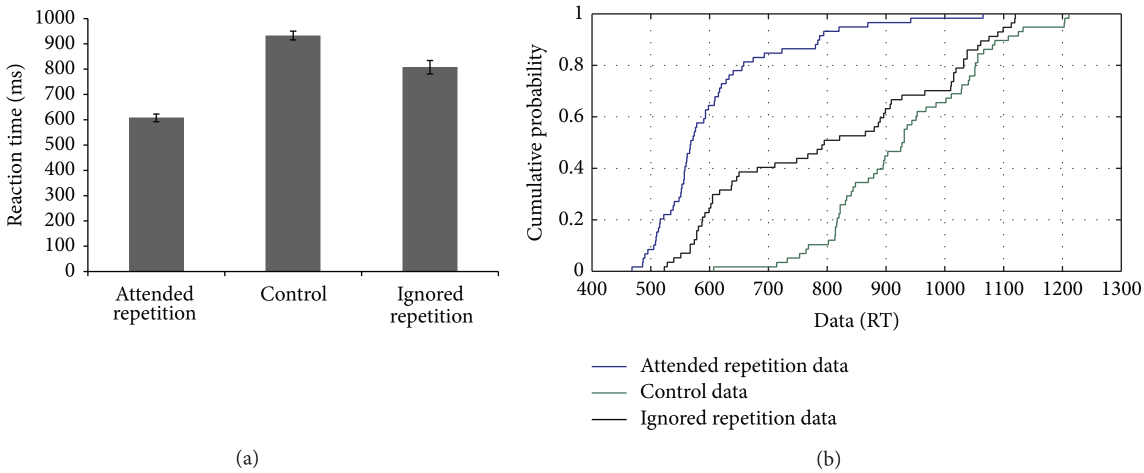

Figure 2: (a-b): Reaction time data and CDF plot based on the performance of MMH on the negative priming task.

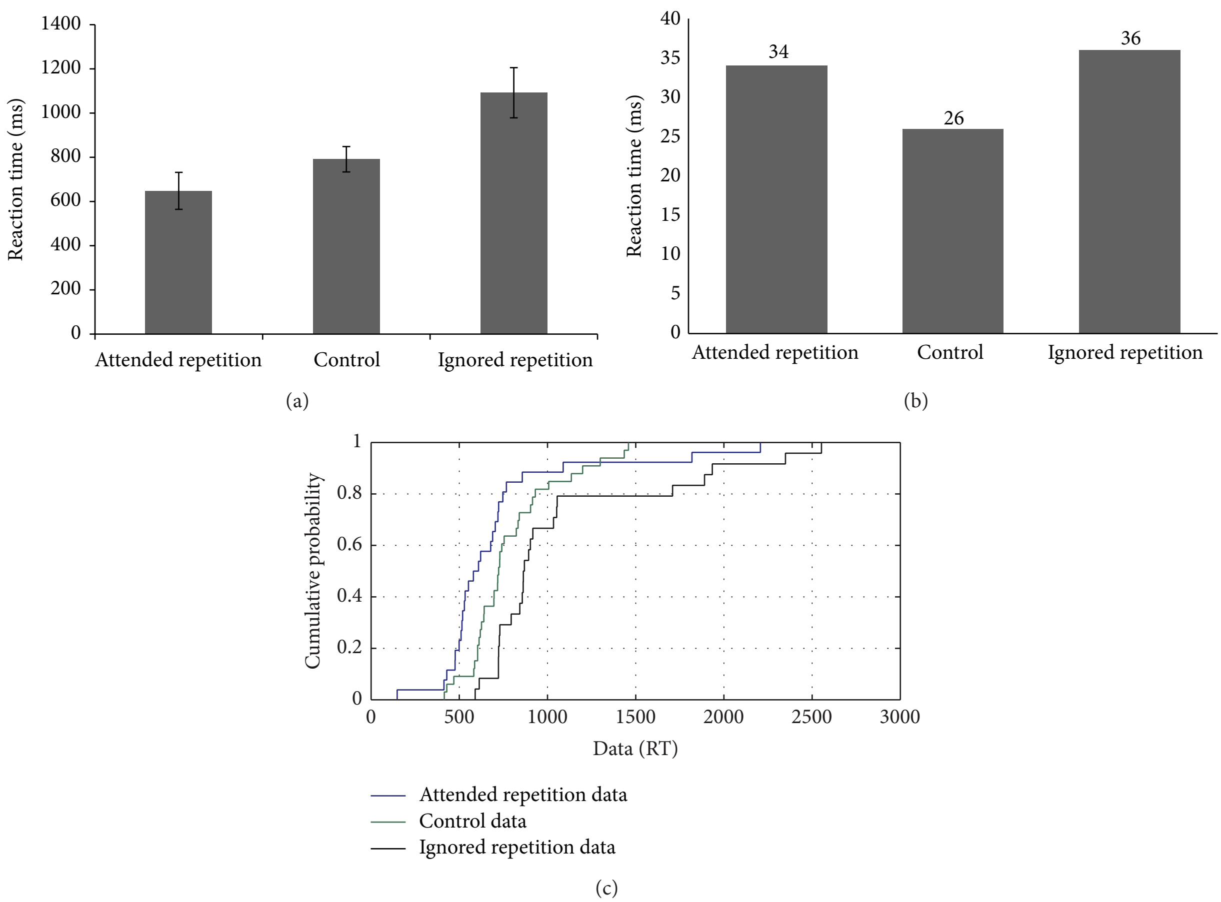

Figure 3: (a–c): Reaction time data, error analysis, and CDF plot based on the performance of SC on the negative priming task.

MU's performance on the negative priming task with nonlinguistic stimuli, similar to CR and MMH, showed the presence of a facilitation effect and the absence of a persisting inhibitory effect (see Figure 4(a)), which was translated in the same manner in the CDF analysis. However, for the ignored repetition condition, there were variations in performance throughout the distribution compared to the control condition. CDF plots indicated that the inhibitory or negative priming effect only appeared on the slow trials, indicating the involvement of reactive control mechanisms (see Figure 4(b)).

Thus, the performance of all the participants on the negative priming task primarily reflected the involvement of reactive control mechanisms. Proactive control mechanisms

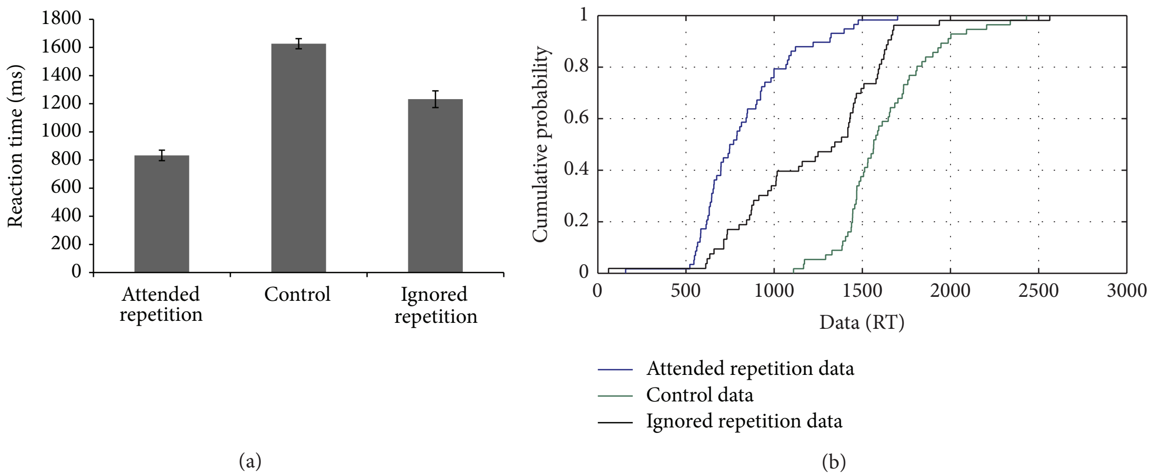

FIGURE 4: (a-b): Reaction time data and CDF plot based on the performance of MU on the negative priming task.

appear to be affected with respect to the persistent inhibitory effects as indicated by the subjects' performance on the negative priming task.

3.2. Flanker Task with Nonlinguistic Stimuli. All of the participants performed the flanker task with nonlinguistic stimuli with good accuracy except for SC, who showed less accuracy but at an above chance level.

CR's performance on the nonlinguistic flanker task showed a congruency effect (i.e., mean reaction times on the congruent trials were faster than incongruent trials) (see Figure 5(a)). Unlike the usual effects observed on flanker tasks, neutral trials were slower compared to the incongruent trials. Error analysis showed a greater number of errors on the incongruent condition compared to the congruent and neutral conditions as expected in a flanker task (see Figure 5(b)). Cumulative distribution function plots were derived and showed differences across the three conditions only in the range of the 60th to 90th percentile, which was not consistent with the mean RT performance, and showed less congruent RTs compared to neutral RTs and less neutral RTs compared to incongruent RT conditions (see Figure 5(c)). The trend of slower incongruent trials compared to congruent trials was also observed at the 5th percentile (fast trials) level.

MMH showed a 98.8% accuracy on the standard flanker task, demonstrating the expected congruency effect with faster RTs on congruent trials compared to the incongruent trials. According to the CDF analysis, a congruency effect was observed with respect to the neutral condition only on slow trials, indicating the involvement of reactive control (see Figures 6(a) and 6(b)). The CDF plots indicated that RTs for the neutral condition were faster than the incongruent condition throughout the distribution, which is suggestive of the presence of an interactive and efficient inhibitory control mechanism.

SC demonstrated a 67.2% accuracy on the nonlinguistic flanker task. However, all the errors were made on the incongruent trials. Thus, the flankers' identity was influencing judgment more than the target's identity on the incongruent trials (see Figure 7(a)). The flanker effect was observed with slower RTs on incongruent trials compared to the congruent trials. RTs on incongruent trials were also compared with congruent and neutral conditions. And the RT distributions showed a uniform difference across conditions throughout the distribution (see Figure 7(b)). These results indicated that SC showed no difference between the slow versus fast trials on any of the conditions, demonstrating that both the proactive and reactive control mechanisms contributed to the flanker effects.

MU's performance on the nonlinguistic flanker task showed a congruency effect with respect to the mean RTs, although his performance on the neutral condition was exceptionally slow compared to the incongruent trials (see Figure 8(a)). CDF analysis showed that the congruency effect was absent (showing no difference between congruent and incongruent trials) on slow trials (i.e., 95th percentile and above), suggesting the involvement of proactive control mechanisms in the efficient performance, which was also highlighted by a high accuracy throughout the distribution (see Figure 8(b)). Uniformity was also observed in the distribution, which changed only in the slow trials, where the distribution shifted to its usual trend of differences across conditions.

Thus, performance on the flanker task with nonlinguistic stimuli showed a similar involvement of the reactive and proactive control mechanisms, contributing to the flanker effects for all four participants. All of the participants similarly showed conflict resolution and executive control effects on slow and fast trials, indicating the efficiency of the control processes in current trial inhibitory effects with nonlinguistic stimuli.

3.3. Flanker Task with Linguistic Stimuli. All of the participants performed the flanker task with linguistic stimuli with a fair amount of accuracy. Flanker effects with respect to the reaction times and accuracy on congruent and incongruent

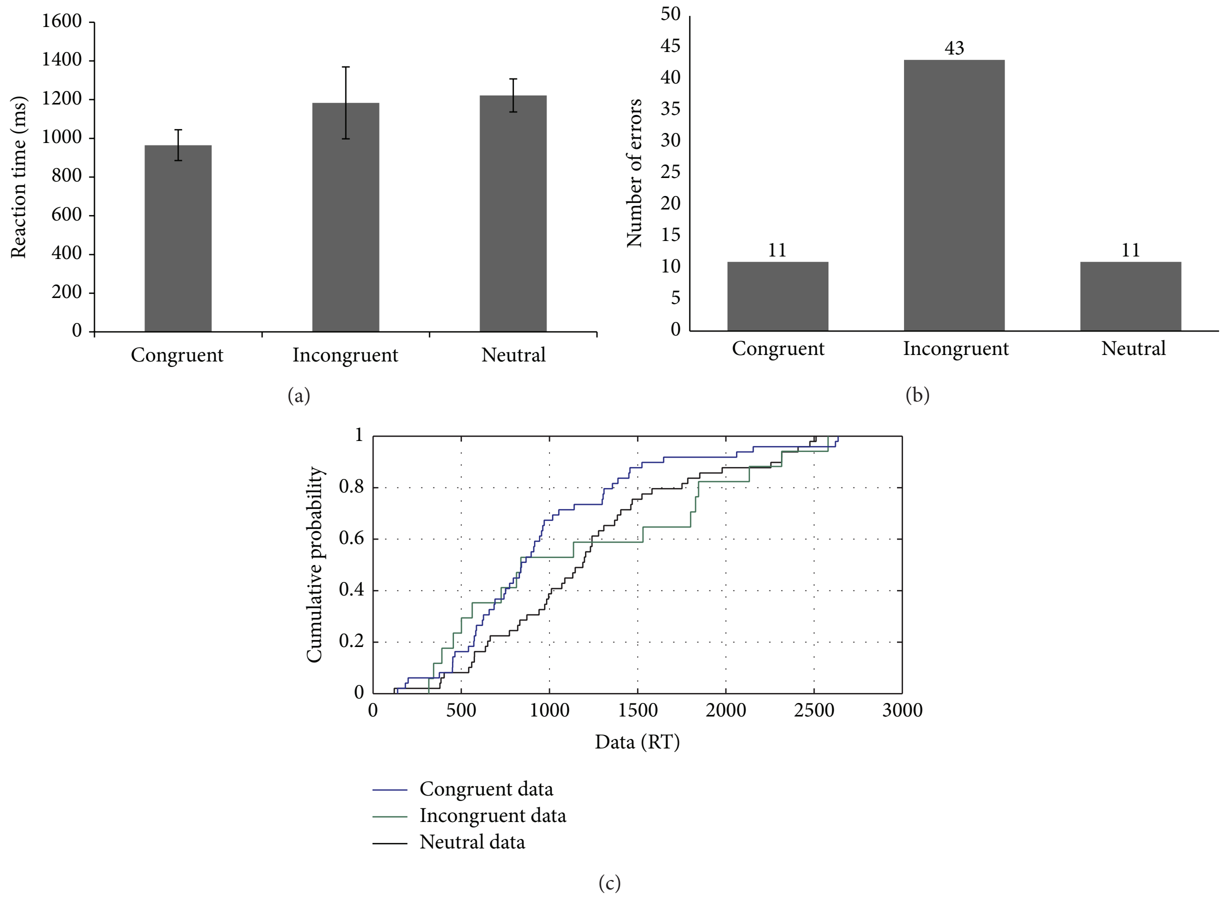

Figure 5: (a–c): Reaction time data, error analysis, and CDF plot based on the performance of CR on the flanker task with nonlinguistic stimuli.

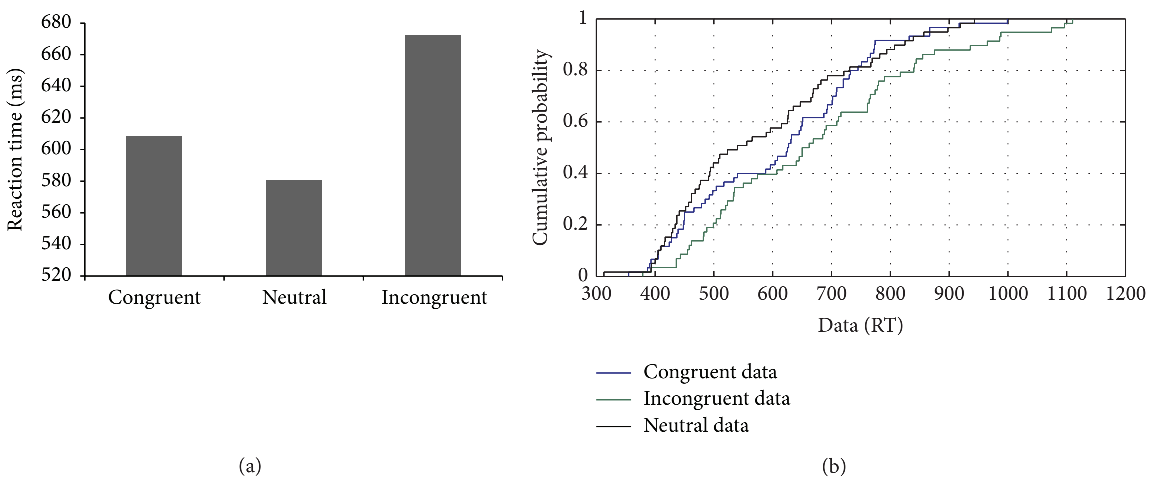

Figure 6: (a-b): Reaction time data and CDF plot based on the performance of MMH on the flanker task with nonlinguistic stimuli.

trials for L1 and L2 were observed, and the patterns of these effects on slow and fast trials were examined based on the CDF plots.

CR's performance on the linguistic flanker task showed a congruency effect for L2, whereas there was an absence of the congruency effect for L1 (see Figure 9(a)). The overall errors across all the conditions were greater for L1 compared to L2. L1 showed errors mostly on the congruent trials, whereas L2 showed a greater number of errors on the incongruent trials (see Figure 9(b)). For the language incongruent condition,

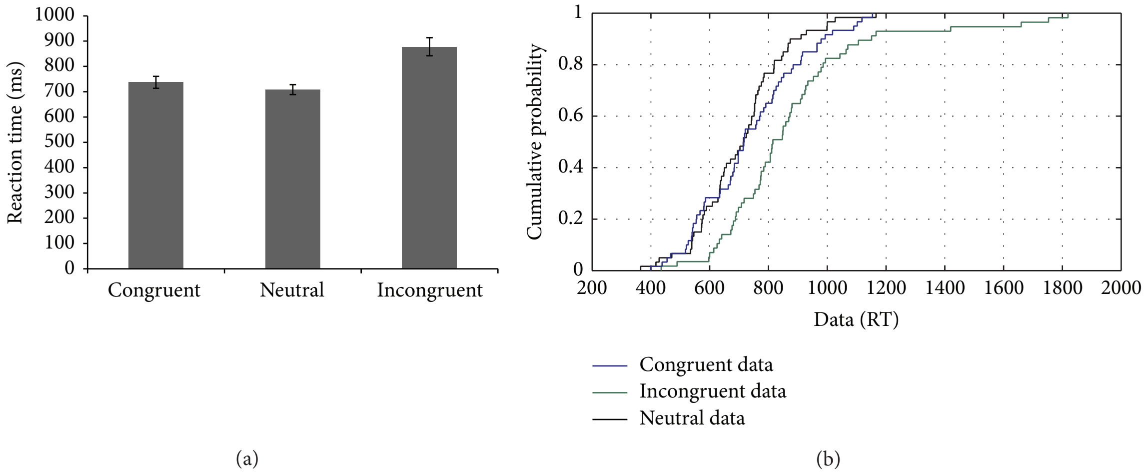

Figure 7: (a-b): Reaction time data and CDF plot based on the performance of SC on the flanker task with nonlinguistic stimuli.

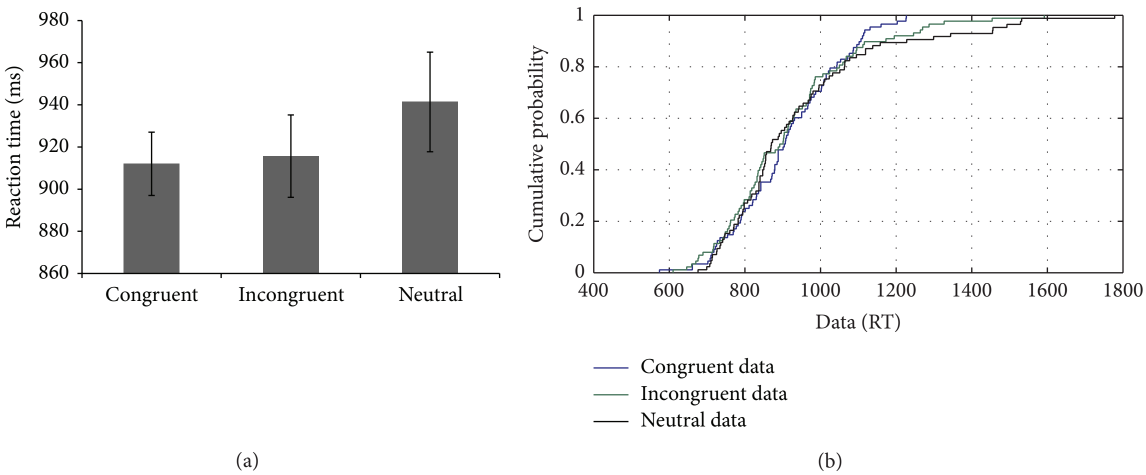

Figure 8: (a-b): Reaction time data and CDF plot based on the performance of MU on the flanker task with nonlinguistic stimuli.

the congruency effect was observed only for L2 throughout the distribution (see Figure 9(c)). Both L1 and L2 showed a flanker effect on the language incongruent condition on the fast (5th–20th percentile) and slow (70th–95th percentile) trials. Interestingly, similar patterns for the congruency effect for both L1 and L2 on the cross language incongruent condition were observed. The discrepancy in the mean scores for L1 versus L2 with respect to the congruency effect is suggestive of different underlying processes operating for L1 compared to L2. However, this difference was not explained by the CDF plots, which showed similar patterns of performance on the slow and fast trials for both languages (see Figures 9(c) and 9(d)).

MMH's performance on the linguistic flanker task showed a congruency effect for both types of incongruent conditions (i.e., IC within and IC across) for L2, whereas for L1, the flanker effect was absent in the within language condition (see Figure 10(a)). The CDF plots showed no difference in the pattern of RT distributions across the three conditions for L2, whereas for L1, the across language incongruent trials showed a congruency effect between the 20th and 70th percentile, which was not observed for the within language incongruent condition (see Figure 10(b)). The congruency effect for the within language incongruent trials was observed only on the slow trials (see Figure 10(c)).

Unlike his performance on the flanker task with nonlinguistic stimuli, SC demonstrated a higher overall accuracy on the linguistic flanker task (92.69%), which supports our assumption with respect to his performance on the previous task; that is, the errors were not due to difficulties in the response selection. Although the differences in the mean reaction times were very small (see Table 4), there was a congruency effect for L1 only on the across language incongruent trials. However, the RT distributions of L1 showed an absence of a congruency effect on the fast trials for the across language incongruent condition (see Figure 11(b)). These results indicated that the interference caused by the flankers in L2 while attending to the target in L1 was resolved using proactive control mechanisms because the effect was not sustained throughout the distribution and was only present

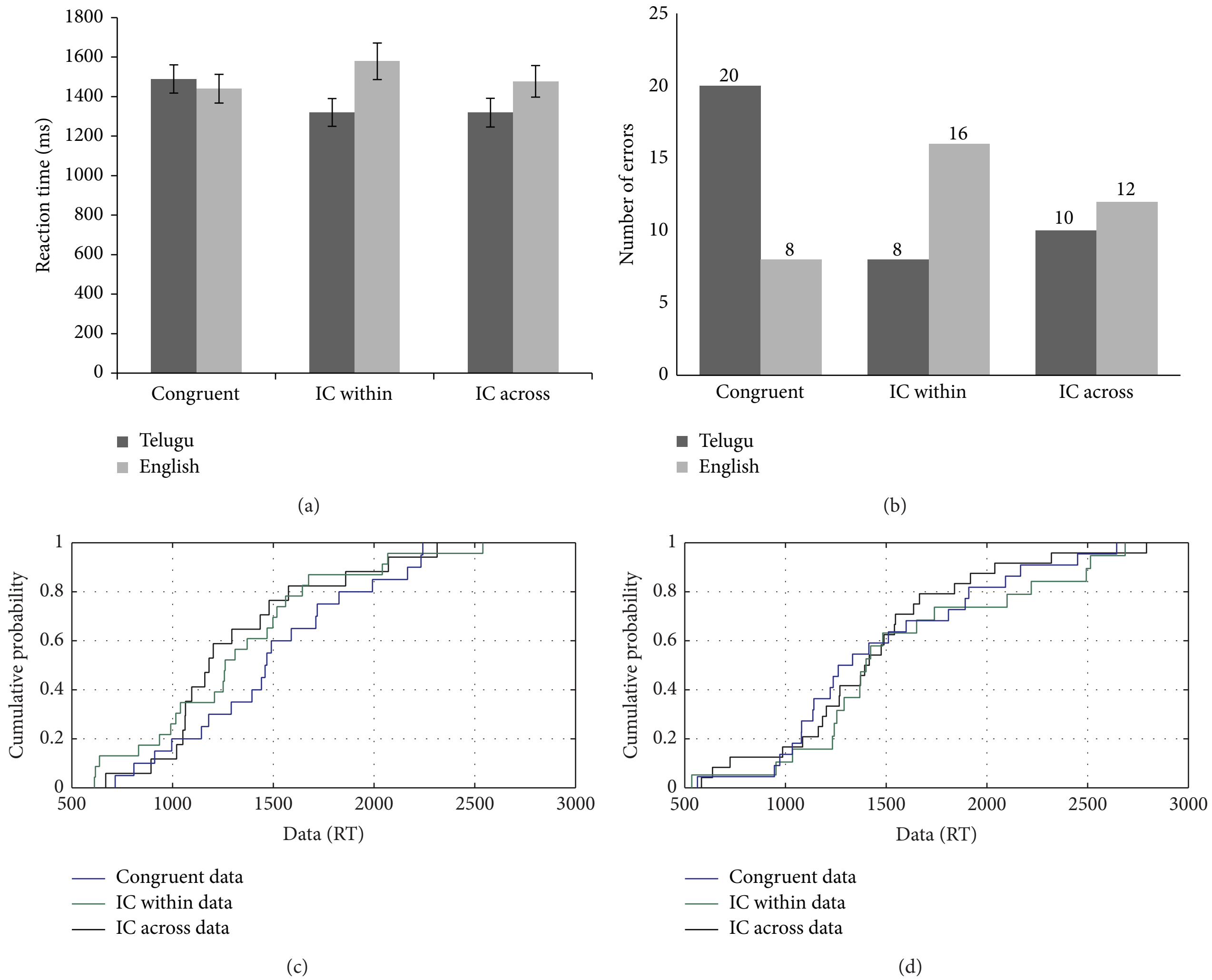

FIGURE 9: (a–d): Reaction time data, error analysis, and CDF plot based on the performance of CR on the flanker task with linguistic stimuli.

for the fast trials. For L2, CDF analysis showed a congruency effect on the within language incongruent condition, but only at the 5th percentile level (fast trials) and was not observed throughout the distribution (see Figure 11(c)). These results indicated a greater dependence on proactive control mechanisms because the difference between the congruent and incongruent trials within a particular language (L2) surfaced only on the fast trials.

MU's performance on this task showed a congruency effect for L1 and not for L2 with respect to the mean reaction time data (see Figure 12(a)). The flanker effect was present for L1 for the across language incongruent condition and not for the within language incongruent condition. These results indicated that the interference experienced was less when the flankers and the target were from the same language compared to the bilingual trials. Visual inspection of the CDF plots showed the presence of a congruency effect on the slow and fast trials, and these effects were absent only in the range of the 15th–50th percentile. CDF analysis of the across language congruency effect in L1 showed the presence of a flanker effect throughout the distribution. CDF plots showed slowing on the across language incongruent condition compared to the congruent condition for L2 with RTs ranging from 75th to 95th percentiles (see Figure 12(b)). These results indicated an involvement of reactive control mechanisms in a more demanding situation where one needs to inhibit the flankers in L1 to attend to the targets in L2.

Thus, results based on the linguistic flanker task with respect to the within language and across language flanker effects for L1 and L2 indicated a greater variability in performance across the four participants as well as for each participant for L1 versus L2. Our results clearly show that in the case of bilingual language control, bilingual individuals with aphasia appear to show differences in the patterns of performance for L1 versus L2 as well as the recruitment of control mechanisms in resolving conflicts with linguistic stimuli. In addition, the flankers also greatly influenced inhibitory control processes compared to target processing of linguistic stimuli. Thus, it would be equally important to examine suppression-related mechanisms among individuals

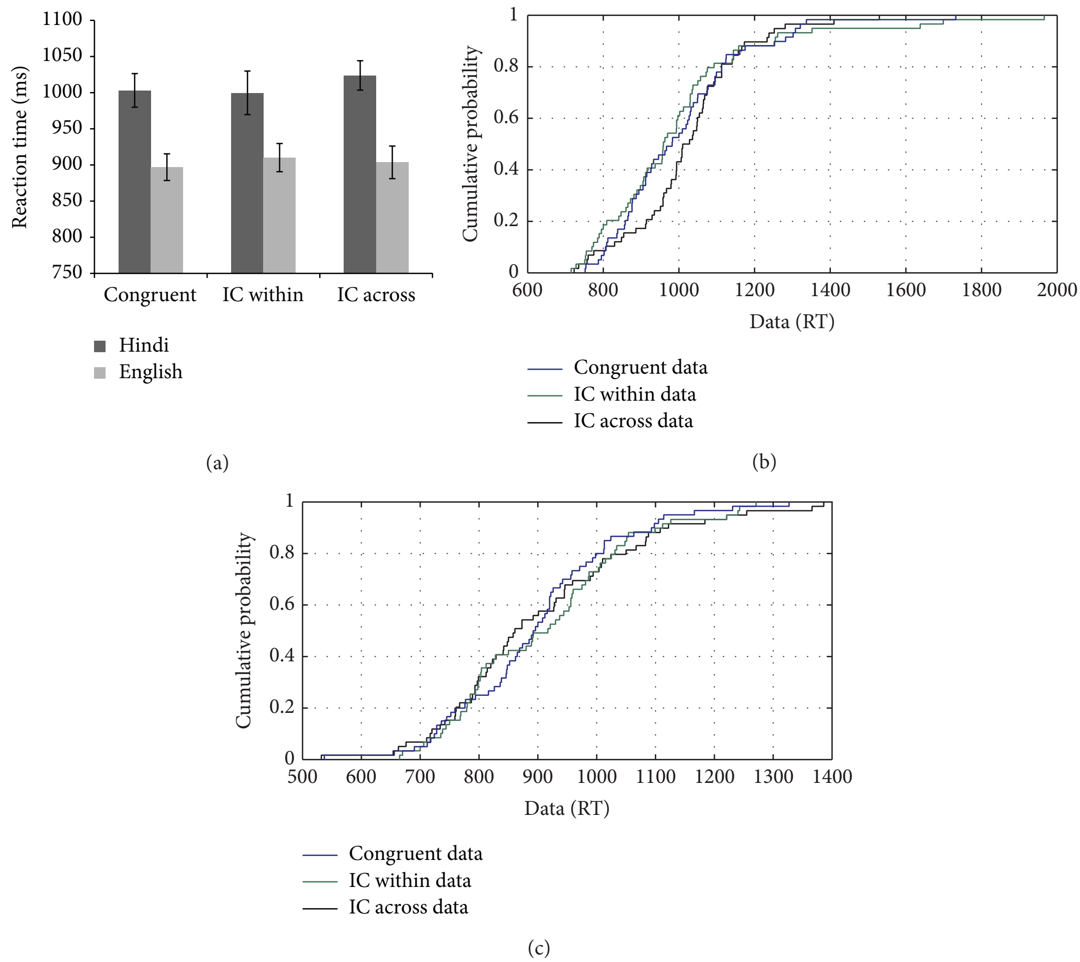

Figure 10: (a–c): Reaction time data and CDF plot based on the performance of MMH on the flanker task with linguistic stimuli.

with bilingual aphasia to investigate the activation-related mechanisms for languages affected in an individual with bilingual aphasia.

3.4. Correlation Analysis (Language History Variables and Performance on Control Tasks). Correlations were determined to examine the relationship between bilingualism-related factors, such as language use and self-rated language proficiency with the experimental task performance across the four participants.A bivariate correlation analysis was performed using two sets of variables: those related to the language background information (language use in L1 and L2, overall language proficiency in L1 and L2, proficiency in speaking, and understanding domain) and those pertaining to the control tasks (flanker effect for L1/L2 in the within language incongruent condition, flanker effect for L1/L2 in the across language incongruent condition, flanker effect for nonlinguistic stimuli, and a positive priming effect and negative priming effect on the negative priming task).

Language use did not show a significant correlation with performance on any of the control tasks. However, interesting trends were observed with respect to the relationship between L1 and L2 proficiency and control tasks, and specifically with linguistic stimuli. Language proficiency in L1 was negatively correlated with the flanker effect of L2 in the within language incongruent condition ($r = -.970$, $p = .03$), whereas it was positively correlated with the flanker effect of L2 in the across language incongruent condition ($r = .979$, $p = .02$). L2 proficiency showed a negative correlation with the flanker effect of L1 and L2 across language incongruent condition ($r = -.986$, $p = .01$ and $r = .964$, $p = .03$, resp.). However, L2 proficiency was positively correlated with L2 within language incongruent condition ($r = .977$, $p = .02$). The observed correlations indicated that the relationship between proficiency and the control task performance among aphasic individuals emerged mostly in bilingual competition on the across language incongruent condition on the linguistic flanker task. When L1 proficiency is low or when L1 is the affected language in aphasia, the flanker effect would also be less on the across language incongruent condition in L2 because the competition/conflict from the weaker L1 flankers would be less. Second language proficiency has been reported to be enhanced compared to L1 by all participants. The negative correlation between L2 proficiency and the flanker effect for L1 and L2 on bilingual trials manifested differently across participants based on individual data. For

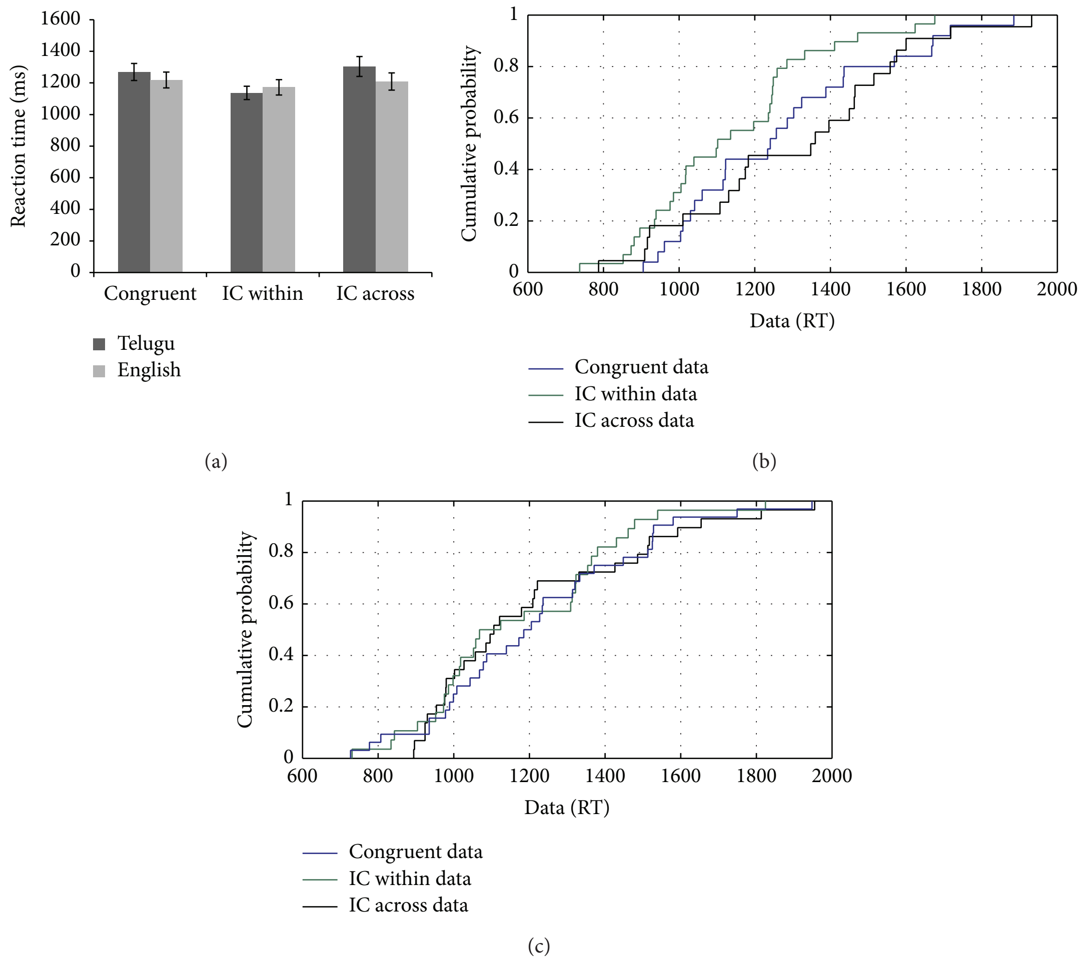

Figure 11: (a–c): Reaction time data and CDF plot based on the performance of SC on the flanker task with linguistic stimuli.

instance, CR showed a negative correlation in terms of a better L2 proficiency and reduced flanker effect for L1 on the L1 across language incongruent condition. However, for SC and MU, a lower L2 proficiency was correlated with greater flanker effects for L1 in the L1 across language incongruent condition. There was a near significant negative correlation between proficiency in the speaking/understanding domain in L1 and an inhibitory effect ($r = -.919$, $p = .08$) on the nonlinguistic negative priming task. These results suggested that the inhibitory effects on a nonlinguistic negative priming task might increase in lower L1 proficiency. This suggested a potential relationship between L1 proficiency and domain general inhibitory control.

Thus, results based on the correlation analysis suggested that a weaker or affected language in bilingual individuals with aphasia was not correlated with flanker effects in the weaker language compared to the L2 proficiency, which showed a significant relationship with flanker effects in L1 and L2. Inhibitory effects in L1 and L2 surfaced in bilingual competition and are more closely related to proficiency, particularly in the less affected language, which is L2 in most of the participants in the current study. These interesting trends in the current data should be further tested using a larger number of bilingual individuals with aphasia.

To summarise our results, all participants showed the presence of a facilitation effect, in the absence of an inhibitory effect (except for SC) on the negative priming task. CDF analysis showed the presence of an inhibitory effect only on the slow trials for CR, SC, and MU. SC also demonstrated inhibitory effects on fast trials. The flanker task with linguistic and nonlinguistic stimuli showed varying effects across the four participants. A congruency effect was evident on the nonlinguistic flanker task for all the participants with respect to the mean reaction times. CDF analysis revealed interesting patterns of performance. CR and SC showed a congruency effect throughout the distribution, whereas MMH showed a congruency effect only on the slow trials. Conversely, MU showed a congruency effect only on the fast trials. Thus, a rather complex picture emerged from the linguistic version of the flanker task, based on the mean reaction time data. A congruency effect was observed for L2 (i.e., while comparing the congruent condition with the incongruent within language and incongruent across language conditions) only for CR and MMH. However, SC and MU showed a congruency effect only for L1 compared to the congruent condition with the incongruent across language condition. CDF plots also showed varying patterns of performance across participants on the cross linguistic flanker task. CDF

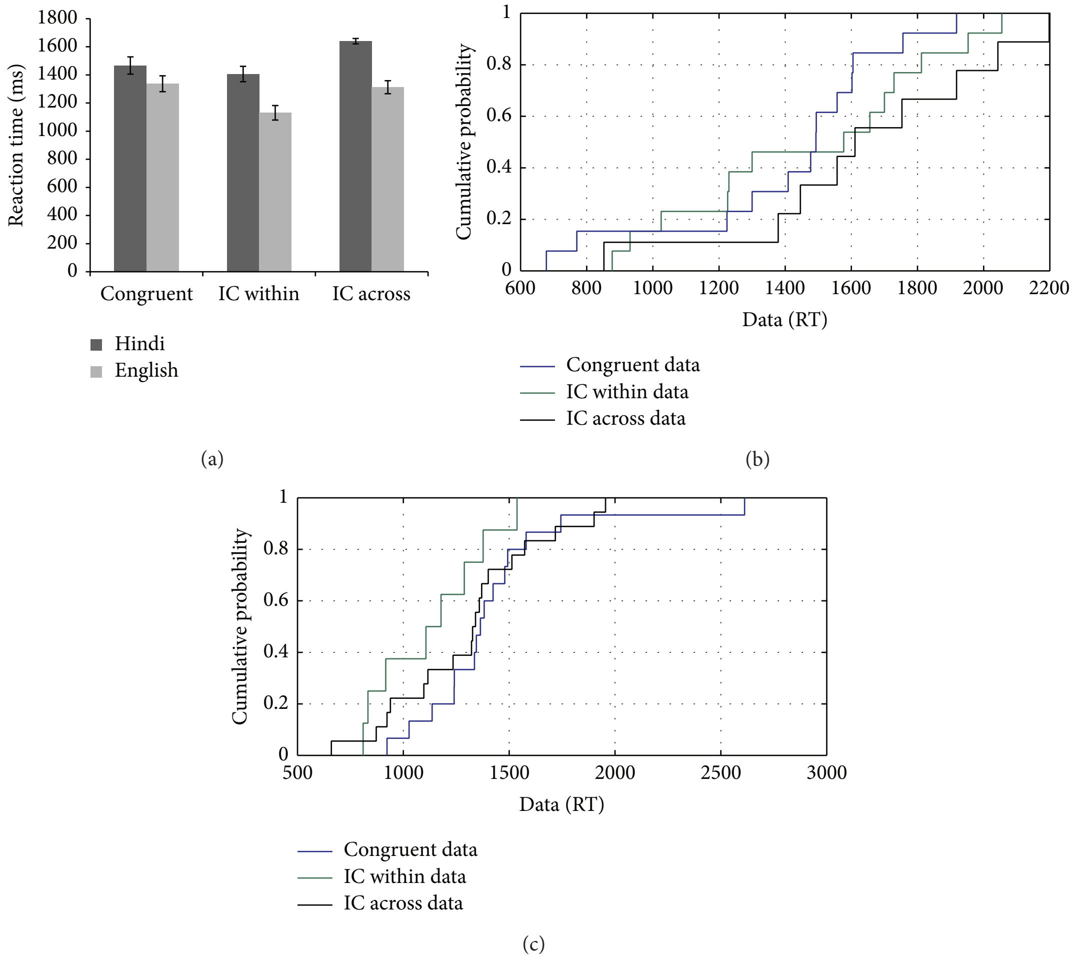

FIGURE 12: (a–c): Reaction time data and CDF plot based on the performance of MU on the flanker task with linguistic stimuli.

plots for L1 (compared to the congruent condition with the within language incongruent condition) showed an absence of a congruency effect except for MMH who showed a congruency effect on slow trials. Interestingly, the congruency effects for L1 (i.e., congruent condition versus incongruent across language condition) throughout the RT distribution of CR and MU on slow trials were observed. All participants showed different patterns of performance in their L2. Error analysis helped to understand the within subject variability in reaction times. However, the highly accurate performance of all the participants in different tasks limited our ability to draw any commonality among them.

4. Discussion

The findings of the current study are consistent with the view that the acquisition of another language involves an adaptation to an existing network. Different languages are represented in shared brain regions with common organising principles [36]. Specific patterns of deficits reflect problems of control rather than deficits of pure linguistic origin. Inferences drawn from deficits involve reverse extrapolation to a premorbid state of functioning. An influential aspect of this approach is that patterns of performance (both intact and impaired) suggest selective damage to one or more components or processing pathways. The results of the current study suggest that although inhibitory control underlying selective attention may be impaired in participants with anterior aphasia. The ability to differentiate the target from the distracter may be preserved; thus, the presence of flanker effects in the flanker task. The flanker task and negative priming task are dependent on different processing mechanisms. The presence of positive priming in the absence of negative priming with respect to the RT data observed in our participants is suggestive of the dual route involved in the negative priming task. It has been postulated that positive priming is strongly affected by perception in contrast to negative priming, which emerges during selection [37]. We have found that such dissociations between positive and negative priming effects in the current study suggest difficulties with respect to selection as a component of control processes among bilingual individuals with aphasia.

Reactive and proactive control mechanisms underlying the performance on each task for each participant were explored using CDF analysis. All four participants showed a dependence on the reactive control mechanisms with specific variations observed between the two languages that were known by each of the four participants. For example, CR's congruency effect on the linguistic flanker task showed an interesting language specific variation. L2 (English) showed the involvement of reactive control, whereas L1 showed a reliance on proactive control mechanisms. MMH showed an L1 congruency effect only when L1 was flanked by L2 on slow trials, suggesting the involvement of reactive control. These effects were similar to those observed in CR's performance. An interesting observation was that MU showed greater interference from the same language (when flankers were in the same language as the target) compared to the condition that involved across language competition. However, this effect was only observed for L2, whereas L1 showed the congruency effect in across language conflict. The nonlinguistic flanker task showed the involvement of both proactive and reactive control mechanisms, except for MMH and MU. MMH showed an involvement of the reactive control mechanism and MU showed a reliance on proactive control. These two mechanisms are not mutually exclusive. Thus, it is possible that CR and SC showed the involvement of both mechanisms to resolve the conflict for efficient performance. CDF plots suggested that the magnitude of the effects was larger for facilitation or the positive priming effect on slow trials, and differences between the control condition and ignored repetition condition were more prominent on fast trials for MMH and MU on the negative priming task. In both cases, it is probable that the sustained activation of all four items (2 pictures from the prime trial and 2 from the probe trial) resulted in the slowing of the response in the control condition, due to a greater interference from unattended stimuli. There was an interesting dissociation observed in CR's performance, demonstrating an involvement of proactive control during facilitation and reactive control for inhibition. Such a tradeoff may be due to dual mechanisms involved in facilitation versus inhibition. The distinction between proactive and reactive control is useful in elucidating the variations in cognitive control mechanisms due to the influences from bilingualism-related factors, which need to be explicitly manipulated and examined in future research. As a result of their limited processing resources, the effective engagement of proactive control may be problematic for individuals with aphasia and may thus engage the reactive control mechanisms, which do not require the individual to sustain control over an extensive period of time [27].

Another interesting area to explore is the interaction of bilingual language control and general purpose cognitive control and thus, we compared the performance on linguistic and nonlinguistic flanker tasks. Performance-based differences were evident on flanker tasks with nonlinguistic versus linguistic stimuli. Interestingly, the variations in the performance of each participant surfaced to a greater degree in the linguistic stimuli for both L1 and L2. Except for CR, all of the other participants showed differences in their performance between the two tasks. For example, more reliance on reactive control mechanism in the performance of MMH on the nonlinguistic flanker task was observed, whereas the proactive control was predominant in the across language incongruent condition on the linguistic flanker task. This trend was reversed for MU.

Results obtained from the current study helped to form the stage for further studies to enhance our understanding of language control and cognitive control in bilingual aphasia as well as to improvise the rehabilitation process. This is supported by the fact that therapy in L2 was related to a better performance in L2 on the linguistic flanker task (in the case of CR and MMH), while therapy focusing predominantly on L1 resulted in a better performance in L1. Such a domain specific effect of therapy was also reported in a study by Abutalebi et al. [2], where improvement in the naming performance resulted in an improvement in the naming network only. Abutalebi and colleagues [2] also discussed the dissociation between the naming and control pathways, which was consistent with the observations of the present study with respect to the variations in performance between linguistic and nonlinguistic control tasks.

We also observed that individuals with better scores on the WAB did not show an involvement of the proactive control mechanism with the data based on the negative priming task. Thus, there is a need to perform both linguistic and nonlinguistic control tasks while profiling individuals with bilingual aphasia. It is possible that individuals with bilingual aphasia may respond to speech and language therapy and show an improvement in language skills in the affected language, but may still demonstrate problems with executive control. Another interesting relationship between subjective information (see Tables 1, 2, and 3) and task performance was via premorbid language use (in percentage) and the linguistic flanker task. Premorbid language use was the same for SC and MU, whereas for CR and MMH, L1 was the dominant language. This was translated to the performance on linguistic flanker task, where language was dominant premorbidly and was affected compared to the other language (in these cases L2). SC and MU with a similar dominance of language use premorbidly, showed an absence of the flanker effect in both languages. In contrast to CR and MMH, their L1 performance was better than L2. Although such links between language use and task performance are interesting, the extrapolation of such findings via only single case studies should be carefully performed. However, the descriptive account of language use and task performance shows a relationship between the two variables, but the correlation analysis did not show a statistically significant correlation with the performance on any of the control tasks, which could be due to the variance across participants with respect to language use.

Studies investigating the interaction between bilingualism and control processes have theoretical and clinical implications. The case study approach employed in the current study provided an individually specific profile of bilingual individuals with aphasia with respect to cognitive control processes and the nature of control mechanisms, which may influence the recovery patterns and could thus be considered during the rehabilitation process. This study also highlighted that the performance of no two bilingual aphasics was the same and thus required a detailed assessment of both language control and cognitive control processes particularly relevant for individuals with bilingual aphasia. It has been reported by Abutalebi and Green [2] that the effect of treatment in bilingual aphasia was dependent on the integrity of naming and control pathways, indicating the need to address both linguistic and control systems. Apart from providing insight into language control and cognitive control mechanisms, such a profile of individuals with aphasia may help to decide the language for therapy in bilingual aphasia. Although, the current data are limited in establishing such a claim, they open new avenues of research. Performance on the flanker task and negative priming task may indicate the use of selective language therapy or bilingual language therapy based on the level of interference. Apart from the treatment decisions, clinical implications of language control and cognitive control mechanisms may act as a main determinant of cognitive-linguistic recovery in aphasia [2].

Taken together, the variations observed in the performance of each participant across tasks and stimuli strongly suggested that there is dissociation between bilingual language control and general purpose cognitive control mechanisms. These observations were further strengthened by the findings based on the correlation analysis between bilingualism-related factors (language use and proficiency) and performance on control tasks, which showed that the relationship between proficiency and inhibitory effects in L1 and L2 surfaced primarily in case of bilingual competition. L1 proficiency with respect to the speaking/understanding domain was correlated with a sustained inhibitory control (negative priming effect with nonlinguistic stimuli) and L2 proficiency was correlated with cross-linguistic flanker effects for both L1 and L2, indicating a dissociation between the role of L1 versus L2 proficiency in domain general cognitive control and bilingual language control, respectively. These interesting trends in the current data need to be empirically tested further with explicit manipulations related to L1 and L2 proficiency using a larger group of individuals with bilingual aphasia and their performance on a range of control tasks.

5. Conclusion

The present study was designed to examine the performance of bilingual aphasics on executive control tasks that test the circuits implicated in language control and cognitive control. CDF analysis was a promising tool used to examine the variations in performance within and across individuals, tasks and stimuli. Current trial inhibitory effects were observed among individuals with bilingual aphasia, whereas a sustained inhibitory control (as assessed on the negative priming task with nonlinguistic stimuli) was found to be compromised. Interestingly, sustained inhibitory control was correlated with L1 proficiency. All the participants demonstrated the use of reactive control mechanisms to compensate for the limited resource system. We also found differences in the involvement of control mechanisms for linguistic stimuli between L1 and L2 with L1 depending more on proactive control and L2 depending more on the reactive control mechanisms. Importantly, these mechanisms were not mutually exclusive but interacted for efficient inhibitory control. The observations of the current investigation involved a series of four case studies, which provided valuable insight into the nature of the control mechanisms and were not limited to the task performance and deficits in cognitive abilities. A longitudinal study on individuals with bilingual aphasia helped to monitor the changes in cognitive control (which also appeared to be affected among bilingual aphasics). Control processes, such as selection, inhibition, and monitoring particularly sustained inhibitory control, appear to serve as the underlying resource systems for bilingual language control.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Clinical Study

Executive and Language Control in the Multilingual Brain

Anthony Pak-Hin Kong,[1,2] Jubin Abutalebi,[2,3] Karen Sze-Yan Lam,[2] and Brendan Weekes[2]

[1] *Department of Communication Sciences and Disorders, University of Central Florida, HPA-2 106, P.O. Box 162215, Orlando, FL 32816-2215, USA*
[2] *Laboratory for Communication Science, University of Hong Kong, Pokfulam, Hong Kong*
[3] *Psychology Department, San Raffaele University and San Raffaele Scientific Institute, 20132 Milano, Italy*

Correspondence should be addressed to Anthony Pak-Hin Kong; antkong@ucf.edu

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Neuroimaging studies suggest that the neural network involved in language control may not be specific to bi-/multilingualism but is part of a domain-general executive control system. We report a trilingual case of a Cantonese (L1), English (L2), and Mandarin (L3) speaker, Dr. T, who sustained a brain injury at the age of 77 causing lesions in the left frontal lobe and in the left temporo-parietal areas resulting in fluent aphasia. Dr. T's executive functions were impaired according to a modified version of the Stroop color-word test and the Wisconsin Card Sorting Test performance was characterized by frequent perseveration errors. Dr. T demonstrated pathological language switching and mixing across her three languages. Code switching in Cantonese was more prominent in discourse production than confrontation naming. Our case suggests that voluntary control of spoken word production in trilingual speakers shares neural substrata in the frontobasal ganglia system with domain-general executive control mechanisms. One prediction is that lesions to such a system would give rise to both pathological switching and impairments of executive functions in trilingual speakers.

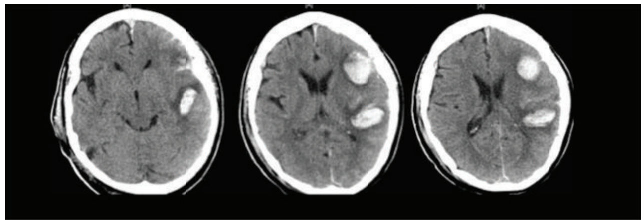
1. Introduction

Aphasia among multilingual speakers is a research topic of increasing importance [1]. Paradis [2] estimated there were at least 45,000 new cases of bilingual aphasia in the United States every year. According to the most recent census report [3], the number of multilingual speakers is expected to grow in the United States. It is therefore reasonable that the number of bilingual speakers with aphasia will increase in the coming years.

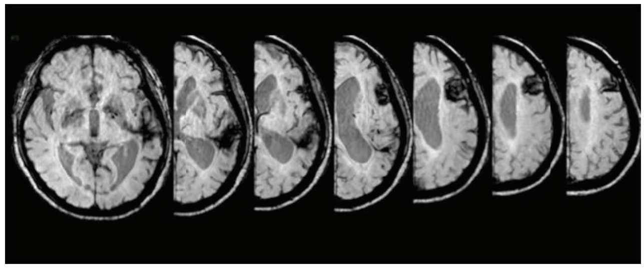
One unique feature of multilingual aphasia is involuntary and uncontrolled language switching and mixing [4]. Pathological language switching is characterized by the alternation of utterances from one language to another across sentence boundaries. Pathological language mixing, on the other hand, involves the mixing of elements of two languages in a single utterance [4–7]. Language switching and mixing are considered pathological if they occur involuntarily and are beyond the control of the speaker as in bilingual aphasia [8]. One explanation of these phenomena is that language switching and mixing results from the malfunctioning of a "language control" device that separates the languages of a multilingual speaker during production [9].

Goral et al. [10] described a Hebrew-English-French trilingual speaker with aphasia, EC, who showed a differential pattern of recovery and suggested an asymmetric connection between native language (L1) and nonnative languages. Specifically, EC experienced the least degree of language interference when conversing in L1 (Hebrew), which was the most recovered language, and demonstrated more interlanguage activations when producing narratives in L3 (French), which was the least recovered language. Goral et al. also found that during language production in French, interference from L2 (English) was more frequent than from Hebrew. The authors proposed that interlanguage lexical intrusions observed among multilingual speakers with aphasia could be related to the degree of language similarity (e.g., shared vocabulary) and premorbid pattern of language use in addition to other factors such as the age and manner of language acquisition. Faroqi-Shah and Waked [11] also reported a trilingual speaker with aphasia, NK, who spoke Arabic (L1), French (L2), and English (L3). They reported dissociations between nouns and verbs in which NK demonstrated a pervasive verb production deficit irrespective of the task (confrontation naming and narrative speech) or language of elicitation. Therefore, there were no differential effects of language similarity.

As to the neural locus of the language control device, clinical case studies have shown that damage to a frontal-subcortical circuit not only leads to uncontrolled behavior in brain damaged individuals, but also pathological switching between languages and language mixing [12–14]. Functional neuroimaging studies with unimpaired multilingual speakers have corroborated such findings [15–17] showing that language switching relies on a prefrontal-caudate ACC (anterior cingulate cortex) circuit. However, other findings from neuroimaging studies also suggest that the neural network involved in language control is not specific to bi-/multilingualism but is part of a domain-general executive control system [18, 19]. We report evidence that impaired language control and executive functions are associated with lesions to a partially overlapping cognitive and neural system in a multilingual speaker, Dr. T. This is the first case report of pathological switching [6] that is specifically associated with executive control impairments following damage to the executive control system in the frontal cortex.



(a)



(b)

Figure 1: CT scans of the trilingual patient carried out in the acute phase following brain damage reporting the two brain lesions in the left hemisphere (a). MR scanning performed in the chronic phase revealing the extension of the two lesions is illustrated in (b).

2. Case Report

Dr. T is a 77-year-old right-handed female trilingual Cantonese-English-Mandarin speaker who sustained a traumatic brain injury causing a fluent aphasia with pathological switching and mixing [8]. CT scanning in the acute phase (Figure 1) and MR imaging in the chronic phase (Figure 2 and bottom row in Figure 1(b)) revealed two lesions, a major one in the left frontal lobe and a minor one in left temporoparietal areas. She was a retired radiologist premorbidly. Her first language, Cantonese (L1), was acquired from birth and used extensively in daily life and at work in Hong Kong. She started to learn English, her second language (L2), formally from the age of 13 years and used English regularly in professional life. Mandarin, the third language (L3), was learned in her early twenties when she obtained her medical degree and worked as a doctor in Mainland China. Premorbidly, Dr. T mainly used Cantonese and English to communicate with her husband in Hong Kong and grandchildren who are living in the United Kingdom, respectively. Dr. T's husband was recruited as a control because he was perfectly matched in age, handedness, education level, and trilingual language knowledge.

Cognitive functions were assessed using Raven's Standard Progressive Matrices [21] and the Symbol Trials of the Cognitive Linguistic Quick Test (CLQT) [22]. According to the smoothed 1986 Raven norms for urban Mainland China [22], the performances of the case and control were within normal limits (50th percentile: 34/60 versus 75th percentile: 46/60). Both participants also scored above the criterion-referenced cut score in the CLQT Symbol Trials (8/10 versus 10/10). These results suggested normal cognitive ability. However, Dr. T scored significantly lower on a modified Stroop color-word test [23] (3/25 versus 25/25) and the Wisconsin Card Sorting Test (WCST) [24] (total error numbers: 2nd versus over 99th percentile; perseverative responses: less than 1st versus 97th percentile; conceptual level responses: 4th versus 99th percentile), revealing impairment of her executive functions.

Based on the Cantonese version of the Western Aphasia Battery (CAB) [25], Dr. T was diagnosed with Wernicke's aphasia in L1, with a total aphasia quotient of 46.6 (out of 100). Specifically, during the spontaneous speech task, Dr. T produced fluent unintelligible jargon and neologisms with severe word retrieval difficulty. She frequently switched between her Cantonese, English, and Mandarin during conversation, which decreased comprehensibility. Auditory comprehension was impaired at the sentence level with difficulty comprehending complex sentences and decontextualized questions as well as following one-step commands. In terms of repetition, Dr. T showed breakdown of performance at two-syllable words. Dr. T's reading and writing abilities were better than verbal comprehension and production. She was able to comprehend written sentences and commands with occasional errors. Reading comprehension ability was significantly better than her reading aloud performance. As for writing ability, Dr. T showed impairment even at the single-word level with better written than verbal naming.

Dr. T's multilingual ability was examined using the Bilingual Aphasia Test (BAT) [26]. Moderate impairment in auditory comprehension and oral production across the three languages was found. Dr. T demonstrated slightly better auditory comprehension abilities in Cantonese (L1: 44%) and Mandarin (L3: 46%) than in English (L2: 39%), but the opposite was observed in oral production (L1: 35%, L2: 46%,

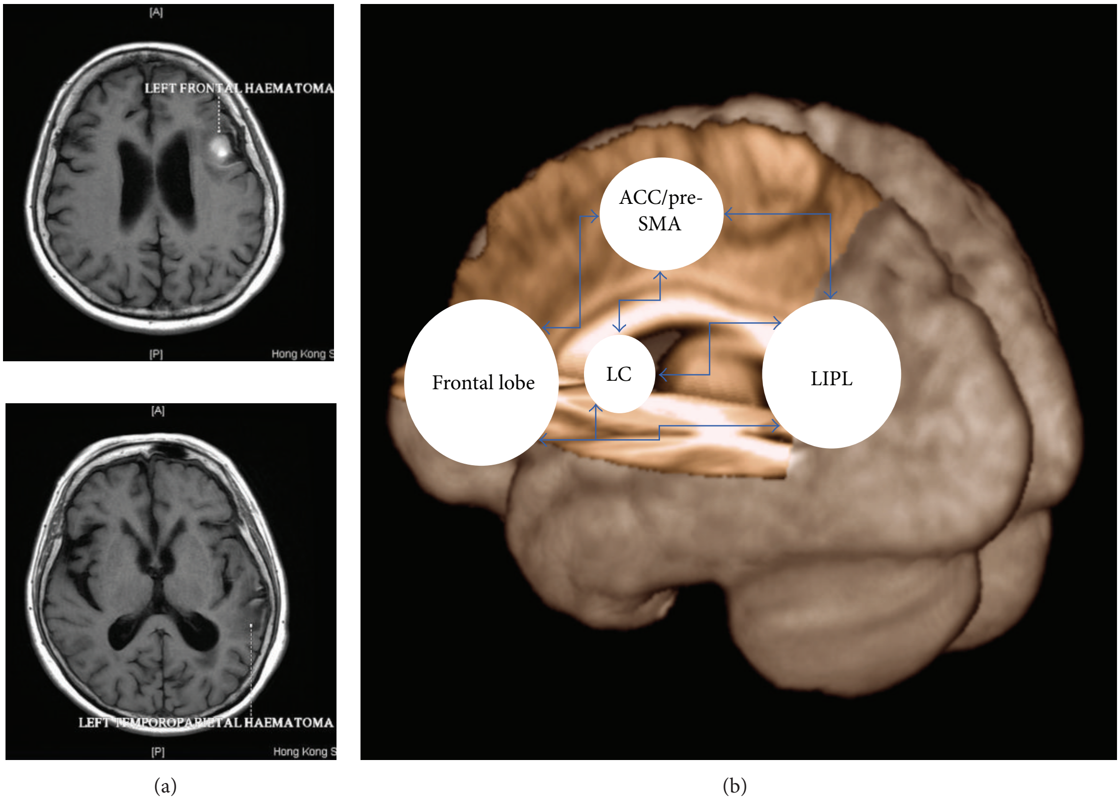


Figure 2: (a) MR scans of the trilingual patient revealing a major haematoma localized in the left frontal lobe and a minor one in the left temporoparietal junction. (b) The neural circuitry involved in language control (adapted from [20]) with the four key areas is identified. The ACC (anterior cingulate cortex) is involved in monitoring functions such as error detection (i.e., if the speaker has selected the correct language), the frontal lobe is involved in error correction and response inhibition, and the left caudate (LC) is involved in supervising the correct selection of the language and language planning while the left inferior parietal lobule (LIPL) along with its right-hemispheric counterpart is involved in more attentional processes such as biasing selection towards and from the language in use. This network resembles the domain-general executive control network (see [20] for details). Of note, the lesions of our trilingual patient reported in (a) may have interrupted the connections between the frontal and parietal areas of this neural circuitry, hence leading to an inability to inhibit the unwanted language (i.e., frontal lobe) and focusing attention on the language in use (i.e., parietal lobe).

and L3: 35%). Dissociations were also observed in her reading comprehension (L1: 75%, L2: 75%, and L3: 85%) and reading aloud (L1: 31%, L2: 73%, and L3: 4%) abilities. To summarize, the BAT revealed Wernicke's aphasia of moderate grade in all three languages for Dr. T, which is consistent with the above-mentioned CAB results. In addition, Dr. T's linguistic profile contrasts with performance over 93% accuracy demonstrated by the control across all BAT tasks on these languages.

Pathological language switching and mixing demonstrated by Dr. T, when compared to the control, were examined in multilingual confrontation naming and discourse production in three languages. Both participants were required to name 85 colored pictures from Snodgrass and Vanderwart [27] in Cantonese, English, and Mandarin. The stimuli were grouped into 18 conversation topics, for which the participants conversed on each topic in three languages on separate days with author K. Lam for at most 15 minutes. The middle six minutes of three selected topics (a subset of the language samples was selected according to the following criteria: (1) the duration of each topic in each language was at least ten minutes, (2) the participants were familiar with the topic in which at least four items overlapped with those in the confrontation naming task, and (3) the maximum amount of neologisms in each topic in each language was less than 25%) were transcribed verbatim and the percentage of correct code-switched words was calculated (the percentage of code switching was calculated based on five parameters adopted in each elicitation, including (1) total number of Cantonese words, (2) total number of English words, (3) total number of Mandarin words, (4) total number of neologisms, and (5) total number of words in all languages including neologisms (i.e., sum of words in parameters one to four). Pauses and intelligible words were used to determine the word boundary for defining neologisms. Each instance of a neologism (regardless of the length) following a pause or an intelligible word was counted as one neologism). Pairwise comparisons revealed significantly less code switching in Cantonese confrontation naming compared to discourse production for the same lexical items ($P < 0.001$). No differences were observed in English (L2; $P = 0.44$) or Mandarin (L3; $P = 1.00$). Chi-square comparisons showed that in confrontation naming, code switching from the target language

Table 1: Pairwise comparison of code-switched words (%) across naming contexts.

Naming context	Target language	Correct code-switched words (%)			Chi-square
		Cantonese	English	Mandarin	
Confrontation	Cantonese (L1)	—	3.56	6.72	0.82
	English (L2)	21.85	—	4.64	10.70*
	Mandarin (L3)	30.77	1.40	—	28.13**
Discourse production	Cantonese (L1)	—	1.07	30.97	28.13**
	English (L2)	26.93	—	5.65	13.36**
	Mandarin (L3)	30.89	0.52	—	28.13**

Note: * $P < 0.01$. ** $P < 0.001$.

Table 2: Samples of Dr. T's code switching at the single-word level (confrontation naming).

Language	Examples
Cantonese (L1) to **English (L2)** or Mandarin (L3)	(i) 車厘子 (*cherry*): "嗰個嗰個 (*that… that*) **strawberry**… 嗰啲叫咩 (*what is that called*)… xxx… xxx… **cherry**" (ii) 士巴拿 (*spanner*): "他 (*he*) xxx… 好 (*ok*) … xxx… 你 (*you*) xxx **opener**… 開心 (*happy*) xxx啦 (*a sentence final particle in Cantonese*)… 不會 (*will not*) xxx… xxx… xxx" (iii) 檸檬 (*lemon*): "**lemon** 好酸架 (*is very sour*)… 端 (*a phonemic paraphasia of the Cantonese word "sour"*)… 酸 (*sour*)… 端 (*a phonemic paraphasia of the Cantonese word "sour"*)… 酸 (*sour*)"
English (L2) to Cantonese (L1) or Mandarin (L3)	(i) **Lion**: "[**laigə**]… **the nail one, the male one**… **like**… xxx … 他們 (*they*) xxx… 他們 (*they*) xxx… 飛飛 (*fly, fly…*)… xxx" (ii) **Ant**: "**flies**… 唔係 (*not really*)… 他們 (*they*) xxx… xxx… **ant, ant**" (iii) **Lemon**: "**apple**… 唔係唔係係 (*not really, not really*), **moon**… 農 (*farm*), 農 (*farm*), 難便 (*difficult*)… **lemon, lemon**"
Mandarin (L3) to Cantonese (L1) or **English (L2)**	(i) 梨子 (*pear*): "**pear**" (ii) 檸檬 (*lemon*): "**lemon**" (iii) 腳 (*leg*): "腳 (*leg*)" (iv) 手錶 (*watch*): "錶 (*watch*)"

Notes: all verbal responses in English were **bold** and all verbal responses in Mandarin were boxed. Glosses and/or remarks in English were *italicized* and given in parentheses. Unintelligible vocalizations (or jargons) were transcribed as xxx. Note that several xxx strings were used in a row, in case the number of unintelligible words could be distinguished.

to Cantonese was significantly more common when targets were given to name in English (L2) and Mandarin (L3). This pattern was generally similar in discourse production, except that more Mandarin words were produced in Cantonese discourse production (L1 → L2: 1.1%, L1 → L3: 31.0%). Table 1 displays the code switching pattern of Dr. T. Note that the control, unlike Dr. T, only showed rare-to-absent incidence of code switching behavior. Examples of Dr. T's code switching during confrontation naming and discourse production are given in Tables 2 and 3, respectively. Note that given the high proportion of lengthy unintelligible neologisms produced by Dr. T, which lead to difficulty in determining sentence boundaries, language switching and language mixing could not be differentiated in the present study.

3. Discussion

A key question in bilingual language production is the specificity of the language control device that is used by multilingual individuals. Failures in language control may lead to unwanted language switching as observed in some cases of bilingual aphasia [10], and in the case reported here. On the other hand, in healthy subjects, voluntary language switching is considered an instance of task switching as it involves, at a minimum, a switch between different stimulus-response sets.

Based on the results from Goral et al.'s study [10], it could be hypothesized that Dr. T produces more code switching from Mandarin (L3) to Cantonese (L1) because the language pairs are linguistically closer to each other than English (L2) and Cantonese (L1). The data in Table 1 (30.8% and 30.9% code-switched words from L3 to L1 during confrontation naming and discourse production task, resp.) are partly consistent with this hypothesis. On the other hand, the relatively high incidence of switching from English (L2) to Cantonese (L1) by Dr. T, that is, 21.9% and 26.9% code-switched words in confrontation naming and discourse production, respectively, was unexpected. We contend that the pattern of code switching in her language production does not reflect language similarity and is more likely due to the age of acquisition or the language dominance of Cantonese [28, 29].

Table 3: Samples of Dr. T's code switching at the discourse level.

Language	Examples
Cantonese (L1) to **English (L2)** or Mandarin (L3)	(i) "好好架 (*very nice*), 好甜 (*very sweet*), 好好架 (*very nice*) xxx... 他們 (*they*) xxx... 他們 xxx都好好 (*they "jargon" are very good*)... 係 (*yes*)... xxx 因爲係 這個 天氣... 天氣 架喇 (*because of this weather...weather*), 他們 xxx好好呀 (*they "jargon" very good*), 但是 xxx好多xxx (*but "jargon" many "jargon"*)... 那麼 xxx好多好多 (*then "jargon" many many*)... /er/... 怎麼 xxx都好架 (*how "jargon" is also good*)... 因爲呢但係呢 (*because, however*)... 係 (yes)... /er/... 有有 怎麼呢 (*there is... there is ... then what?*), 他們 xxx, xxx, 什麼 xxx (*they "jargon" "jargon" so-called "jargon"*)... 所以他們 xxx (*therefore they "jargon"*)... 這麼什麼 xxx好好 (*then what "jargon" is very good*)" (ii) "**Taiwan, you can**, 西...西瓜 (*water...watermelon*)" (iii) "我 (*I*)/er/...夏天 (*summer*)... 你有冇 的那麼 個嗰個/er/(*did you have that one?*)...眞xxx個好好似**cotton** (*that really "jargon" look like cotton*)... /ar/... 咁就好好 (*then that is good*) ... 好好/sou/喇 (*very nice;/sou/is a phonemic paraphasia of the Cantonese word "nice"爽*)"
English (L2) to Cantonese (L1) or Mandarin (L3)	(i) "**very kind... in some team, in source, the the the light go** xxx **to be some** xxx **in a sweet** xxx... 好好啲 (*become better*)... **then some are and some are** 好/song/(*very sour;/song/is a phonemic paraphasia of the Cantonese word "sour"酸*)... **strawberry** 嗰啲唔係唔係 (*those are not right*), 係咪嗰啲 **the/ar/... grapes** (*are those/ar/grapes?*), 好多xxx好早 (*many "jargon" very early*) **in a, in join**, 好 (*good*)... **North Point in .../um/.../er/... North... /er/...** (*North Point is a town in Hong Kong*) **join sight** xxx... **sometime they** 係要好 **bad** xxx (*sometimes they need the bad ones*)" (ii) "係呀 (*yes*) xxx... **come** xxx **the tie, tie**, xxx **and then the trousers of/Chin.../**(*target: Chinese*) **the Chinese of** xxx... 有什麼 (*with the*) xxx **white** xxx xxx **and** 那個 /trou.../xxx (*that /trou.../; the target was trousers*)" (iii) "xxx xxx **jacket** xxx xxx xxx 好好 (*is very*).../um.../xxx... **a free** xxx xxx xxx, 都是呢 ... (*is very*) 他們兩個都是怎麼呢 (*both of them are very... how should I say it*)"
Mandarin (L3) to Cantonese (L1) or **English (L2)**	(i) "梨...梨...桃...桃...係呀 (*pear... pear...peac...peach... right*), 逃 (*a tonal paraphasia of the Cantonese word "peach"桃*), 西...西果 (*a semantic paraphasia of the Cantonese word "fruit"生果*) xxx xxx 但是 xxx 那 xxx 不是這樣 ... (*but "jargon" that "jargon" is not the case*) 但是 xxx 好多好多 (*but "jargon" many many*) xxx... 你看 xxx 不要 xxx... 都不是這 (*look "jargon" do not "jargon" ... is not that one*)" (ii) "**lemonie, lemon, lemon**... 個呢 檸...檬 (*the lemon*)"

Notes: all verbal responses in English were **bold** and all verbal responses in Mandarin were boxed. Glosses and/or remarks in English were *italicized* and given in parentheses. Unintelligible vocalizations (or jargons) were transcribed as xxx. Note that several xxx strings were used in a row, in case the number of unintelligible words could be distinguished.

We found a strong association between pathological language switching and control over task switching on standardized tests of executive control and function. Apart from taking time to invoke new stimulus-response mappings according to a new goal and choosing which attributes to attend to on such tasks, changing tasks might require the inhibition of competing stimulus-response mappings [30]. As such, we contend that language switching engages the same neural network used for task switching, that is, the frontobasal ganglia executive control system circuit (Figure 2). Hence, we would predict that lesions to that system would produce pathological switching and impairments of executive function, such as perseveration errors committed by Dr. T on the WCST.

We believe that Dr. T's pathological code switching can be attributed to impairment in the executive control resulting from damage to the frontal lobe. Interestingly, Dr. T's code switching was significantly less prominent in Cantonese oral confrontation naming compared to Cantonese spontaneous speech. Studies show that code switching can vary depending on the amount of stress in the environment [31]. The increased demand for linguistic, cognitive, and pragmatic skills in connected speech when compared to confrontation naming may pose more cognitive load on the neural system for Dr. T, resulting in limited capacity to regulate her code switching and leading to more frequent code switching in discourse production. The more frequent intrusions of Mandarin words than English words in imposed Cantonese tasks and the more prevalent intrusions of Cantonese words than English words in Mandarin tasks indicate that switches are more likely to the linguistically similar languages (e.g., Cantonese or Mandarin) than the linguistically different language (e.g., English). When English was the target language, a significantly higher proportion of switches were Cantonese than Mandarin, which may be explained by the fact that Cantonese was the dominant language in Dr. T's life.

Our case provides novel empirical evidence about the neural mechanism in bilingual brains. We contend that language control and domain-general executive control are served by a partially overlapping cognitive and neural system. The frontal lobe lesion damaged frontostriatal connections within the control network causing both pathological language switching and impairments to executive function. On the other hand, the lesion in the temporoparietal junction may be responsible for fluent aphasia with no effect upon language and executive control. On the basis of the language and cognitive control model proposed by Abutalebi and Green [8, 9] we cannot rule out the possibility that different lesions may be separately responsible for impaired language control and for impaired executive functions. However, it should be noted that pathological language switching has never been observed after parietal lesions and most typically results from lesions involving the left caudate-frontal lobe circuitry [9]. Left parietal lesions, on the other hand, mostly explain difficulties switching from one language to another, that is, pathological fixation on one language [32]. Likewise, the dysexecutive syndromes reported result from lesions to the frontal lobes [8]. Hence, although we may not totally rule out the possibility that each single lesion was responsible for different deficits (such as the frontal lesion for impaired executive functions and the parietal lesion for impaired language control or vice versa), it is more parsimonious to assume that the frontal lesion was responsible for both impairments. As to the crucial role of the left caudate-frontal lobe circuitry in language control, evidence provided by Mariën et al. [14] shows remission of language mixing and switching is associated with increased perfusion of left frontal lobe and left caudate nucleus. Interestingly, in their bilingual case, perfusional deficits remained in left temporoparietal areas and the patient continued to display fluent aphasia in L1 and in L2. It is of interest that the lesions in the present case were due to head trauma. MR imaging might not be sensitive to microscopic injury or small areas of molecular and/or physiological damage within brain tissues. Therefore, it is possible that the language and executive function deficits demonstrated by Dr. T were at least in part due to additional lesions not seen on the MR imaging. This limits the implications that can be drawn from the present case study.

Recent studies have speculated on the implications of utilizing the same system, in which bilinguals are more proficient in executive tasks than monolinguals [33]. Dr. T, who showed more prominent (higher-incidence and more frequent) switching in connected speech than confrontation naming, may provide insight into the demands for linguistic and cognitive resources in relation to task processing in multilingual speakers.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Research Article

The Nature of Lexical-Semantic Access in Bilingual Aphasia

Swathi Kiran, Isabel Balachandran, and Jason Lucas

Department of Speech Language and Hearing Sciences, Boston University Sargent College, 635 Commonwealth Avenue, Boston, MA 02215, USA

Correspondence should be addressed to Swathi Kiran; kirans@bu.edu

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Background. Despite a growing clinical need, there are no clear guidelines on assessment of lexical access in the two languages in individuals with bilingual aphasia. *Objective.* In this study, we examined the influence of language proficiency on three tasks requiring lexical access in English and Spanish bilingual normal controls and in bilingual individuals with aphasia. *Methods.* 12 neurologically healthy Spanish-English bilinguals and 10 Spanish-English bilinguals with aphasia participated in the study. All participants completed three lexical retrieval tasks: two picture-naming tasks (BNT, BPNT) and a category generation (CG) task. *Results.* This study found that across all tasks, the greatest predictors for performance were the effect of group and language ability rating (LAR). Bilingual controls had a greater score or produced more correct responses than participants with bilingual aphasia across all tasks. The results of our study also indicate that normal controls and bilinguals with aphasia make similar types of errors in both English and Spanish and develop similar clustering strategies despite significant performance differences between the groups. *Conclusions.* Differences between bilingual patients and controls demonstrate a fundamental lexical retrieval deficit in bilingual individuals with aphasia, but one that is further influenced by language proficiency in the two languages.

1. Introduction

Naming deficits are a commonly acquired disorder, manifesting in all types of aphasia [1, 2]; however, we are still unclear about the nature and mechanisms underlying lexical processing deficits in monolingual and bilingual individuals with aphasia. Theories of normal bilingual language processing indicate variable degrees of overlap between the two languages. For instance, the *revised hierarchical model* (RHM; [3–5]) allows for language proficiency differences by proposing connections between both L1 and L2 and the semantic system; these connections differ in their strengths as a function of fluency in L1 relative to L2. In bilingual individuals with a dominant language, the lexicon of L1 is generally assumed to be larger than that of L2 because more words are known in the dominant language. Also, lexical associations from L2 to L1 are assumed to be stronger than those from L1 to L2. Conversely, the links between the semantic system and L1 are assumed to be stronger than from the semantic system to L2. With regards to activation of phonological representations from the semantic system, the prevailing theory suggests that activation flows from the semantic system to the phonological system of both languages simultaneously, indicating that lexical access is target language-nonspecific [6, 7]. Thus, targets in both languages are potentially active subsequent to semantic activation, but through a process of competitive selection, the target in the accurate language is ultimately produced. An alternate, but not necessarily contradictory hypothesis, is the fact that in order for bilinguals to access the target language, the nontarget language must be inhibited [8–10]. In other words, a speaker activates target language lemmas while simultaneously inhibiting the lemmas of the nontarget language.

There are several methods to examine lexical access in bilingual individuals. The most common approach has been confrontation picture naming. In general, performance on picture naming tasks is constrained by the images presented and influenced by word frequency and imageability. One such picture naming task that has been used extensively as a measure of lexical access in monolinguals and bilinguals is the Boston Naming Test (BNT, [11]). For instance, Kohnert et al.

[12] showed that normal young bilinguals performed better in English than Spanish on the BNT and that naming accuracy significantly correlated with self-ratings of language skills. Similarly, Roberts et al. [13] examined naming on the BNT in French/English and Spanish/English bilinguals and found that both bilingual groups scored significantly below the monolingual English group on the BNT.

Another approach to examining lexical access includes category generation verbal fluency tasks [14–17]. Verbal fluency has been found to be dependent on a multitude of factors, including two qualitative features, clustering and switching ability. These strategic processes are mediated by executive functioning and verbal memory storage and have therefore been a successful predictor of lexical access ability [18, 19]. Performance on the task is highly contingent on the success of the generation of semantically related words in a subcategory, or clustering, which utilizes an individual's language stores. There is also an equally essential component of switching between subordinate categories in the verbal fluency task, which relies on an efficient cognitive flexibility [20–22]. Therefore, simply examining the number of correct words is not sufficient to understand the performance on the task [16].

The nature of semantic organization in the two languages of a bilingual individual affects influences their performance on verbal fluency tasks. For instance, Roberts and Le Dorze [23] examined category generation in French-English participants and found that there was no language effect on the number of correct responses across languages. However, for *animals*, French-English bilinguals recalled more subcategories (*birds, insects, etc.*) in French than English. The authors suggested that some semantic fields may have similar type of semantic organization across languages, whereas others may differ between languages even in balanced bilinguals. The authors suggested that childhood experiences and the cultural environment play an important role in determining the nature of semantic system.

In another set of studies, Rosselli et al. [24] first compared Spanish-English bilinguals with English monolinguals and Spanish monolinguals on word fluency task using either phoneme letter cues or semantic categories. Results showed a lower performance in the bilingual participants compared to their monolingual counterparts on the semantic category cued task but not on the phoneme letter cue task. They indicated that the shared elements of concrete nouns across languages may further the interference between the two languages. There may also be a greater conflict between the languages while the individual is searching through their verbal stores for semantically related words [24]. Interestingly, age of acquisition of L2 did interact with language, bilinguals who learned English earlier in life as L2 performed significantly higher than later learners on English versions of the tests. In a follow-up study, Rosselli et al. [25] examined the use of grammatical words versus content words for phonemic word generation and analyzed the relationship between productivity and semantic association for the responses in category generation. Results for generation of words within phonemic categories were similar to the previous study [24] in which bilinguals produced almost an identical number of words as both English and Spanish monolinguals. There are other studies that have examined verbal fluency as a measure of lexical-semantic access in bilingual individuals in other language combinations (e.g., Zulu/English, [26]; Finnish/English, [27]) and found differences in the degree of performance across the two languages of the bilingual. To summarize, most studies examining category fluency in bilingual individuals have demonstrated that participants tend to produce more items in one language relative to another and to task set (e.g., semantic or phonological cues), but no study has systematically examined the nature of category fluency in bilingual individuals across a set of semantic categories by taking into account language proficiency.

Both lexical access tasks described above, picture naming and verbal fluency, test lexical access but in slightly different ways. In both tasks, the measure of lexical access theoretically involves parallel activation of both languages with highly interactive phonological and semantic representations that spread through the levels of language representation [6]. However, sufficient crucial differences in the theoretical basis between the tasks exist to investigate different properties of lexical access. Performance on picture naming tasks is constrained by the images presented, making nonlinguistic strategies like clustering and switching ineffective. Performance on the picture naming tasks is driven mainly by word frequency and imageability. Also, categories in the category generation task have a certain degree of flexibility with regard to items that belong to a given category which is not present in a picture naming task. On the verbal fluency task, however, nonlinguistic and semantically unrelated phonological strategies are effective means of performing the task. Grouping clusters is dependent on the way semantically related words are organized in the brain. Clustering and switching abilities on the verbal fluency task are dependent on individual language exposure. The relative freedom of the category generation task (to semantically organize the categories) also aids in the performance of the task by facilitating the individual language abilities of the participants.

In contrast to studies on lexical access in nonbrain damaged bilingual individuals, examination of lexical access in bilingual aphasia is relatively sparse and most studies are case studies of individuals with interesting but atypical language impairment profiles [11, 28–33]. In one group study, Tschirren et al. [34] examined the interaction of late age of acquisition (AoA) on L2 syntactic deficits in bilingual aphasia. A total of 12 late bilingual patients with aphasia (six with anterior lesions and six with posterior lesions) were examined. The authors found that, as a group, the L1 and L2 aphasia severity scores did not differ; however, four patients with lesions in the prerolandic area did exhibit lower scores in L2 syntactic processing compared to L1 syntactic processing.

A few studies have specifically examined lexical access in bilingual aphasia. For instance, Roberts and Deslauriers [35] examined the relationship between the mental representation of the two languages and how effectively individuals switched between languages. During naming performance on cognate nouns, the study found that bilingual individuals with aphasia produced cognate nouns with higher accuracy than noncognates in both languages. In another study, Muñoz and Marquardt [36] compared language history and language proficiency self-ratings with poststroke picture naming and identification ability in four Spanish-English patients with bilingual aphasia with 20 neurologically healthy Spanish-English adults who were gender, ethnicity, and age matched and completed the same experiment diagnostics. The bilingual nonbrain damaged individuals showed that more frequent use of the English language is consistent with between-language differences in proficiency and literacy. The four patients fell into three patterns. For two patients differences in naming and identification scores in Spanish and English were correlated with varying degrees of skill between two languages instead of a differential impairment. For a third patient, it was predicted that his performance in English would outperform Spanish based on the language history; however, this trend was not observed and the authors identified a differential impairment. Finally, the fourth patient presented with a language profile that predicted similar impairments across languages; however, the English picture naming task was less impaired than the Spanish whereas the opposite trend in results was observed for the picture identification task. For this patient, the authors speculate that higher English picture naming scores may be attributed to strategies learned in years of English therapy that did not transfer to Spanish. Overall, the experiment results strongly suggest that an in-depth premorbid language history is a vital piece to the evaluation and identification of deficits and language pattern impairments in bilingual aphasia.

These studies highlight the fact that lexical retrieval is influenced by proficiency and the nature of brain damage, but these results are not necessarily generalizable to the larger population of bilingual aphasia. A systematic examination of a larger group of patients on different language tasks while accounting for language proficiency will help better understand the nature of lexical access in individuals with bilingual aphasia and guide better diagnosis and treatment of lexical impairment in these individuals.

The present study examines lexical access in English and Spanish with respect to both premorbid proficiency and the effect of stroke on language ability in ten patients with bilingual aphasia and their nonbrain damaged controls. We compared picture naming on the BNT with a separate normed naming task to examine any differences (or similarities) between these two tasks. While the BNT is used often in the assessment of lexical impairment in individuals with bilingual aphasia, it has clear limitations as a valid measure of lexical access due to the relatively low frequency of certain items in the task [27]. Therefore, in the present study, we directly compared performance on the BNT with another naming task that developed to examine lexical retrieval in bilingual individuals [37, 38] and that has items that are generally frequent in both English and Spanish cultures. Additionally, we compared confrontation naming on these two tasks with category generation across three categories for the reasons described above. In addition to examining accuracy on the confrontation naming task, we also systematically examined the nature of target and nontarget language errors that were produced by patients and controls. Likewise, in addition to examining the number of correct words generated on the category generation task, we also examined strategies in verbal fluency including semantic clusters and switches between subclusters across three semantic categories.

In addition to comparing the three lexical access tasks across two languages (English, Spanish), the main goal of this paper was to examine the effect of language proficiency on differences in bilingual lexical access in normal bilingual controls as well as in individuals with bilingual aphasia. To this end, we obtained detailed measures of language background, use, and proficiency in both bilingual controls and in patients with bilingual aphasia. We predicted that bilingual controls would outperform the patients on all three measures of lexical access, but both groups would demonstrate a variance in the nature of strategies employed in lexical retrieval. As such, we expected bilingual controls to produce different semantic clusters and switches and fewer semantic errors compared to bilingual individuals with aphasia. In addition, we predicted language proficiency measures such as language exposure, self-rating of language proficiency, and other parameters to positively correlate with the extent to which participants successfully retrieved words in the two languages.

2. Methods

2.1. Participants. Twelve Spanish-English bilingual nonbrain damaged individuals between the ages of 18 and 70 (mean age = 34.92 years, standard deviation = 18.89, see Table 1 for a complete description of demographic information). Control subjects were paid $10 each for their participation. Ten Spanish/English bilingual speakers with aphasia participated in the study (see Table 2 for a complete description of demographic information). All participants experienced a single, unilateral cerebral vascular event (CVA, or stroke) in the distribution of the left middle cerebral artery at least 6 months prior to initiation of the experiment with the exception of BA04 who experienced a gunshot wound in the left hemisphere. Participants with apraxia were excluded from the study because the motor complexity can impact oral naming, which was the main task in the study.

2.1.1. Assessment of Language Proficiency Levels. All participants received extensive background language assessments and a comprehensive LUQ [39]. This questionnaire obtained information about the period of *age of language acquisition* (AoA). Next, participants were required to *self-rate their proficiency* (prestroke for bilinguals with aphasia) in each language in terms of their ability to speak and understand the language in formal and informal situations and read and write in each language. Again, an average proportion score in each language reflected participants' perception of their own *language ability rating* (LAR). Additionally, a proportion of language exposure in hearing, speaking, and reading domains during the entire lifetime for each individual was obtained. A weighted average of the proportion of language exposure in the three domains was obtained for each language; for the participants, this information primarily reflected their prestroke *lifetime language exposure*.

Table 1: Demographic information for bilingual normal controls.

Control	Age	Sex	AoA		Lifetime exposure %		Confidence %		Current exposure %		Family proficiency %		Education history %		Language ability rating %	
			Eng.	Sp.	Eng.	Sp.	Eng.	Sp.	Eng.	Sp.	Eng.	Sp.	Eng.	Sp.	Eng.	Sp.
BC01	18	F	5	0	40.83	59.17	48.33	75.83	79.35	20.65	58.33	91.67	55.56	44.44	97.14	85.71
BC02	19	F	8	0	53.89	46.11	87.50	98.61	93.33	6.67	58.33	91.67	61.11	38.89	100.00	91.43
BC03	21	F	0	9	82.94	17.06	100.00	31.25	58.14	41.86	100.00	33.33	72.22	27.78	100.00	91.43
BC05	42	M	0	0	54.63	45.37	88.10	100.00	75.21	24.79	91.67	91.67	11.11	88.89	100.00	100.00
BC06	20	F	2	0	57.34	42.66	88.33	89.44	63.79	36.21	75.00	100.00	72.22	27.78	100.00	100.00
BC07	60	M	30	0	45.13	54.87	55.00	100.00	88.95	11.05	8.33	100.00	33.33	66.67	62.86	100.00
BC08	20	M	0	0	38.10	61.90	95.56	95.56	50.00	50.00	91.67	100.00	50.00	50.00	80.00	100.00
BC09	20	F	3	0	50.00	50.00	86.94	85.56	57.50	42.50	37.50	100.00	72.22	27.78	100.00	94.29
BC10	58	F	48	0	20.46	79.20	24.14	75.86	45.58	54.42	0.00	100.00	0.00	100.00	48.57	100.00
BC11	34	F	14	0	88.07	11.93	100.00	40.63	91.07	8.93	100.00	0.00	100.00	0.00	100.00	71.43
BC12	62	M	12	0	42.47	57.53	61.54	100.00	82.77	17.23	50.00	100.00	16.67	83.33	94.29	100.00
BC14	61	F	10	0	43.90	56.10	37.91	100.00	40.91	59.09	0.00	100.00	25.00	75.00	45.71	100.00

Note: AoA: Age of acquisition, Eng.: English, Sp.: Spanish.

Table 2: Demographic information for bilingual individuals with aphasia.

Patient	Age	Sex	AoA		Lifetime exposure %		Confidence %		Current exposure %		Family proficiency %		Education history %		Language ability rating %	
			Eng.	Sp.	Eng.	Sp.	Eng.	Sp.	Eng.	Sp.	Eng.	Sp.	Eng.	Sp.	Eng.	Sp.
BA01	43	M	19	0	28.00	72.00	42.00	94.00	22.00	78.00	33.00	100.00	0.00	100.00	89.00	89.00
BA04	36	M	0	0	74.00	26.00	81.00	100.00	66.00	34.00	67.00	100.00	100.00	0.00	100.00	89.00
BA07	65	F	45	0	10.00	90.00	5.00	100.00	2.00	98.00	0.00	100.00	0.00	100.00	32.00	100.00
BA10	76	M	40	0	4.00	96.00	15.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00	47.00	100.00
BA17	53	M	6	0	66.00	34.00	96.00	98.00	55.00	45.00	75.00	100.00	58.00	42.00	100.00	100.00
BA18	73	F	17	0	40.00	60.00	80.00	100.00	0.00	100.00	58.00	100.00	25.00	75.00	100.00	100.00
BA19	75	M	27	0	16.00	84.00	13.00	76.00	15.00	85.00	0.00	100.00	0.00	100.00	20.00	100.00
BA21	88	F	5	0	72.00	28.00	100.00	100.00	99.00	1.00	100.00	100.00	100.00	0.00	31.00	23.00
BA22	42	M	18	0	10.00	90.00	11.00	92.00	38.00	63.00	17.00	100.00	0.00	100.00	34.00	94.00
BA23	42	F	9	0	33.00	67.00	42.00	100.00	29.00	71.00	33.00	100.00	22.00	78.00	66.00	94.00

Note: AoA: Age of acquisition, Eng: English, Sp: Spanish.

Table 3: Average scores for bilinguals with aphasia and bilingual normal controls on BAT-Comprehension, BAT-Semantics, BNT, and BPNT in English and Spanish. Scores for bilingual normal controls are provided for BNT and BPNT (standard deviations are in parenthesis).

Group	BAT Comp %		BAT Sem %		Boston naming test %		Bilingual picture naming task %	
	English	Spanish	English	Spanish	English	Spanish	English	Spanish
Controls					75.00 (21.66)	61.81 (15.33)	85.52 (19.45)	80.73 (12.41)
Patients	47.96 (28.33)	69.26 (20.72)	45.71 (14.90)	51.67 (13.54)	18.83 (22.91)	24.51 (19.44)	34.73 (34.72)	46.05 (29.95)

A similar set of questions obtained a proportion of confidence in hearing, speaking, and reading domains during the entire lifetime for each individual. A weighted average of the proportion of confidence in language use in the three domains was obtained for each language; for the participants, this piece of information primarily reflected their prestroke *language confidence use*. Participants estimated the time spent conversing in each language hour by hour during a typical weekday and typical weekend. A weighted average of this score reflected the proportion of language use in the two languages; for the participants with aphasia this piece of information reflected their *current (poststroke) language* use. Participants were also asked to rate their *family proficiency* (estimates of parent/sibling proficiency) in each of the two languages. Finally, participants also filled out a detailed *educational history* form in which they were asked to provide the language of instruction and the predominant language used during educational interactions.

2.1.2. Assessment of Language Impairment for Participants with Aphasia. Because there is inadequate evidence to guide *a priori* hypotheses about lexical-semantic impairments, no explicit criteria other than the ability to perform the experimental task were set for inclusion in the experiment. The three pictures subtest of *Pyramids and Palm Trees (PAPT)* [20], the *Bilingual Aphasia Test (BAT)* [40], and the *Boston Naming Test* [12, 41] were administered in both languages (English/Spanish) on separate days by separate examiners (see Table 3 for score information). The BNT was administered in its entirety (all sixty items) according to the protocol including the guidelines for basal and ceiling scoring as indicated in the manual. Scoring for the Spanish items was done according to the procedures reviewed by Kohnert et al. [12]. With the exception of the BNT which was analyzed further for differences, results from the remaining tests are reported as patient demographic information to provide additional information about the nature of language impairment.

2.2. Materials. In addition to the BNT, a second picture naming task that included primarily high frequency concrete nouns obtained from specific categories (Bilingual Picture Naming Task, BPNT) was administered. Stimuli for this task were chosen from our previous work that included a corpus of 200 words that varied across semantic categories [37, 38]. In both language pairs, cognates (e.g., *elephant* and *elefante*) and words with at least 50% phonetic similarity (e.g., *cat* and *gato*) were eliminated from the set. The picture stimuli were chosen from Art Explosion Software (NOVA Inc.) and modified to approximately 4×6 inches. The picture naming task consisted of 108 pictures. Stimuli were presented in language blocks with the order of stimuli pseudorandomized within each block to ensure that items from the same category were not presented sequentially. Prior to presentation of stimuli in each language, the bilingual clinician verbally conversed with the participant for a minimum of five minutes (i.e., general everyday conversation) to ensure that participants were aware of the target language and to facilitate lexical access of the target language.

All participants were also administered a Category Generation (CG) task as a measure of verbal fluency. Three categories were selected: *animals, clothing*, and *food* in English and Spanish. Participants were asked to produce as many semantically related words in two minutes in each of the assigned categories. Again, the order of presentation of languages and categories for the task was counterbalanced across sessions for each participant.

2.3. Data Scoring

2.3.1. Picture Naming Scoring. For both naming tests, bilingual controls were shown the target stimuli and given up to thirty seconds to generate a response. Responses were counted as correct if they matched the target response. All other responses were coded on a 20-point error scale that included the following error codes: no response; neologism; perseveration; unrelated word; circumlocution; semantic error; mixed error; phonemic error; correct in nontarget language; accent influence in target language (see Table 6 for descriptions and examples). Target language indicates the language in which testing was taking place at the time. Nontarget language denotes responses that were given in the language not being tested.

The same scoring procedure was used for patients and controls, with minor differences made to compensate for the participants' deficits. In particular, responses were counted as correct if they matched the target response, or contained one phonemic substitution, omission, or addition to the target response; however, for controls, responses had to be accurate productions of the target. Additionally, participants with aphasia were given up to one minute to generate a response to the stimuli pictures.

2.3.2. Category Generation Scoring. For the CG task, the responses of all participants were transcribed and tabulated. This was performed separately for each category and each language. Three measures were obtained from this data: (a) the total number words produced, (b) total correct words produced, (c) mean semantic cluster size, and (d) mean semantic switching in each subcategory for each language, Spanish and English [22, 34]. Outlined below is the scoring procedure for the four categories analyzed.

(a) Total Words. The number of responses, either intelligible or unintelligible, was calculated for each category and language.

(b) Total Correct Words. The accuracy of the words produced in the task was determined through a 20-point error analysis procedure outlined in Table 6. Only intelligible and appropriate words for each category and language were deemed correct. Incorrect responses and any cross linguistic errors, perseverations, two or more repetitions of the same item, were considered as incorrect items.

(c) Mean Semantic Cluster Score. In order to calculate clusters produced within each category, several constraints were utilized based on previously published work. For the category of *animals*, the method of analysis was taken directly from Tschirren et al. [34]. The coding system for *clothing* was guided by work done by Rosselli et al. [25]. A coding system for *food items* was developed by applying the methods stated in [21]. The average of all of the semantic clusters in one category and one language was then determined for each subject to produce a final score. (The individual categories are listed in Appendix A.)

(d) Mean Semantic Switching Score. The scoring for the mean semantic cluster score was consistent between each category and each language [34]. This score was calculated as the total amount of changes between clusters (Appendix A).

We did not collect formal measures of reliability. The transcription of oral responses was completed by the testing clinician and the error coding was performed by a research assistant who checked all transcribed responses against the targets prior to coding the errors.

3. Results

3.1. Analysis of Language History and Proficiency. Tables 1 and 2 reveal that there were differences between the two groups in terms of language history and proficiency. Simple factorial ANOVAs were performed on the various variables (e.g., language ability rating, lifetime language exposure) with group (patient, control) and language (English, Spanish) as independent variables. Results showed a significant main effect of group ($F(1, 42) = 6.9$, $P < 0.01$) and language ($F(1, 42) = 4.3$, $P < 0.05$) indicating that language ability ratings were generally higher for the controls relative to the patients ($P < 0.05$) and in Spanish relative to English ($P < 0.05$). For lifetime language exposure, a significant interaction effect of group and language was observed ($F(1, 42) = 6.8$, $P < 0.01$) indicating that lifetime exposure in Spanish was higher than English for patients ($P < 0.01$) but no significant differences were observed for controls. Similarly, for current language use, a significant interaction of group and language was observed ($F(1, 42) = 25.7$, $P < 0.0001$) indicating that current language use was higher in English than in Spanish ($P < 0.01$) for controls, whereas current language use was higher in Spanish than in English ($P < 0.001$) for patients. Interestingly, current use of Spanish in the patients was higher than controls ($P < 0.01$). Analysis of language confidence revealed a significant effect of language ($F(1, 42) = 5.7$, $P < 0.02$) with the overall confidence in Spanish being higher than in English. Analysis of family proficiency revealed significant main effects of language ($F(1, 42) = 19.5$, $P < 0.0001$) and interaction effects of group and language ($F(1, 42) = 4.8$, $P < 0.03$) essentially indicating higher family proficiency in Spanish relative to English in patients ($P < 0.0001$), however, the differences were not significant for controls. Analysis on education history was not significant for patients or controls. In summary, these results indicate that both groups demonstrated greater language history and proficiency in Spanish than in English, with the difference between the two languages being larger for the patient group than the control group. Notably, controls demonstrated an interesting split between language history (where values were generally higher in Spanish than English) and current language use (where current use was higher in English than in Spanish).

3.2. Picture Naming. Separate regression analyses were used to analyze the dependent variables (performance on the BNT and BPNT) to investigate the factors most responsible for the performance of the groups. The categorical predictors were group (patient, controls) and language (English, Spanish), and the continuous predictors were the variables of the LUQ: LAR, Confidence, Lifetime Exposure, Current Exposure, Family Proficiency, and Education History. For BNT, the overall regression equation was significant ($R^2 = 0.834$, $F(1, 38) = 21.14$, $P < 0.00001$). The significant predictors were group ($\beta = 0.68$, $t(38) = 9.31$, $P < 0.0001$), LAR ($\beta = 0.29$, $t(38) = 3.01$, $P < 0.001$) and language ($\beta = 0.25$, $t(38) = 2.74$, $P < 0.01$). For the *BPNT*, which was also significant ($R^2 = 0.765$, $F(1, 36) = 13.03$, $P < 0.0001$) significant predictors of performance were group ($\beta = 0.52$, $t(34) = 5.91$, $P < 0.0001$) and LAR ($\beta = 0.46$, $t(34) = 4.00$, $P < 0.001$).

Since the regression equations revealed group and at least one aspect of language proficiency to be major predictors for both the BNT and BPNT, the data for the patients and bilingual controls were separated andanalyzed to examine if differences in language performance was observed once language proficiency measures were controlled within each participant group. Also, since the regression analysis for both picture naming tasks revealed LAR as the only significant LUQ predictor, only this variable was entered into a subsequent ANCOVA analysis, with language as the independent variable. For the BNT, there was a significant effect of language even after controlling for LAR ($F(1, 21) = 16.68$, $P < 0.001$). Post hoc tests indicated that naming accuracy on the BNT was higher in English than Spanish ($P < 0.005$). For the BPNT, there was also a significant effect of language after controlling for LAR ($F(1, 21) = 8.87$, $P < 0.05$). However, the post hoc analysis was not significant ($P > 0.20$) with trends indicating that naming performance in English was slightly

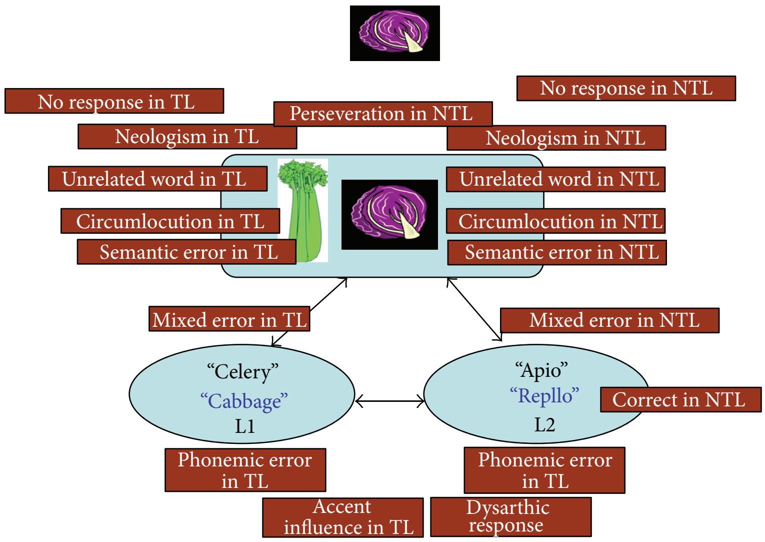

FIGURE 1: Schematic explaining the hypothesized locus of naming errors that is based on a two-step model of naming that includes semantic access and phonological access in the two languages. All error types may occur in the target language (TL) or nontarget language (NTL). No responses, perseverations, and neologisms are presumed to occur prior to semantic access of the target lemma. Unrelated word, circumlocutions, and semantic errors may occur due to varying degrees of incomplete access at the semantic representation level. Mixed errors (combinations of semantic and phonological errors) may occur due to impaired connections between semantic and language specific phonological levels. Phonemic errors, accent influences, and dysarthric responses are all presumed to occur after language specific phonological access has occurred. Cross-language translations are coded as correct responses in the nontarget language.

higher than in Spanish. Results for the bilinguals with aphasia were not significant on the ANCOVA analysis for either BNT or BPNT.

3.3. Error Analysis. Responses on the BPNT were further analyzed for the nature of errors produced (providing stimulus cues during BNT makes it difficult to interpret the nature of semantic errors on the task) and interpreted within a framework of lexical access (see Figure 1). Analysis of responses for the BPNT showed that despite the significant differences in accuracy and distribution of error types, no significant differences were observed between bilingual controls and participants with aphasia on English error types ($t(20) = 0.32$; $P = 0.06$). As seen in Figure 2, bilingual controls performed with 84.3% accuracy on English targets. Error types greater than 1% were (a) Circumlocution in target language (4.9%), (b) Semantic error in target language (4.9%), (c) No response/idk in target language (3.8%), and (d) Correct in nontarget language (1.3%). The remaining error types were produced either less than 1% of the time or were not produced at all by bilingual controls in English. Participants with aphasia produced a greater variety of error types, evidenced by their average accuracy of 27.5% in English. The main error types were No response/idk in target language (30%), Correct in nontarget language (9.4%), Circumlocution in nontarget language (10.9%), Neologism in target language (4.8%), Semantic error in target language (3.9%), Neologism in nontarget language (2.4%), Semantic error in nontarget language (2.4%), Unrelated word in nontarget language (2.1%), Unrelated word in target language (1.7%), and Circumlocution in target language (1.1%).

The Spanish data in Figure 2 show even greater similarity between the bilingual controls and participants with aphasia in terms of types of errors produced than the English data ($t(20) = 0.33$, $P = 0.20$). Bilingual controls performed with 79.5% accuracy. Error types greater than 1% included (a) No response/idk in target language (9.3%), (b) Semantic error in target language (6.2%), (c) Circumlocution in target language (2.1%), and (d) Correct in nontarget language (1.07%). Other error types were produced either below 1% or not produced at all by this group. Participants with aphasia performed with 38.1% accuracy in Spanish. The main error types were No response/idk in target language (27%), Circumlocution in target language (17%), Semantic error in target language (9.2%), Neologism in target language (7.8%), Unrelated word in target language (1.5%), and Correct in nontarget language (1.3%).

3.4. Category Generation Task. As in the picture naming tasks, a regression analysis was performed on the number of correct words (across the three categories), mean semantic cluster scores, and mean semantic switching scores on the CG task, the categorical predictors were group (patient, bilingual controls) and language (English, Spanish), and the continuous predictors were the variables of the LUQ: LAR, Confidence, Lifetime Exposure, Current Exposure, Family Proficiency, and Education History.

(a) Correct Words. A regression analysis for total correct words was significant ($R^2 = 0.922$, $F(1, 36) = 22.58$, $P = 0.00$), the strongest predictor on the task was group ($\beta = 0.764$, $t(36) = 10.56$, $P = 0.00$), followed by language of the task ($\beta = 0.273$, $t(36) = 3.09$, $P < 0.001$). Thus, controls

Table 4: Mean correct words on the category generation task, mean semantic cluster scores, and mean semantic switching scores for bilingual normal controls and bilinguals with aphasia (standard deviations are in parenthesis).

Group	Correct words		Mean semantic cluster score		Mean semantic switching score		Mean ratio of correct words to semantic switches	
	English	Spanish	English	Spanish	English	Spanish	English	Spanish
Controls	29.70 (9.10)	24.36 (6.18)	2.07 (0.86)	1.47 (0.50)	8.94 (2.53)	9.75 (2.89)	3.36 (0.81)	2.55 (0.41)
Patients	4.60 (5.90)	5.87 (4.24)	0.36 (0.41)	0.41 (0.36)	5.10 (3.84)	3.93 (2.54)	1.06 (0.84)	1.58 (0.65)

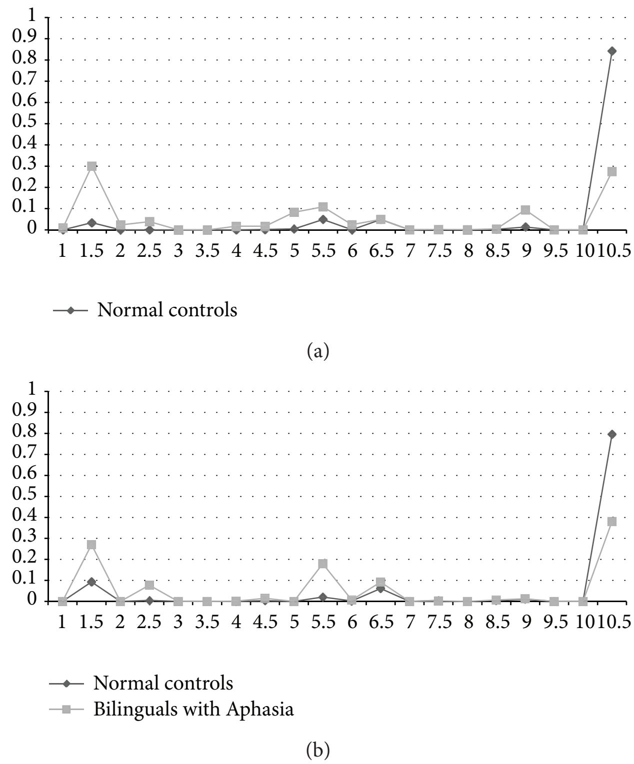

Figure 2: (a) Comparison between accurate production and errors on BPNT for normal controls and bilinguals with aphasia on English targets. (b) Comparison between accurate production and errors on BPNT for normal controls and participants with aphasia on Spanish targets. Correct responses are scored 10.5 (Correct responses in TL). The greatest errors made being No response/idk in TL (1.5), Circumlocution in TL (5.5), Correct response in NTL (9). Error Percentages Spanish (across patients): (1) No response/idk NTL. (1.5) No response/idk TL. (2) Neologism in NTL. (2.5) Neologism in TL. (3) Perseveration to a nonprobe. (3.5) Perseveration to a probe in session. (4) Unrelated word in NTL. (4.5) Unrelated word in TL. (5) Circumlocution in NTL. (5.5) Circumlocution in TL. (6) Semantic error in NTL. (6.5) Semantic error in TL. (7) Mixed error in NTL. (7.5) Mixed error in TL. (8) Phonemic error in NTL. (8.5) Phonemic error in TL. (9) Correct in NTL. (9.5) Dysarthric/apractic intelligible response. (10) Accent Influence in TL. (10.5) Correct in TL.

produced more words than patients, and words generated in English were higher than in Spanish ($P < 0.05$). Also, of the variables assessed with the LUQ, LAR was the only significant predictor ($\beta = 0.226$, $t(36) = 2.65$, $P < 0.01$).

(b) Mean Semantic Cluster Score. The regression analysis for the mean semantic cluster scores was significant ($R^2 = 0.753$, $F(1,36) = 12.89$, $P < 0.0001$), and the strongest predictor of performance on the task was group ($\beta = 0.677$, $t(36) = 5.30$, $P < 0.0001$). Bilingual controls performed significantly higher semantic clusters in both English and Spanish ($P < 0.05$). The only other significant predictor of performance was once again LAR of the LUQ ($\beta = 0.222$, $t(36) = 2.06$, $P < 0.05$).

(c) Mean Semantic Switching Score. The regression analysis for mean semantic switching score for the normal subjects or participants with aphasia did not reveal any significant influence of the LAR on the categorical measures or differences between the measures. Table 4, however, showed differences between controls and patients, which was confirmed in individual t-tests; bilingual controls had a higher semantic switching score in English ($t(20) = 2.8$, $P = 0.01$) and Spanish ($t(20) = 4.96$, $P < 0.001$) than their patient counterparts.

To further understand patterns of lexical-access within each of the participant groups, data were separated and analyzed. Three ANCOVAs (with LAR as the covariate) were performed for each group for each of the dependent variable (total correct words, mean semantic cluster scores, and mean semantic switching scores).

(a) Correct Words. An ANCOVA for the bilingual control data revealed that LAR did in fact influence the effect of language and category on the correct words. Firstly, there was a significant main effect of language ($F(1,71) = 32.8$, $P < 0.000001$) and a main effect of category ($F(2,71) = 11.8$, $P < 0.00005$) after controlling for the LAR. Post hoc tests indicated that, for language, the total correct words were significantly greater in English than Spanish ($P < 0.0001$). For category, the total correct words for *food* items differed significantly from the *clothing* items ($P < 0.00005$) and the total correct words for *animals* differed significantly from *clothing* ($P < 0.05$). The ANCOVA was not significant for the participants with aphasia (Figure 3).

(b) Mean Semantic Cluster Score. A significant main effect of language was seen on the mean semantic cluster score on the ANCOVA ($F(1,71) = 10.2$, $P < 0.005$) and the main effect of category was also significant ($F(2,71) = 3.32$, $P < 0.05$). The post hoc tests for the mean semantic cluster score analysis revealed that, for language, the mean semantic cluster scores in English were significantly more than Spanish ($P < 0.01$). Additionally, for the categories, the mean semantic

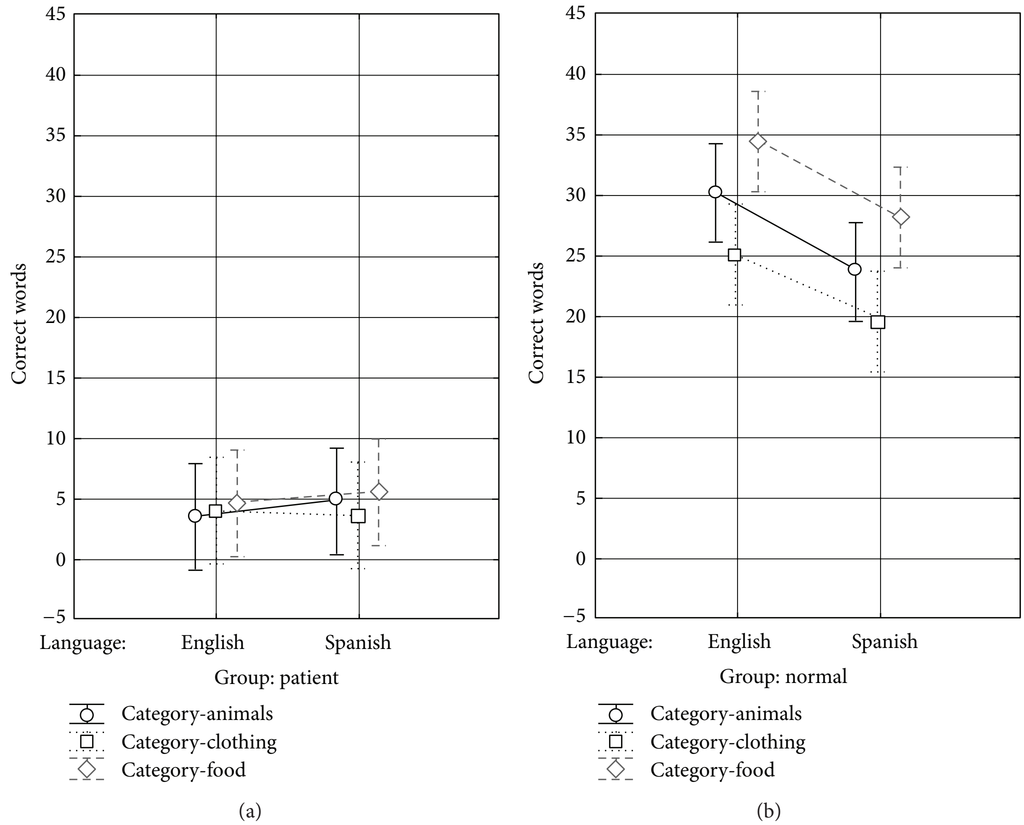

Figure 3: Mean number of correct words for the category generation task for (a) patients with aphasia and (b) normal controls in English and Spanish for three categories: animals, clothing, and food.

cluster scores for the *food* items were significantly higher than for the *clothing* items ($P < 0.05$). The categories of *food* items and *animals* did not show any significant difference. The ANCOVA for participants with aphasia data was not significant.

(c) Mean Semantic Switching Score. The final ANCOVA analysis on the mean semantic switching score for the normal controls or participants with aphasia did not reveal any significant influence of the LAR on the categorical measures or differences between the measures.

3.5. Individual Patient Analysis. Because the parametric statistical analysis for the patients was mostly nonsignificant, a more qualitative inspection of the data was carried out. As is evident in Figures 4 and 5 the results of the participants with aphasia showed more variation than did those of the normal controls on all three tasks (BNT, BPNT, and CG task). Individual inspection of the participant data showed that participants BA04 and BA17 produced more correct responses in English than Spanish across the three tasks. On the other hand, participants BA07, BA10, BA19, BA22, and BA23 produced more correct responses in Spanish than English in all three tasks. Two patients, BA01 and BA18, received scores that were remarkably similar in both languages, while participant BA21 produced either no correct responses or performed with very low accuracy in both languages, for all tasks. With regards to the nature of category-specific access on the category generation task, the broad variety of responses and scores were independent of category; however, it was clear that the categories *Animals* and *Food* were easier to access than *Clothing* for most patients, a finding that was similar to the control data. Also, only two of the ten patients showed language differences in their semantic clustering ability, with BA17 producing more clusters in English and BA10 producing more clusters in Spanish. Likewise, only a few patients (BA04, BA17, and BA22) showed language-specific differences in their semantic switching scores, while other patients demonstrated similar switching patterns in English and Spanish.

3.6. Across Task Correlations. Recall that, in the introduction, we argued that the three word retrieval tasks assessed similar aspects of lexical access, but the nature of the tasks placed slightly different demands on lexical access. In the final analysis, we systematically correlated the three tasks administered with the only significant continuous predictor in the regression analysis, LAR to examine to what extent these measures actually correlated with each other. Bilingual controls and bilingual individuals with aphasia were separated for this analysis again to prevent group-driven effects in the results. The bivariate correlation analysis revealed for the bilingual controls, significant ($P < 0.05$) correlations emerged between

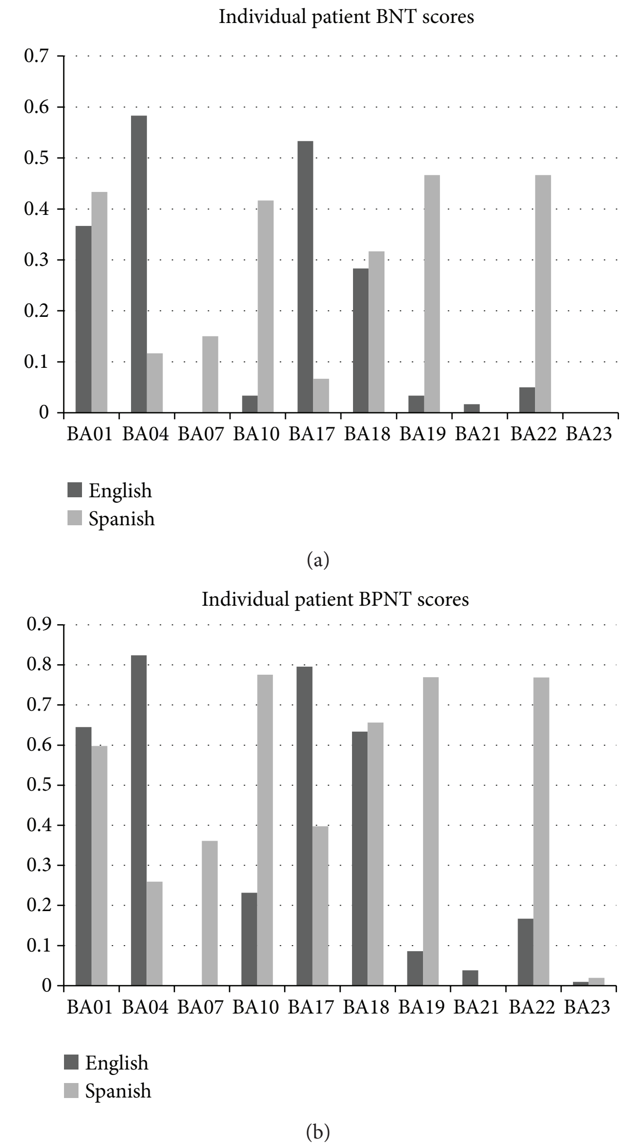

Figure 4: Individual patient accuracy on the two naming tasks: BNT (a) and BPNT (b) in English and Spanish.

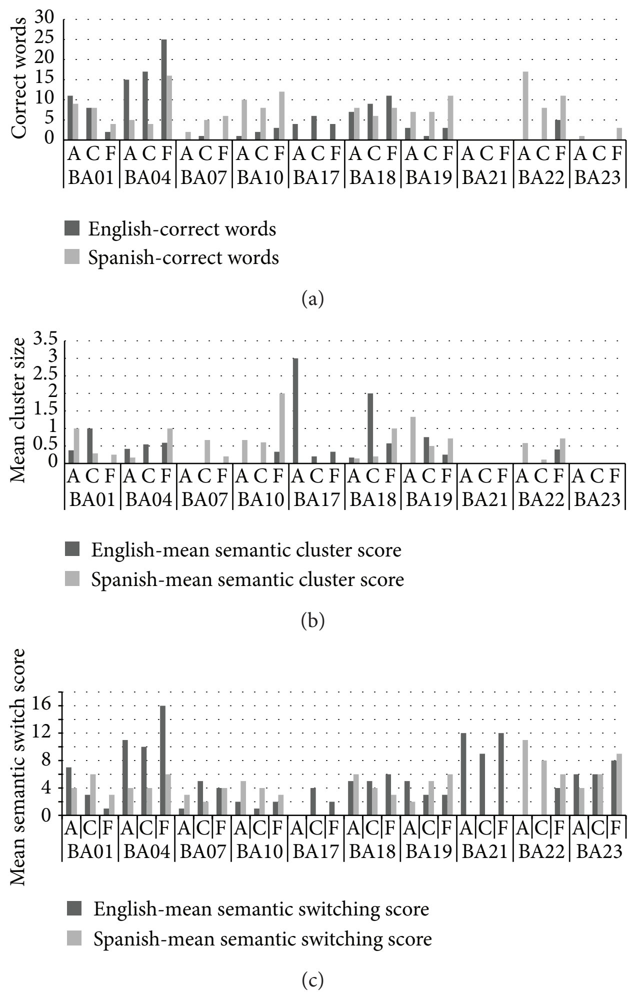

Figure 5: Results of category generation task for individual patients across three categories Animals (A), Food (F), and Clothing (C) in English and Spanish. (a) Correct Word Scores for the Category Generation Task in English and Spanish across each participant in the categories, (b) Mean Semantic Cluster Scores, and (c) Mean Semantic Switching Scores. Comparing each participant in their correct responses provided in English and Spanish exemplifies their dominant languages and individual differences.

LAR and correct words generated, LAR and BNT, and LAR and BPNT in English (see Table 5). Additionally, significant correlations were observed between BPNT and BNT, and correct words generated and BPNT (and BNT) responses. In Spanish, significant ($P < 0.05$) correlations emerged between correct words generated and BNT, BNT and BPNT, LAR and BNT, and LAR and BPNT. For bilingual individuals with aphasia, in English significant ($P < 0.05$) correlations emerged between correct words and BPNT, LAR, and correct words, LAR, and BNT, and LAR and BPNT. In Spanish, significant ($P < 0.05$) correlations emerged only between correct words generated and BPNT.

4. Discussion

The present study examined the nature of lexical-access in normal bilinguals and in participants with bilingual aphasia across three different lexical-semantic access tasks (BNT picture naming, BNPT picture naming, and verbal fluency). Results are discussed in the context of the goals proposed in the study.

4.1. Comparison of the Three Lexical Retrieval Tasks. The results from the three lexical retrieval tasks revealed several similarities and some important differences. Notably, the results from the two confrontation naming tests, the BNT and BPNT, were somewhat different regarding the factors that drove performance for each test. For the BPNT, Group, LAR, Confidence, and Family Proficiency were significant determiners of performance. However, for the BNT, only Group, LAR, and Language were significant determiners of performance.

Table 5: Pearson correlations of BNT, BPNT, correct words on the category generation task, and LAR administered for bilingual controls and individuals with aphasia. Correlations significant at $P < 0.05$ are highlighted with an asterisk.

Group	Variable	Correct Words-E	Correct Words-S	LAR-E	LAR-S	BPNT-E	BPNT-S	BNT-E	BNT-S
Bilingual controls	Correct Words-E	1	0.277	0.892*	−0.506	0.769*	−0.385	0.818*	−0.211
	Correct Words-S		1	0.270	0.382	−0.137	0.555	−0.003	0.612*
	LAR-E			1	−0.440	0.737*	−0.207	0.787*	−0.147
	LAR-S				1	−0.337	0.846*	−0.364	0.820*
	BPNT-E					1	−0.311	0.961*	−0.118
	BPNT-S						1	−0.281	0.855*
	BNT-E							1	−0.097
	BNT-S								1
Bilingual individuals with aphasia	Correct Words-E	1	0.286	0.707*	−0.151	0.799*	0.027	0.045	−0.229
	Correct Words-S		1	0.013	0.347	0.051	0.796*	−0.386	0.254
	LAR-E			1	0.310	0.878*	0.049	0.636*	−0.183
	LAR-S				1	0.058	0.625	0.325	0.494
	BPNT-E					1	0.132	0.490	−0.428
	BPNT-S						1	−0.070	0.186
	BNT-E							1	−0.122
	BNT-S								1

As previously mentioned, the BPNT included two sets of high frequency words in English and Spanish. Many of the items on the BNT, however, are low frequency words in spontaneous speech (e.g., *abacus*) and are not translated particularly well in Spanish. Indeed previous studies that have examined BNT in Spanish and English in normal bilinguals have described lower performance accuracy [13] in Spanish. After comparing two groups of bilingual adults (Spanish/English and French/English) and monolingual English adults on the BNT, it was determined that, for both bilingual groups, mean test scores were significantly below the monolingual group while not significantly differing from each other. The study suggests variability between each bilingual group and individual participants, with less significance derived from background influences. Consequently, one would expect performance in the dominant language in bilinguals to be far greater than performance in the nondominant language for the BNT, while differences between the two languages on the BPNT would be less great due to the high frequency of the items in both languages, which was one of the findings of the study.

With respect to the category generation task, results indicated that the ability to semantically cluster, switch, and efficiently produce correct words in the task was influenced by Group, Language, and LAR. Previous studies assessing the performance of bilingual Spanish/English and monolingual English and Spanish speakers additionally demonstrated a significantly greater performance of bilingual participants in verbal fluency tasks depending on the age of acquisition and level of bilingualism without, however, an effect of language [23, 25]. Differences may have arisen between the above two studies and the data presented here based on the geographic sampling of patients and level of balanced bilingualism found within our groups (see further on individual patient analysis). What our results indicate is that, across the three tasks, when language proficiency self-rating was controlled for, at least for the controls, performance in English was higher than performance in Spanish. These results are underscored by the fairly robust correlations between the three lexical retrieval tasks and their overall correlation with LAR.

4.2. Performance Differences between Languages. Overall, the data revealed that the normal controls were more accurate in English than in Spanish on the BNT, BPNT, and both correct words and mean semantic cluster scores on the category generation task, even when language proficiency was taken into account. In contrast, for aphasic participants, there was no significant effect across languages. This observation is interesting against the comparison of the analyses of language use and background for both groups. While both groups demonstrated greater language exposure and proficiency in Spanish than in English, the difference between the two languages was larger for the patient group than the control group. Notably, controls demonstrated an interesting split between language history (where values were generally higher in Spanish than English) and current language use (where current use was higher in English than in Spanish). Since the current lexical retrieval tasks tap into real-time lexical access, perhaps current language use may be reflective of the degree of lexical access. For patients, the overall group analysis were not significant; however, individual analyses showed that there were more patients with higher performance in Spanish than in English.

Results from the three categories, *animals*, *food*, and *clothing* on the category generation task revealed that the differences between *food* and *clothing* items for the total

Table 6: Description of error types and examples of errors produced in English and Spanish.

Error	Description	Example	
		English target	Spanish target
No response in nontarget language (1)	No response or response of "I don't know" in the language not being tested	Target: cabbage Response: No me recuerdo	Target: lechuga Response: I don't remember
No response in target language (1.5)	No response/response of "I don't know" in the language in session being tested	Target: glove Response: I don't know	Target: media Response: No sé
Neologism in nontarget language (2)	Unrecognized word in any dialect of the language not being tested after correcting for possible phonemic errors	Target: Counter Response: clov	Target: tiburón Response: babberi
Neologism in target language (2.5)	Unrecognized word in any dialect of the language being tested after correcting for possible phonemic errors	Target: shelf Response: crademan	Target: rastrillo Response: serame
Perseveration to a nonprobe (3)	Repetition at least three times of a neologism or word unrelated to the target and not previously presented to the subject	Target: arm Response: go go	Target: brazo Response: go go
Perseveration to a probe in session (3.5)	Repetition at least three times (in any language) of a word previously presented to the subject but unrelated to the target	Target: necklace Response: baseball (if generated at least twice before)	Target: brazo Response: ring ring (if generated at least twice before)
Unrelated word in nontarget language (4)	Word semantically and phonologically unrelated to the target word in the language not being tested	Target: counter Response: perro	Target: puerta Response: berry
Unrelated word in target language (4.5)	Word semantically and phonologically unrelated to the target word in the language being tested	Target: hook Response: coach	Target: jarra Response: ardilla
Circumlocution in nontarget language (5)	Utterance (description) providing semantic information about the target in the language not being tested	Target: hamburger Response: algo que se come	Target: oso Response: an animal
Circumlocution in target language (5.5)	Utterance (description) providing semantic information about the target in the language being tested	Target: building Response: a structure	Target: perica Response: un para hombre
Semantic error in nontarget language (6)	Semantic substitution/paraphasia in the language not being tested	Target: mop Respose: rastrillo	Target: anillo Response: diamond
Semantic error in target language (6.5)	Semantic substitution/paraphasia in the language being tested	Target: pitcher Response: coffee pot	Target: brazo Response: mano
Mixed error in nontarget language (7)	Combination of two or more errors from analysis criteria in the language not being tested	Target: sword Response: fecha	Target: mapache Response: racooco
Mixed error in target language (7.5)	Combination of two or more errors from analysis criteria in the language being tested	Target: leg Response: musolos	Target: hormiga Response: arinas
Phonemic error in nontarget language (8)	Greater than one phonemic substitution or omission in the language not being tested	Target: robe Response: bete	Target: edificio Response: build
Phonemic error in target language (8.5)	Greater than one phonemic substitution or omission in the language being tested	Target: celery Response: cerelec	Target: aspiradora Response: astirador
Correct in nontarget language (9)	Correct response (including single phoneme substitutions) in the language not being tested	Target: shelf Response: estante	Target: taburete Response: stool
Dysarthric/apractic intelligible response (9.5)	Response from a patient with known dysarthria or apraxia		
Accent influence in target language (10)	Correct response in target language but containing the phonology of the language not being tested	Target: duck Response: dok ([dog])	Target: pollo Response: polo ([powlo])
Correct in target language (10.5)	Correct response (including single phoneme substitution, addition or omission for aphasic participants only) in the language being tested	Target: giraffe Response: giraffe	Target: avestruz Response: avestruzo

correct words and mean semantic cluster score and the differences between the *animals* and *clothing* items for the total correct words also remained after controlling for LAR for the controls (and to a lesser extent for some of the patients). Therefore, the differences in performance observed for the normal controls between each category had a large cultural influence and were based on the individual's own vocabulary and lifetime experiences [23]. In contrast, Pekkala et al. [27] showed that, between two normal monolingual groups of Finnish and English-speaking subjects, differences in performance on semantic verbal fluency tasks were minimal even after normalizing for educational influences. They, therefore, suggested that cultural and language differences do not have a significant contribution to performance in monolingual normal controls. As an alternative explanation, the normal controls, in general, possessed a much greater ability of producing sequential clusters of words and the ability to switch between clusters in all categories that were tested, which was assumed to be a function of their greater level of cognition and effective semantic strategizing techniques [21].

4.3. Differences across Participant Groups. As would be expected, normal controls were significantly better at lexical retrieval on all three tasks relative to bilingual patients with aphasia. At first glance this difference between the groups may suggest that patients and normal controls perform radically differently on the picture naming tests. However, Figure 2 shows that both groups produce similar errors in both languages, with the difference being the rate of each error type between the groups. This finding suggests that despite lexical retrieval deficits associated with stroke, the basic mechanism and potential breakdown of lexical retrieval in participants with aphasia on naming tasks are no different from that of the normal controls (Figure 1). For instance, both patients and controls produced mainly semantic paraphasias and circumlocutions in the target language/nontarget language. Consistent with our findings, in a study examining the nature of semantic errors in monolingual aphasia, Dell et al. [42] found that individuals with and without aphasia performed similarly with respect to error type and that semantic paraphasias produced by aphasic individuals are a continuation of semantic substitution errors in nonaphasic speech.

With respect to the category generation task, even though bilingual controls produce many more items than bilinguals with aphasia, the differences between the two groups are smaller for the semantic cluster scores, contrary to the initial predictions of the study (Table 4). This suggests that the strategies for clustering may not be all that different for the two groups. Troyer et al. [18] found that while clustering and switching were correlated with performance on verbal fluency, there was a greater effect of switching on phonemic fluency. Although a negative correlation between semantic clustering and switching was found in the Troyer study, optimal performance requires a balance between a decrease in the number of switches and the total number of words produced. In summary, these results suggest that while bilingual individuals with aphasia may not be able to access an item successfully, they appear to cluster their responses within appropriate semantic subcontexts. Finally, while patients with aphasia produced fewer semantic switches than their controls, the ratio of correct words to semantic switches was not all that different between patients and controls (Table 4).

4.4. Individual Patient Performance. In general, the low overall accuracy of the aphasic participant group precluded the possibility of drawing conclusions about the effect of brain damage once prestroke language proficiency was controlled. For all three tasks, it was observed that there were large individual differences creating much variation in the data to interpret. Observations of the results for BA04 and BA17 for the BNT and BPNT are especially noteworthy. Despite reporting Spanish as the L1 and near equal amounts of time speaking each language, BA04 and BA17 performed with greater accuracy in English than in Spanish on both the BNT and the BPNT. Other patients' naming accuracies were commensurate with their premorbid relative dominance in each language.

Similarly on the CG task, closer inspection of the results for individual participants revealed that participants with aphasia, like their controls, produced items within each category and each language, reflective of their relative dominance in each language. While a few participants reported they were English dominant (BA04, BA17, and BA21), only BA04 and BA17 produced more items in English. Other participants who were Spanish dominant (BA07, BA10, BA19, BA22, and BA23) produced more items in Spanish. There were also participants who showed no differences between the outputs in the two languages. These results underscore the influence of premorbid language proficiency on lexical retrieval even after brain damage and provide some validation for our reported measures of language use, exposure, and proficiency.

4.5. Influence of Language Proficiency on Lexical Retrieval. Interestingly, the initial regression analyses showed that, of all the LUQ variables, only LAR was consistently a significant predictor of performance across all five measures of lexical access (across the three tasks). This effect is due to nature of the variable: LAR is a compound, albeit subjective, judgment comprised of all the other variables of the LUQ. It therefore represents all the other variables of the LUQ combined. The results of the regression suggest that each factor of the LUQ does predict performance on the lexical retrieval tasks examined, but only when they are combined do the individual factors become significant as performance predictors. Of note is the difference between current language use and all other measures of the language exposure and proficiency for the bilingual controls. These results validate the need to obtain a multidimensional view of language use and exposure, and possibly the LAR captures some of that multidimensionality as it is a measure of the participants own judgment of their proficiency.

Importantly, LAR-English correlated with naming accuracy on BNT-English, BPNT-English, and correctly generated words in English for both the bilingual controls and bilingual patients with aphasia. Correlations between LAR-Spanish were less robust for both the controls and patients, perhaps indicating the lack of stability of this measure in obtaining a comprehensive lifespan history of Spanish language usage, of notable concern since all the patients (and several controls) were native Spanish speakers. Nonetheless, the observation that different measures of lexical retrieval correlated with a compound measure of language proficiency is an encouraging preliminary observation. The results of Kohnert et al. [12] and the present study underline the importance of independent self-reported measures of language proficiency in assessing language impairment of bilingual individuals with aphasia. While much work needs to be done in terms of delineating specific aspects of language proficiency (life time exposure, family proficiency, or education) that differentially influence various language processing tasks, the present study demonstrates that, until then, a composite albeit subjective measure of self-rated language ability is a good place to start.

5. Conclusion

The large differences in performance of the normal subjects and bilingual participants with aphasia demonstrate a fundamental lexical retrieval deficit in bilingual individuals with aphasia, but one that is further influenced by language proficiency in the two languages. The findings of our study indicate that normal controls and participants with aphasia make similar types of errors in both English and Spanish and develop similar clustering strategies despite significant performance differences between the groups.

Appendix

A. Categorization of Items on the Category Generation Task

Animals

(1) *Living Environment*

(a) Africa

(i) aardvark, antelope, buffalo, camel, chameleon, cheetah, chimpanzee, cobra, eland, elephant, gazelle, giraffe, gnu, gorilla, hippopotamus, hyena, impala, jackal, lemur, leopard, lion, manatee, mongoose, monkey, ostrich, panther, rhinoceros, tiger, wildebeest, warthog, zebra;

(b) Australia

(i) emu, kangaroo, kiwi, opossum, platypus, Tasmanian devil, wallaby, wombat

(c) Arctic/Far North

(i) auk, caribou, musk ox, penguin, polar bear, reindeer, seal;

(d) Farm

(i) chicken, cow, donkey, ferret, goat, horse, mule, pig, sheep, turkey;

(e) North America

(i) badger, bear, beaver, bobcat, caribou, chipmunk, cougar, deer, elk, fox, moose, mountain lion, puma, rabbit, raccoon, skunk, squirrel, wolf;

(f) Water

(i) Alligator, auk, beaver, crocodile, dolphin, fish, frog, lobster, manatee, muskrat, newt, octopus, otter, oyster, penguin, platypus, salamander, sea lion, seal, shark, toad, turtle, whale;

(2) *Human Use*

(a) Beasts of Burden

(i) Camel, donkey, horse, llama, ox

(b) Fur

(i) Beaver, chinchilla, fox, mink, rabbit

(c) Pets

(i) budgie, canary, cat, dog, gerbil, golden retriever, guinea pig, hamster, parrot, rabbit

(3) *Zoological Categories*

(a) Bird

(i) budgie, condor, eagle, finch, kiwi, macaw, parrot, parakeet, pelican, penguin, robin, toucan, woodpecker;

(b) Bovine

(i) bison, buffalo, cow, musk ox, yak;

(c) Canine

(i) coyote, dog, fox, hyena, jackal, wolf;

(d) Deer

(i) antelope, caribou, eland, elk, gazelle, gnu, impala, moose, reindeer, wildebeest;

(e) Feline

(i) bobcat, cat, cheetah, cougar, jaguar, leopard, lion, lynx, mountain lion, ocelot, panther, puma, tiger;

(f) Fish

(i) bass, guppy, salmon, trout;

(g) Insect

(i) ant, beetle, cockroach, flea, fly, praying mantis;

(h) Insectivores

- (i) aardvark, anteater, hedgehog, mole, shrew;

(i) Primate:

- (i) ape, baboon, chimpanzee, gibbon, gorilla, human, lemur, marmoset, monkey, orangutan, shrew;

(j) Rabbit

- (i) coney, hare, pika, rabbit;

(k) Reptile/Amphibian

- (i) alligator, chameleon, crocodile, frog, gecko, iguana, lizard, newt, salamander, snake, toad, tortoise, turtle;

(l) Rodent

- (i) beaver, chinchilla, chipmunk, gerbil, gopher, groundhog, guinea pig, hamster, hedgehog, marmot, mole, mouse, muskrat, porcupine, rat, squirrel, woodchuck;

(m) Weasel

- (i) badger, ferret, marten, mink, mongoose, otter, polecat, skunk.

The scoring system is outlined below. The only constraint utilized was for subordinate examples of a particular item. In this case, items were considered to be correct if they had distinct functions (e.g., long sleeve shirt versus short sleeve shirt) or were different species of an animal (pilgrim hawk versus red hawk).

An example of this procedure is from the pretesting task from BA01. This set of words would be grouped successively giving the following scores:

bee

dog

raccoon

ant

raccoon

raccoon

cat

rabbit

horse

bunny

raccoon.

Firstly, *bee* would be given a score of 0 because it is not semantically related to dog in any way. In the same way, *dog*, *raccoon*, and *ant* are all not semantically related, so they would each receive a score of 0. As repetitions are counted, the next two words produced, *raccoon* and *raccoon*, are semantically related (as they are the same word), so they would receive a score of 1. Of the remaining five words, *cat*, *rabbit*, *horse*, *bunny*, and *raccoon*, the first fourare semantically related giving a score of 4, as *cat, rabbit, horse,* and *bunny* are pets and *bunny* and *raccoon* are animals from North America.

$$0 + 0 + 0 + 0 + 1 + 4 = 5$$

The mean of these scores is then taken to determine an average score for each category:

$$\frac{5}{6} = 0.833. \tag{A.1}$$

This same procedure is repeated for the posttesting task, and the two values from pre- and posttesting are compared with a basic bar graph.

The semantic switching score for the example above would be 5 (5 arrows above). Again, the scores are calculated for pre- and posttesting and a bar graph is created to compare the values.

Clothing Items. The scoring system is still the same for the semantic cluster and semantic switching score as above. The subcategories for clothing are as follows:

(1) *similar weather conditions*

- (a) clothing for each season
  - (i) winter (jacket, sweater, hat, etc.)
  - (ii) summer (shorts, bathing suit, sunglasses, etc.);

(2) *upper body versus lower body*

- (a) upper Body
  - (i) shirt, sweater, coat, vest, and so forth;
- (b) lower body
  - (i) pants, shorts, capris, shoes, and so forth;

(3) *accessories*

- (a) accessories are matched to their appropriate category in the above two subcategories
  - (i) sunglasses, cap, to summer clothing
  - (ii) hat, scarf, gloves, mittens, to winter clothing
  - (iii) necklace, earrings, rings, tie to upper body clothing;

(4) *sets of matching clothing (strong pairs)*

- (a) pairs of clothes that are usually worn together
  - (i) coat and tie; sweatshirt, and sweatpants, jeans and, t-shirt, socks and shoes, and so forth;
- (b) different occasions
  - (i) formal wear
    - (1) suit, dress shirt, blouse, tuxedo, and so forth.

Food Items. The scoring system is the same as stated in the previous two categories. The subcategories have been grouped based on the following criteria:

(1) *beans*

(2) *beverages*

 (a) water, soda, juice, milk, and so forth

(3) *breads*

(4) *candy*

(5) *cold cereals*

(6) *condiments*

(7) *desserts*

(8) *fish*

(9) *fruits*

(10) *grains/cereals*

(11) *junk food*

(12) *meats*

 (a) cold cuts

 (b) poultry

(13) *dairy products*

(14) *nuts/seeds*

(15) *prepared foods and meals*

 (a) sandwiches, pasta, cake

(16) *seafood*

(17) *spices/herbs*

(18) *spreads*

(19) *vegetables*

(20) *ethnic foods*

 (a) spanish/mexican

  (i) beans, burrito, quesadilla, rice, and so forth

 (b) italian

  (i) pizza, pasta, spaghetti, and so forth

 (c) other ethnicities not specified

(21) *occasions*

 (a) breakfast foods (time of day)

  (i) pancakes, waffles, eggs, bacon, cereal, and so forth

 (b) birthday foods

  (i) cake, pizza, ice-cream, and so forth.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Review Article

Aphasia Therapy in the Age of Globalization: Cross-Linguistic Therapy Effects in Bilingual Aphasia

Ana Inés Ansaldo[1,2] **and Ladan Ghazi Saidi**[1]

[1] *Centre de Recherché de l'Institut Universitaire de Gériatrie de Montréal, 4565 Queen Mary Road, Montréal, QC, Canada H3W 1W5*
[2] *Speech-Language Pathology and Audiology Department, Faculty of Medicine, University of Montreal, Pavillon 7077 Avenue du Parc, local 3001-1, Montréal, QC, Canada H3N 1X7*

Correspondence should be addressed to Ana Inés Ansaldo; ana.ines.ansaldo@umontreal.ca

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Introduction. Globalization imposes challenges to the field of behavioural neurology, among which is an increase in the prevalence of bilingual aphasia. Thus, aphasiologists have increasingly focused on bilingual aphasia therapy and, more recently, on the identification of the most efficient procedures for triggering language recovery in bilinguals with aphasia. Therapy in both languages is often not available, and, thus, researchers have focused on the transfer of therapy effects from the treated language to the untreated one. *Aim*. This paper discusses the literature on bilingual aphasia therapy, with a focus on cross-linguistic therapy effects from the language in which therapy is provided to the untreated language. *Methods*. Fifteen articles including two systematic reviews, providing details on pre- and posttherapy in the adult bilingual population with poststroke aphasia and anomia are discussed with regard to variables that can influence the presence or absence of cross-linguistic transfer of therapy effects. *Results and Discussion*. The potential for CLT of therapy effects from the treated to the untreated language depends on the word type, the degree of structural overlap between languages, the type of therapy approach, the pre- and postmorbid language proficiency profiles, and the status of the cognitive control circuit.

1. Introduction

1.1. Bilingualism Is a Distinctive Feature of Globalization. Contemporary society is characterized by a bilingual or multilingual mode of communication. Whether for historic, economic, or migration reasons, bilingualism is no longer exceptional, but most often the rule. Whereas some countries have a history of bilingual and polyglot modes of communication, the era of globalization has contributed to the promotion of bilingualism around the world. Nowadays, bilingualism provides better career opportunities in all sectors of the economy and human activity, a fact that has motivated a wider interest in second language learning. Parents are increasingly choosing bilingual education as a result of evidence suggesting that bilingual children may develop specific cognitive advantages [1, 2], including enhanced intellectual development, greater creativity and flexibility, and openness to cultural diversity. For all of these reasons, social, educational, healthcare, and political policies are expected to adapt to such multilingual and multicultural societies.

1.2. Bilingual Aphasia. Aphasia is an acquired language disorder resulting from brain damage. It refers to a breakdown in the ability to formulate, retrieve, or decode the arbitrary symbols of language. It is usually acquired in adulthood [3].

The bilingual population is large and growing worldwide; therefore, bilingual aphasia is becoming more and more frequent. The complexity of the behavioural patterns observed in bilingual aphasia is big, since it concerns two (or more) languages, whose recovery does not always follow equivalent patterns. Moreover, given the almost endless possible combinations of language pairs, the issue of bilingual aphasia therapy is a big challenge. Thus, even the most avant-garde educational policies aimed at training bilingual speech-language pathologists are likely to provide only partial solutions to the clinical management of this population [4, 5]. Consequently, the study of cross-linguistic-language-therapy effects is likely to become an unavoidable topic in the field of aphasiology in the years to come.

From a neurorehabilitative perspective, bilingualism imposes a certain number of challenges regarding the assessment and intervention provided to bilingual clinical populations, particularly, those that suffer from cognitive impairment. The complexity of this issue extends well beyond the linguistic knowledge required to interact with the patient so as to detect impaired language abilities. Beyond language, there is communication, that is, the ability to decode the pragmatics that characterize a specific linguistic community. This is essential for the proper understanding of communicative behavior, meaning, what is normal, and what is not, in the context of a given culture.

The issue of language impairment in bilinguals has interested cognitive neuroscientists for more than a century. In particular, the study of bilingual aphasia first focused on the variety of aphasia patterns characterizing bilingual clinical populations [5–8]. Furthermore, the development of testing procedures that take into consideration the linguistic particularities gave raise to bilingual aphasia tests for a variety of language pairs, among which the BAT [9, 10] developed for more than 59 languages and the Multilingual Aphaisa Examination developed in six languages [11], along with tests normalized in several languages, such as the Aachen Aphasia [12–14], and the Boston Diagnostic Aphasia Examination [15–18]. These tests provide a linguistically valid assessment of bilingual aphasia.

More recently, aphasiologists have focused on the complex issue of bilingual aphasia language therapy, with the purpose of developing the most efficient procedures for triggering language recovery in this population. This is a relatively new field, and a complex one, given that it requires juggling the complexities of bilingual language processing, which amounts to more than simply the additive processing of two languages.

2. Aims

The purpose of this paper is to discuss the literature on bilingual aphasia therapy, with a focus on the cross-linguistic effects that language therapy provided in one of the two languages of the patient may (or may not) have on the untreated language.

This paper will discuss a number of factors with CLT potential: (a) word category (cognates versus non-cognates), (b) language distance (same versus distant language families), (c) pre and post morbid proficiency in either language, and (d) the impact of cognitive control issues on transfer of therapy effects. Finally, the main clinical implications of research findings on cross-linguistic transfer of therapy effects (CLTE) in bilingual aphasia therapy will be discussed, with the purpose of proving intervention efficacy in bilingual populations with language impairment, while optimizing health care efficiency in terms of resource training and allocation. This research will contribute to intervention efficacy in bilingual populations with language impairment, while optimizing health care efficiency in terms of resource training and allocation.

3. Methods

The evidence discussed in this paper was collected from the following databases: Medline, ASHA, Cochrane, Aphasiology Archive, Evidence-Based Medicine Guidelines, NHS Evidence, and PsycBite et Speechbite. The key words bilingual, aphasia, cross-language, generalization, cognates, naming treatment, and transfer guided the search. This resulted in fifteen articles, two of which received the largest weight in the analysis, since they were systematic reviews [19, 20] with an A-level recommendation that witnesses for good quality patient-oriented research, according to the AFF taxonomy [21]. The remaining articles report case series, or single-case design studies whose level of evidence is much lower; however, all of these were selected because they respected a number of criteria that allowed some degree of generalization of the reported findings. Specifically, the inclusion criteria consisted the following:

(a) provide details on pre- and posttherapy bilingual aphasia profiles,

(b) describe therapy procedures in sufficient detail to make them replicable,

(c) provide information on therapy frequency,

(d) discuss a number of variables that may have influenced the presence or absence of cross-linguistic transfer effects,

(e) reported evidence which concerns the adult population with acquired language impairment,

(f) reported that patient speaks at least two Indo-European languages with different degrees of proficiency across languages before brain damage,

(g) focused mostly on therapy for word-retrieval deficits, namely, anomia, which constitutes the most widespread aphasia symptom across all aphasia types.

4. Results

4.1. Cross-Linguistic Effects in Bilingual, Healthy, and Brain Damaged Populations. Understanding the mechanisms that rule cross-linguistic transfer in bilingual healthy populations highlights the functioning of the bilingual language system.

There is convergent evidence on the fact that the speech of a bilingual person reflects the influence of one language on the other [22, page 5]. This influence, which results from similarities and differences between the target language and any other previously acquired language, is referred to as *cross-linguistic influence* or *cross-linguistic transfer* (CLT) [22, page 27]. Similarities and differences can be observed at different levels of language processing, namely, the word level, the syntax, and phonology levels, as well as the proficiency level. Thus, the study of CLT effects among healthy bilinguals provides clues about the mechanisms that rule CLTE, some of which have been exploited in bilingual aphasia therapy.

4.1.1. Word Type: Cognates, Clangs, and Noncognates. There is extensive evidence on CLT effects with cognates and clangs, as opposed to noncognates [23, 24]. Cognates are formally equivalent words whose meanings may be identical or almost so [25, page 73] (e.g., "tiger" (/ˈtīgər/) and "*tigre*" (/tigr/)), whereas clangs (or homophones) are phonologically similar words with different meanings (e.g., "bell" /bɛl/; metal object that makes a ringing sound when struck; Sonnette in French) in English and "*belle*" in French (/bɛl/; meaning beautiful). Finally, noncognates are translation equivalents that share semantics but not phonology, such as "butterfly" in English and its Spanish equivalent, "*mariposa*".

Evidence for the effects of CLT is reflected in faster response times for cognates as compared to noncognates in picture naming [23, 26–31], as well as in word recognition and word translation [30, 32–34]. It has also been argued that cognates are processed as efficiently as monolinguals process mother tongue [35, 36]. Accordingly, cross-linguistic therapy effects with cognates in cases of bilingual aphasia have been examined. Roberts and Deslauriers [30] showed that highly proficient bilinguals with aphasia could better name cognates than non-cognates, and they also produced distinct error types for each target. Specifically, errors with cognates were no response and target description—the latter having a communicative value—whereas noncognates resulted in semantic errors as well as language switching errors [30].

Finally, although the evidence of a cognate effect in bilingual aphasia therapy is not unanimous [30, 37, 38], a generalization of therapy effects with cognates has been reported in a case of Spanish-English bilingual aphasia. Thus, Kohnert [37] reported cross-linguistic generalization of therapy effects from treated L1 (Spanish) to untreated L2 (English) for cognates only. Language treatment consisted of lexical semantic retrieval strategies such as word recognition, semantic association, and cueing [37]. Conversely, Kurland and Falcon [38] report an interference effect with cognates, following intensive language therapy with a semantic approach, in a case of a Spanish-English bilingual with chronic and severe expressive aphasia. This interference effect can be explained by reference to Abutalebi and Green's model [39]. The patient presented a lesion in the basal ganglia, a component of the corticosubcortical network sustaining the inhibition of the nontarget language; this network includes the left precentral cortex, the anterior cingulate, the inferior parietal lobule, and the basal ganglia [39].

Clangs, or homophones, also share phonological similarities with mother tongue words, but, unlike cognates, clangs refer to different concepts. The evidence of a clang effect in bilinguals is not convergent; thus, some authors argue that both orthographic and phonological similarity are required to facilitate word recognition [40, 41], whereas others claim that processing clangs imposed an extra cognitive load resulting from the inhibition of the nontarget semantic representation [42, 43]. In line with this claim, a recent functional connectivity study shows that healthy adults recruit a cognitive control network to process clangs [44]. The extent to which clangs may facilitate cross-linguistic therapy effects in bilinguals with aphasia has not yet been tested; however, the findings within healthy populations [42–45] suggest that clangs may become particularly difficult in cases of bilingual aphasia, given that brain damage entails decreased cognitive resources [46].

There is also a lack of convergence regarding CLTE with noncognates. Kurland and Falcon [38] reported successful CLTE for noncognates only, after therapy with a semantic approach. However, with a similar therapy approach, Kohnert [37] failed to report such an effect and instead found one with cognates. It is not easy to draw any conclusions given that such a small number of studies have compared cognates and noncognates, particularly because factors other than word type may have influenced therapy results in either language, including lesion location and extension as well as cross-linguistic similarities and differences.

4.1.2. Structural Similarities and Differences across Languages. The degree of structural overlap across languages plays a major role in the potential for CLTE [19, 20]. For example, Goral et al. [47] described the case of a trilingual speaker with mild chronic aphasia, who was treated in English, (L2), first on morphosyntactic skills (i.e., pronoun and gender agreement) and then on language production rate. Measurements in the treated language (English) as well as in the two nontreated languages (Hebrew (L1), and French (L3)) were collected after each treatment block.

An improvement in pronoun and gender agreement in the treated language (L2) as well as in the nontreated L3 was observed following the treatment block on morphosyntactic skills in English. Also, there was an improvement in speech rate in English and in French following the second block, but no changes were observed in Hebrew. The authors concluded that selective CLT from L2 to L3 resulted from the structural similarities between English and French, as compared to a lack of similarity between English and Hebrew.

Similarly, Miertsch [48] administered semantic therapy in French (L3) to a trilingual participant with Wernicke's aphasia. Transfer was observed from L3 (French) to L2 (English), but not to L1 (German). These findings were interpreted as the result of structural similarities between French and English, as compared to French and German. However, there is also the possibility that the results in German reflect a plateau effect resulting from the fact that poststroke proficiency in German was higher than in the other two languages [48]. As discussed by Faroqui et al. [19], the years to come will yield more studies on the impact of cross-linguistic structural similarities and differences on CLTE.

4.1.3. Pre-Morbid and Post-Morbid Proficiency in Either Language. A number of studies provide evidence for cross-linguistic transfer of therapy effects (CLTE) from the treated, less proficient second language, to the untreated and better preserved mother tongue. Kiran and Iakupova [49] administered semantic therapy in L2 (English) and measured naming on trained and untrained words both in L2 and L1

(Russian). Following therapy, the participant showed 100% accuracy in both treated and untreated items, thus reflecting successful CLTE. The authors [49] suggest that CLTE reflects the strengthened connections between the weaker (English) language and the stronger (Russian) language.

Likewise, CLTE was reported following intensive semantic therapy in L2 (English) in the case of a native Spanish bilingual individual with chronic, severe expressive aphasia [38], particularly on naming tasks. The authors argued that although CLTE from premorbid less proficient language (L2) to premorbid more proficient language (L1) had been successful, all gains considered that the patient benefited more from therapy in L1 than from therapy in L2.

There is evidence that balanced bilingualism contributes to CLTE [27, 50, 51], and, in cases of unbalanced bilingualism, transfer is observed from the less proficient language to the dominant language. Specifically, parallel recovery in both languages was observed in a premorbid balanced bilingual woman (Flemish, L1/Italian, L2) suffering from chronic aphasia after 2 weeks of picture-naming training through repetition and reading of names of pictures in L2 [51]. Similarly, Edmonds and Kiran [50] investigated the CLT of gains achieved following therapy with Semantic Feature Analysis to treat naming deficits by examining three English-Spanish bilinguals with aphasia, all of whom received a semantic therapy in Spanish (Participant 1) and in English and Spanish (Participants 2 and 3). Therapy effects were tested on treated items, untreated items, and translations; results showed that both within- and cross-language therapy effects were related to premorbid language proficiency. Specifically, Participant 1, a premorbid balanced bilingual, showed CLTE to the untreated English items, whereas Participants 2 and 3 (who were more proficient in English) showed within-language generalization to semantically related items, but no CLT to the untreated Spanish items. Moreover, though following treatment in Spanish, Participants 2 and 3 did not show any within-language generalization; they did show CLT to English, their dominant language. Thus, this data supports the idea that better CLTE is observed from the less proficient (L2) to the more proficient language (L1).

In another study, the authors [27] provided semantic therapy in Spanish to two Spanish-English bilinguals, one of them English dominant and the other one a balanced bilingual. Therapy in Spanish resulted in CLTE for both participants, whereas therapy in English was followed by CLTE in the balanced Spanish-English participant only.

Thus, some studies [27, 38, 49–51] provide evidence that premorbid proficiency in either language modulates CLTE, arguing that CLTE occurs more easily from a less proficient language to the dominant language in unbalanced bilinguals, whereas balanced bilingualism facilitates CLTE no matter which language is treated. Thus, it has been shown that the less proficient L2 relies upon the stronger L1 lexicon, whereas, at high proficiency levels, L1 and L2 lexicons are mostly overlapping [19, 52]. Nevertheless, it is difficult to draw a final conclusion, as some of these studies did not report poststroke proficiency states [27, 50].

A different point of view on the impact of proficiency is presented by Goral [53], who claims that it is postmorbid proficiency that determines the extent of CLTE. Evidence from four different case studies demonstrating successful CLTE with different patterns in multilingual participants with aphasia, included (a) CLTE in L1 (Hebrew) following treatment of L2 (English), (b) CLTE in L4 (German) following treatment of L5 (English), (c) CLTE in L3 (French) following treatment of the strongest language L2 (English), and (d) CLTE in L2 (German) following treatment of most recovered L3 (English). In all cases, CLTE occurred when the therapy was offered in the language with higher postmorbid proficiency, regardless of premorbid proficiency. This is also the case in the limited (only for cognates) CLTE in an L1 and L2 premorbidly highly proficient Spanish (L1) and English (L2) bilingual suffering from nonfluent aphasia reported by Kohnert [37]. This patient showed improvement after receiving therapy in both languages; however, CLTE was seen only when therapy was administered in the language with higher postmorbid proficiency (L1).

Similarly, Croft et al. [54] examined five English-Bengali bilinguals with aphasia and anomia, who received a phonological approach and a semantic cueing approach, both in L1 and L2. While phonological cueing resulted in no significant CLTE, semantic cueing led to CLTE for three out of five patients. In all cases, CLTE occurred only when therapy was offered in L1 [54]. In observing the data on the participants' aphasia profiles, one notes that, for all cases in which successful CLTE was reported, the language of therapy happened to be the stronger post-morbid language. As this postmorbid more proficient language also happened to be L1, the authors took these results as evidence for successful CLTE from L1 to L2, despite the fact that not all participants who were treated in L1 showed successful CLTE. Another case of unsuccessful CLT despite the balanced proficiency both at premorbid and postmorbid proficiency was reported by Abutalebi and colleagues [55]. Thus, no CLTE was observed following L2 treatment in a case of fluent aphasia. The patient was a highly proficient, balanced Spanish (L1) Italian (L2) bilingual, who had become severely anomic in both languages following aphasia, and involuntary language interference, was observed. Treatment in L2 was successful but did not show any CLTE. Unsuccessful CLTE in this case may result from the therapy approach chosen (phonological approach); however, another possibility is that involuntary language switching and unsuccessful CLTE resulted from damage to areas involved in cognitive control.

4.1.4. Cognitive Control and Transfer of Therapy Effects. It has been shown that damage to the cognitive control circuit can prevent CLTE. However, there is also evidence that choosing an appropriate therapy approach (i.e., Switch Back Through Translation) can result in CLTE even when damage to the cognitive control circuit is observed [56]. This can be accomplished by implementing a strategy of translation of involuntary switches which allows bypassing the effects of impaired inhibitory abilities resulting from damage to the cognitive control circuit.

In the case reported by Abutalebi et al. [55], the Spanish (L1) and Italian (L2) bilingual anomic patient had damage to the left lenticular nucleus and surrounding areas. He showed selective L1 recovery at T0, and, when asked to name pictures in L2, he would unintentionally name in L1. However, after receiving therapy in L2, the selective pattern changed in favor of L2 and, thus, when asked to name in L1, he would unintentionally name in L2.

The change of selective recovery pattern and the fact that EM was unable to translate, together with the presence of a lesion within the cognitive control circuit, lead Abutalebi and colleagues [55] to conclude that EM's behavior supports the Dynamic Model on Recovery Patterns in Bilingual Aphasia, proposed by Green and Abutalebi [57]. According to this model [57], the same neural network supports L1 and L2 processing; however, the processing of the weaker language (usually L2) may as well involve the left prefrontal cortex, the basal ganglia, and the anterior cingulated cortex,as a function of proficiency level.

Based on Green and Abutalebi [57], one can argue that the recovery pattern will depend on the integrity of the circuits normally involved in language control; also, it may be hypothesized that damage to that circuit can affect CLTE. Thus, cognitive control encompasses controlling language selection, and its impairment may result in involuntary language mixing and language switching [56]. However, as previously discussed, the evidence shows that it is possible to compensate for this deficit by choosing an appropriate therapy approach, that can be designed by reference to a comprehensive model of bilingual language processing [56]. Precisely, CLTE can be triggered by stimulating both languages simultaneously in the context of a therapy approach that includes translation tasks, even when therapy is provided primarily in one language. Ansaldo et al. [56] reported the case of a Spanish-English bilingual who suffered from pathological language mixing, which caused alternation between Spanish (L1) and English (L2) utterances, in the context of communicating with monolingual Spanish speakers. The authors [56] analysed this behaviour within the framework of Green's model [46] and developed a procedure called SBTT (Switch Back Through Translation), based on the fact that translation from English to Spanish would provide an economic strategy to switch back to the target language, as opposed to inhibiting the nontarget (English) language, a lost ability resulting from brain damage to the language control circuit [56]. The therapy was primarily administered in Spanish and resulted in significant improvement in naming nouns and verbs in Spanish, but, moreover, CLTE to English was as well observed, both with nouns and verbs. Using translation may favour CLTE by stimulating cognitive processes that are common to the two languages of the bilingual individual (i.e., cognitive control of language selection). Further studies are required to explore this hypothesis in depth.

4.2. Promoting CLTE in Bilingual Aphasia Therapy: Main Clinical Implications of Research Findings. Despite the fact that more work is needed, research on CLTE in bilingual aphasia provides some cues as to the best approach of this clinical population.

In particular, the evidence suggests that language therapy focused on cognates facilitates CLTE. Thus, forming a list of cognates, consulting dictionaries developed for specific language pairs (e.g., Spanish-English: DOC—Dictionary of Cognates and the RDOC—Reverse Dictionary of Cognates [58, 59]) can help clinicians focus language therapy on stimuli with CLTE potential, communicative, and social relevance for the patients, their families, and caregivers. Furthermore, the MDOC project, which aims at joining the cognate matches for five language pairs (http://www.cognates.org/), will become an important resource in the management of bilinguals with aphasia. As for clangs, the evidence in healthy populations shows that their processing implies complex interactions with distinct semantic representations that share L1-L2 phonological forms, which may become particularly challenging for individuals with brain damage. Further research is required to shed light on this issue.

Regarding pre- or postmorbid proficiency, it is not easy to draw an absolute conclusion. Some studies [27, 38, 49–51] suggest that premorbid proficiency matters and that training the premorbid weaker language appears to facilitate CLTE, given that treating the weaker language has a greater effect on the stronger than the reverse. This has proven to be true for premorbidly unbalanced bilinguals and also for balanced bilinguals, who, after a stroke, showed an unbalanced language profile with distinct degrees of impairment in L1 and L2. On the other hand, other cases suggest that postmorbid proficiency is the determinant factor for successful CLTE [53]. Therefore, both premorbid and postmorbid proficiency should be considered when deciding the language of therapy, and, to do so, a thorough assessment of bilingual aphasia is a must.

Moreover, using translation as a CLT strategy may enhance the effects of therapy provided in one language to the untreated language. Translation equivalents are strongly linked, a factor that may facilitate CLTE. This approach may be particularly useful when damage excludes the cognitive control circuit, which supports the ability to switch between L1 and L2.

With respect to the anomia therapy approach, evidence suggests that Semantic Feature Analysis or a combination of this approach with phonological cueing may contribute to CLTE. Semantic Feature Analysis capitalizes on shared semantic representations across languages, and it has been shown to facilitate CLTE in bilinguals with aphasia [27]. Furthermore, the evidence with monolinguals shows that this approach triggers neuroplasticity in cases of severe anomia resulting from extensive brain damage [60].

Also, the impact of semantic and phonological approaches depending on the degree of L1-L2 cognate and clang density or global structural overlap needs to be explored. Hence, the evidence on healthy populations shows that processing structurally distant (i.e., unsimilar) languages entails greater cognitive demands [45]. Considering this evidence, it is likely that brain damage will hinder CLTE in bilinguals speaking distant languages, who suffer from aphasia.

Table 1 summarizes all studies discussed in Section 4.

Table 1

	Cognates	L1	L2	L3	Language family L1	Language family L2	Language family L3	Language proficiency L1	Language proficiency L2	Language proficiency L3	Therapy approach	Language of therapy	Successful transfer of therapy to untreated language
Roberts and Deslauriers (1999) [30]	×	French	English	NA	Roman	Germanic	NA	Pre-H	Pre-H	NA	NA	NA	NA
Kohnert (2004) [37]	×	Spanish	English	NA	Roman	Germanic	NA	Pre-H Post-I	Pre-H Post-L	NA	Lexical semantic retrieval strategies	L1	Cognates only
Kurland and Falcon (2011) [38]	×	Spanish	English	NA	Roman	Germanic	NA	Pre-H Post-I	Pre-I Post-L	NA	Semantic	L2	Noncognates, only
Goral et al. (2010) [47]	NA	Hebrew	Englis0068	French	Canaanite	Germanic	Roman	Pre-H Post-H	Pre-H Post-I	Pre-H Post-L	Morpho-syntactic skills and language production rate	L2	L3 only
Miertsch (2009) [48]	NA	German	English	French	German	Germanic	Roman	Pre-H Post-H	Pre-H Post-I	Pre-H Post-I	Semantic	L3	Only L2
Kiran and Iakupova (2011) [49]	NA	Russian	English	NA	Slavic	Germanic	NA	Pre-H Post-H	Pre-I Post-I	NA	Semantic	L2	L1
Marangolo et al. (2009) [51]	NA	Flemish	Italian	NA	Germanic	Roman	NA	Pre-H Post-I	Pre-H Post-I	NA	Picture-naming training	L2	yes
Edmonds and Kiran (2006) [50]/P1	NA	English	Spanish	NA	Germanic	Roman	NA	Pre-H Post-NR	Pre-I Post-NR	NA	Semantic feature analysis	L2	No
Edmonds and Kiran (2006) [50]/P2 and P3	NA	English	Spanish	NA	Germanic	Roman	NA	Pre-H Post-NR	Pre-I Post-NR	NA	Semantic feature analysis	L1 and L2	yes
Edmonds and Kiran (2006) [50], b/p1	NA	English	Spanish	NA	Germanic	Roman	NA	Pre-H Post-NR	Pre-I Post-NR	NA	Semantic feature analysis	L2 and L1	From L1 to L2 only
Edmonds and Kiran (2006) [50], b/p2	NA	Spanish	English	NA	Roman	Germanic	NA	Pre-H Post-NR	Pre-H Post-NR	NA	Semantic feature analysis	L1 and L2	From L1 to L2 only
Goral (2012) [53], P.1	NA	Hebrew	English	French	Canaanite	Germanic	Roman	Pre-H Post-H	Pre-H Post-I	Pre-H Post-L	Modified constraint-induced therapy	L2	L1
Goral (2012) [53], P.2	NA	Persian	German	English	Iranian	Germanic	Germanic	Pre-H Post-L	Pre-H Post-I	Pre-H Post-H	Modified constraint-induced therapy	L3, L1, and L2	From L2 to L3 only

Table 1: Continued.

	Cognates	L1	L2	L3	Language family L1	Language family L2	Language family L3	Language proficiency L1	Language proficiency L2	Language proficiency L3	Therapy approach	Language of therapy	Successful transfer of therapy to untreated language
Goral (2012) [53], P.3	NA	English	Hebrew	NA	Germanic	Canaanite	NA	Pre-H Post-H	Pre-I Post-I	NA	Modified constraint-induced therapy	L2	L1 but Negative
Goral (2012) [53], P.4	NA	Catalan	Spanish	French	Roman	Roman	Roman	Pre-H Post-H	Pre-H Post-H	Pre-I Post-I	Modified semantic feature analysis, sentence generate-on	L4: German, Pre-I, Post-I	L5: English Pre-I Post-I
Croft et al. (2011) [54]/P.1–5	NA	Bengali	English	NA		Germanic	NA	Post-H for 3 Ps	Post-L for 2 Ps	NA	Phonological and semantic cueing	L1 and L2	For semantic cueing only
Abutalebi et al. (2009) [55]	NA	Spanish	Italian	NA	Roman	Roman	NA	Pre-H Post-L	Pre-H Post-L	NA	Phonological training	L2	No

5. Conclusion

Globalization imposes a number of challenges to the field of neurorehabilitation, including challenges in the clinical management of bilinguals with aphasia. In recent decades, the assessment and intervention techniques available to bilingual clinical populations have become a major clinical and research topic.

The study of intervention with bilingual aphasia populations has evolved from a descriptive perspective, mainly focused on case reports, to a neuropsychological and neurofunctional perspective, aimed at unveiling the cognitive and neural mechanisms underlying the behavioral patterns that characterize bilingual aphasia and its recovery. More and more, this avenue is focusing on disentangling the mechanisms that allow for transferring therapy effects from the treated to the untreated language. Most research has focused on anomia, the most widespread aphasia sign.

The literature suggests that cross-linguistic therapy effects are possible but depend on a number of factors. For example, both pre- and postmorbid proficiency factors can affect CLTE. Thus, while treating the premorbid weaker language can show CLTE benefits [27, 38, 49–51], cross-linguistic transfer of therapy effects are as well reported for eight cases whenever therapy is provided in the postmorbid stronger language or when proficiency after stroke is equivalent in both languages. Regarding therapy approach, the evidence from 16 studies reporting the type of therapy administered suggests that semantic approaches result in better CLTE than phonological approaches [54, 55]. Finally as for word types, cognates have better CLT potential than noncognates [30, 37], but the cognate advantage disappears when cognitive control circuits are damaged [38]. This is the case probably because of reduced excitatory and inhibitory resources secondary to the damage in the cognitive control circuit. This impairment prevents correct selection among highly overlapping and competing lexical units (i.e., cognates). Green's Activation, Control and Resource Model [46, 61] assumes that lexical selection of the target word requires sufficient inhibitory (to suppress the non-target node) and excitatory resources (to activate the target node). Furthermore, 11 studies having reported CLT effects show no evidence suggesting that language distance could play a role on the potential for CLT in bilingual aphasia therapy. Thus, among indo-European languages, therapy effects can transfer across languages regardless of what language family they belong to the Indo-European family of languages [37, 47–49, 51, 53, 54].

Major developments in the field can be expected in the years to come. By combining clinical aphasiology, cognitive models of bilingualism, functional neuroimaging, and functional connectivity analysis it will be possible to better understand the mechanism that subserve CLT of therapy effects, and thus design bilingual aphasia therapy approaches accordingly. This will increase the probability of recovery from bilingual aphasia, while optimizing health care efficiency, in terms of resource allocation and training.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Research Article

Effect of Age, Education, and Bilingualism on Confrontation Naming in Older Illiterate and Low-Educated Populations

Sameer Ashaie and Loraine Obler

Speech-Language-Hearing Sciences, CUNY Graduate Center, 365 Fifth Avenue, New York City, NY 10016, USA

Correspondence should be addressed to Loraine Obler; loraine.obler@gmail.com

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We investigated the effects of age as well as the linked factors of education and bilingualism on confrontation naming in rural Kashmir by creating a culturally appropriate naming test with pictures of 60 objects. We recruited 48 cognitively normal participants whose ages ranged from 18 to 28 and from 60 to 85. Participants in our study were illiterate monolinguals ($N = 18$) and educated Kashmiri-Urdu bilinguals ($N = 30$). Hierarchical multiple regression revealed that younger adults performed better than older adults ($P < 0.01$) and the age effect was quadratic (age^2). It also showed Age X Education and Age X L2 Speaking interactions predicted naming performance. The Age X Education interaction indicated that the advantages of greater education increased with advancing age. Since education is in the second language (L2) in our population, this finding is no doubt linked to the Age X L2 Speaking interaction. This suggests that L2 speaking proficiency contributed more to first language (L1) naming with advancing age.

1. Introduction

Performance on confrontation naming tests, in which individuals have to identify a visual stimulus representing an object or an action and then correctly label the stimulus aloud, has been linked to age, education, and bilingualism. According to most models of word production (e.g., [1, 2]), confrontation naming involves three stages: conceptual preparation, lemma retrieval (lexical selection of relevant names along with their semantic and syntactic properties), and lexeme retrieval (of phonological word-form information). Difficulties with confrontation naming can generally be attributed to problems with the lexeme retrieval stage and such difficulties are mostly age related in non-brain-damaged individuals [3, 4].

The majority of studies investigating confrontation naming in older adults have found that they perform significantly worse than younger adults (e.g., [5–9]) with decline in confrontation naming more pronounced after the age of 70 (see [10]). However several studies have not found age related differences in performance between older and younger adults (e.g., [11, 12]). The discrepancies could be attributed to varying research methods, age ranges, participant characteristics (e.g., education), and statistical methods, as pointed out by Goulet et al. [13]. Schmitter-Edgecombe et al. [14] actually found that older adults perform better on confrontation naming than younger adults. However, upon further examination of their data, they found that four items had generational familiarity that biased them towards older adults and could, thus, they argued, explain the finding. Though the majority of studies suggest age may have an effect on performance in confrontation naming tests, there are likely other variables that can account for performance differences.

An additional factor that has been found to influence naming is education [6, 7, 15–17]. Connor et al. [15] found that individuals with 16 years of education perform better on naming than those with 12 years of education. These studies and others (e.g., [4]) suggest that to a certain extent, higher education could increase performance on naming tests; however, the lower limits of educational levels for participants in these studies have been around the level of eight years of education.

Similar studies on naming in illiterates and low-educated individuals found that illiteracy and low educational levels decreased performance on confrontation naming tests [18, 19]. Manly et al. [19] found that literates with 0 to 3 years of education did significantly better than illiterates on a 15-item Boston Naming Test (BNT). However, Ganguli et al. [20], using three-dimensional models of objects instead of line drawings, did not report any difference in performance between literates and illiterates.

The results on confrontation naming tests with illiterate and low-educated participants can be attributed to a variety of factors including cultural relevance of test items and the participants' familiarity with task protocols as argued by Ardila [21] and Ganguli et al. [20]. Additionally, since line drawings (as compared to photographs or real objects) could be ambiguous or less recognizable for illiterates, the usage of such visual stimuli could make naming objects difficult [22]. To circumvent this problem, culturally appropriate tests have been used to assess naming performance in individuals across culturally diverse populations. Some of these studies, however, only included 8–15 items which makes it difficult to include items of varying lexical frequency. Studies with a small number of items may only include items with similar frequencies. This could potentially skew the results such that if only high frequency items are included, no difference between illiterates and literates is found. In contrast, if only low frequency culturally inappropriate items are used, illiterates will do worse than literates.

Education, like aging, cannot fully explain the variability found in performance of older adults on confrontation naming tests. One other factor, bilingualism, appears to play some role in an individual's performance on confrontation naming tests [23, 24].

Bilingualism has been found to adversely affect confrontation naming in younger and older adults in both L1 and L2 [23, 25, 26]. The bilingual disadvantage on naming tasks has been attributed to factors such as using each language less than a comparable monolingual, lower proficiency, smaller vocabularies in each individual language, and having a somewhat later age of acquisition of individual words.

A few studies have used a set of possible predictors of naming in L2 but not in L1. For example, Roberts et al. used L2 (English) percent usage, self-ratings of L2 auditory comprehension, and L2 verbal expression to investigate naming in L2. They did not address how proficiency in other L2 modalities (e.g., writing) influenced naming. It is, of course, possible that individuals in their study do not have different proficiency levels in different L2 modalities because they have more than 11 years of education and live in L2 speaking environments. Proficiency in speaking an L2 does not necessarily correlate with proficiency in reading and writing it.

We reasoned that individuals who have markedly lower education and live in L1-dominant environments have different L2 proficiency levels from participants like those of Roberts et al. [26]. For example, reading and writing proficiency could be confounded with higher education such that individuals who are highly educated are highly proficient in those modalities in either or both L1 and L2. Speaking, on the other hand, could be related with language usage and not necessarily with education. Indeed, even in their L1, Kashmiri, our participants were not literate; those who were literate among them were literate only in their school language L2, Urdu. Thus, in the current study we recorded individuals' L2 proficiency by individual modalities to determine the potentially different relations among proficiency levels in different L2 modalities and L1 naming scores.

In order to understand the effects of age, education, and bilingual modalities (reading, writing, and speaking) on confrontation naming in illiterates and low-educated individuals, we devised a culturally appropriate naming test to address the following questions: (1) Does performance on confrontation naming decline with advancing age in low-education populations? (2) What are the effects of education on confrontation naming in older illiterates and low educated individuals? (3) Does proficiency in different bilingual modalities impact confrontation naming differently?

2. Methods

2.1. Participants. Forty-eight participants were recruited for our study from a rural area (Mulphak) in Kashmir, India. The participants primarily had agricultural occupations. Half were male and half female with ages ranging between 18–28 and 60–85 years. The adult populations in rural areas of India typically have no memory or official record of their date of birth [27]. Out of 24 older participants (60–85) years, only 6 participants gave us an exact age. The remaining 18 participants gave us their ages in a 5-year range. To further confirm the validity of their age and age ranges, older participants and their family members were asked to estimate the participant's age at the time of major historical events (e.g., India's partition) and their family history (e.g., marriage). The practice of confirming older participants' ages to personal and historical events is consistent with the methodology used in other studies (e.g., [27]). For the analyses reported below, we used as each participant's age either the precise age, when they gave us one, or the upper limit of the 5-year range. A second set of analyses using the lower limit of the range for those 18 participants gave us the same findings so we do not report them here.

Eighteen participants were illiterate, with no years of formal schooling. An illiterate was defined as "someone who cannot, with understanding, both read and write a short, simple statement on his or her everyday life" [28]. The ability to write was assessed by asking the participants to write 2-3 sentences in Urdu about their typical day. The ability to read was assessed by asking the participants to read aloud a paragraph in Urdu from the local newspaper. Those who could do so, even with some errors, were deemed literate. Thirty participants were literate, with education ranging from 1 to 10 years (see Table 1). The educated participants were Kashmiri-Urdu bilinguals because the medium of education in rural areas of Kashmir is Urdu. The educated participants speak in their native language, Kashmiri, but cannot read nor write Kashmiri. They can, however, speak, read, and write Urdu.

2.2. Materials

2.2.1. Kashmiri Naming Test (KNT). Items for the Kashmiri Naming Test were selected based on information from

Table 1: Participant characteristics.

		N = 10 Illiterates (0 education)		N = 7 Low educated (1–5 years)		N = 7 High educated (6–10 years)	
		M	SD	*M*	SD	*M*	SD
Age 18–28	MMSE	25.40	3.86	22.85	3.57	27.42	1.81
	KNT Score	53.90	3.54	52.5	4.27	52.85	3.62
	L2 speaking proficiency	0	0	1.71	1.38	2.85	1.06
	L2 reading proficiency	0	0	.71	.95	1.85	1.34
	L2 writing proficiency	0	0	.71	.95	2.28	1.38
		N = 8		N = 8		N = 7	
		M	SD	*M*	SD	*M*	SD
Age 60–85	MMSE	24.37	3.15	26.50	1.60	26.14	1.77
	KNT Score	42.25	4.92	47.12	8.57	50.14	3.80
	L2 speaking proficiency	0	0	.87	1.12	1.85	1.06
	L2 reading proficiency	0	0	1.25	1.75	2.42	1.27
	L2 writing proficiency	0	0	1.25	1.75	2.57	1.39

Note. One participant was omitted as an outlier (age = 85, MMSE = 28, L2 speaking proficiency = 4, L2 reading proficiency = 4, L2 writing proficiency = 4, and KNT score = 19).

individuals living in the rural area where the confrontation naming test was conducted. Prior to running the confrontation naming study, since no frequency measure of Kashmiri words exists, we spent time with two families in the area where testing would take place (approximately 10 members ranging in ages 16–90) and enquired about picturable items that we deemed to be of low, middle, and high frequency. Sixty items that all the family members of different age levels and education ranges agreed upon as belonging to low (N = 20), middle (N = 19), and high (N = 21) word frequencies were used in the KNT (see Appendix A). Furthermore, the 60 nouns chosen for the KNT would have been acquired in daily life outside the school. In the test itself, the items were not ordered according to difficulty. Since this was the first time illiterates were in a testing situation, we did not want fatigue to influence naming of low frequency items. Furthermore, actual color photographs of the items were used in the KNT because illiterates have difficulty recognizing black and white line drawings [29].

2.2.2. Proficiency Questionnaire. A proficiency questionnaire (Appendix B) was designed to investigate educated participants' L2 proficiency and usage. L2 proficiency was investigated by asking the educated participants to rate their Urdu speaking, reading, and writing proficiencies on a 0–4 scale (0 = no ability, 1 = poor, 2 = functional, 3 = good, and 4 = excellent). We also asked which language was their regularly spoken language (for all it was Kashmiri) and whether they were educated in Kashmiri or Urdu in case some participants might have been educated in Kashmiri although that is not standard in this region; none were.

2.2.3. Adapted Mini-Mental State Exam (MMSE; [30]). The Mini-Mental State Examination (MMSE; [30]) is a widely used neuropsychological test to screen for cognitively impaired or demented individuals. MMSE is a brief and reliable test used in a large number of epidemiological studies [31] and consists of 12 questions which measure various cognitive domains such as memory, orientation, and praxis. This test can be translated and adapted into various languages to make it culturally valid for the populations being tested [32, 33].

There is no official translation of MMSE into Kashmiri and individual doctors may translate the English MMSE into Kashmiri for use with patients. However, relying on an English MMSE for our population would be problematic since it includes items that are culturally inappropriate. For example, the English MMSE asks participants to name hospitals and buildings but rural areas in Kashmir do not have major buildings or hospitals. Thus, we took as a base for our Kashmiri version of the MMSE a Hindi version of the MMSE since it was designed for a similar rural population (see [32] for details). The initial translation was done by an educated Kashmiri speaker and then checked by a professional translator for translation accuracy. The final version of the Kashmiri MMSE was also checked by a local neurologist. Our aim for using the Kashmiri MMSE was to screen participants for any cognitive impairment since we were only interested in naming in healthy older adults. The cutoff score we selected in advance for all participants was 19 out of 30 as Ganguli et al. [32] had used in their study of Hindi speakers. All participants tested met this criterion.

2.3. Procedure. The testing was conducted by a native speaker of Kashmiri in the participants' homes. Before the testing session began, the participants were informed about the tests they would be asked to complete. Since this was the first time the illiterates were in a testing situation, extra care was taken to make them feel comfortable with the investigator and his research assistant. For example, it was the first time some of the older individuals had seen the laptop and they had to be made comfortable looking at the computer screen (e.g., by comparing the computer to a television).

Table 2: Descriptive statistics for variables in the hierarchical multiple regression.

Variable	M	SD	Q_1	Mdn	Q_3	100 × Pearson correlation 1	2	3	4	5	6
(1) Age (years)	47.40	25.62	24	28	75	—					
(2) Education	4.15	3.71	0	5	8	−3	—				
(3) L2 speaking	1.11	1.36	0	1	2	−18	75**	—			
(4) L2 writing	.96	1.37	0	0	2	12	68**	68**	—		
(5) L2 reading	1.04	1.46	0	0	2	8	73**	71**	96**	—	
(6) Naming	49.85	6.32	47	51	56	−57**	18	20	4	9	—

Note. $N = 47$ participants (1 omitted as an outlier). Q_1 = 1st quartile, and Q_3 = 3rd quartile.
$^{**}P < .01$.

Table 3: Results from the five-step hierarchical multiple regression, predicting naming.

Predictor	Step 1 b	Step 1 β	Step 2 b	Step 2 β	Step 3 b	Step 3 β	Step 4 b	Step 4 β	Step 5 b	Step 5 β
Intercept	49.85**		49.85**		54.16**		52.85**		54.73**	
Age[a]	−.14	−.57**	−.15	−.58**	−.12	−.48**	−.12	−.46**	−.09	.37**
Education[a]	.28	.16	.30	.18	.09	−.04	.09	.05	.07	.04
L2 speaking[a]			−.46	−.11	−.05	−.01	.55	.12	1.85	−.39
L2 writing[a]			−1.12	−.24	−1.11	−.24	−1.84	−.40	−5.40	−1.16
L2 reading[a]			1.38	.32	1.53	.35	1.73	.40	4.40	1.00
Age squared[b]					−.01	−.30*	−.01	−.21	−.01	−.28*
Age × education[b]							.02	.27*	.00	.02
Age × L2 speaking[b]									.10	.55*
Age × L2 writing[b]									−.20	−1.12
Age × L2 reading[b]									.16	.94
R^2	.35		.36		.44		.49		.57	
F for R^2	12.05**		4.70**		5.22**		5.43**		4.70**	
ΔR^2			.01		.07		.05		.07	
F for ΔR^2			.20		5.44*		4.20*		2.06	

Note. $N = 47$ participants (1 omitted as an outlier). b = estimate of unstandardized partial regression coefficient. β = estimate of standardized partial regression coefficient.
[a]Centered at sample mean (see Table 1). [b]Square or product computed from centered variable(s).
$^{*}P < .05$. $^{**}P < .01$.

After the informed-consent procedure was carried out, the participants were administered the literacy test and then the adapted Kashmiri MMSE. After a 10-minute break, the KNT was administered to the participants. The participants were shown pictures of the 60 items on the KNT one by one on a laptop computer. The participants' responses to the items were recorded on a scoring sheet. If the participants did not give an answer in 30 seconds, a phonemic cue was provided. A phonemic cue was also provided if the participant described the item but could not name it. The overall correct responses only reflected items that were named correctly without the use of phonemic cues. After the KNT was administered, the educated participants were asked to fill out the L2 proficiency and usage questionnaire.

3. Results

The internal consistency of the 60 items that comprise KNT was measured by obtaining Cronbach's alpha coefficient. The analysis revealed a high alpha coefficient (Cronbach's $\alpha = 0.895$) indicating that items on the KNT are internally consistent.

Descriptive statistics and Pearson correlations are reported in Table 2. In all the analyses below, we only analyzed data from 47 participants because one of the participants was omitted as an outlier on the naming test. Age and KNT scores were significantly correlated, $r = -0.57$, $P < 0.01$. There was also a significant correlation between education and L2 speaking $r = 0.75$, $P < 0.01$, education and L2 writing $r = 0.68$, $P < 0.01$, and education and L2 reading $r = 73$, $P < 0.01$.

Hierarchical multiple regression (HMR) was used to test how age, education, L2 speaking, L2 reading, and L2 writing predicted KNT scores (Table 3). In order to avoid problems of multicollinearity we centered age, education, L2 speaking, and L2 reading and writing at their respective means (see Table 2). Since most studies have found that age and education significantly predict naming scores, we entered them in step 1 of our analysis. The results of step 1 indicated that these two independent variables (age and education)

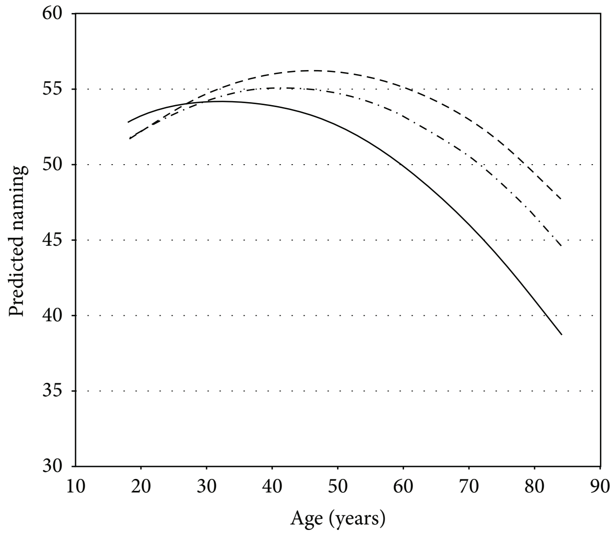

Figure 1: Estimated nonlinear effect of age (age^2) for high education high proficient bilinguals (education = 10, L2 proficiency variables = 3), low-educated low proficient bilinguals (education = 4, L2 proficiency variables = 2), and monolingual illiterates.

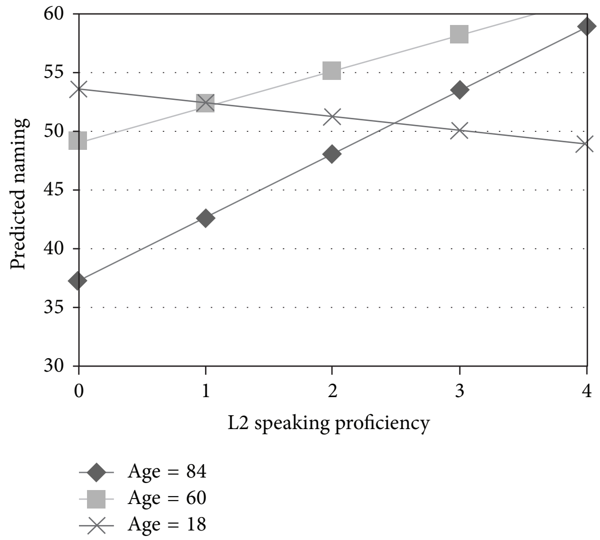

Figure 2: Estimated effect of L2 speaking proficiency on naming (mean values for education, L2 reading, and writing proficiencies).

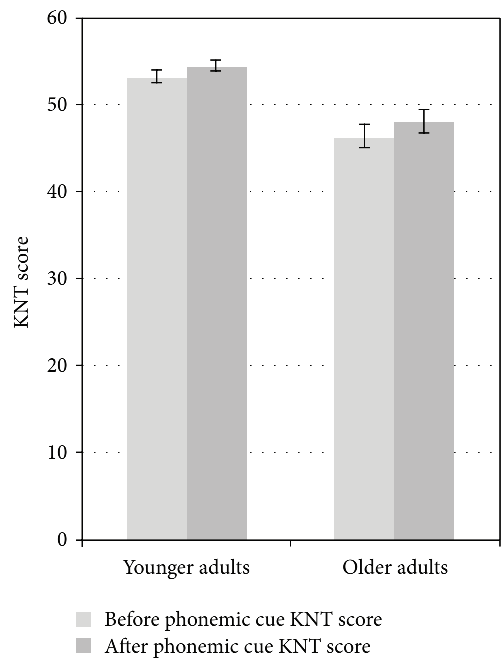

Figure 3: Mean KNT scores before and after phonemic cues.

accounted for 35% of the variance, which was statistically greater than zero, $F(2, 44) = 12.05$, $P < 0.01$. Age was the only statistically significant independent variable ($\beta = -0.57$, $P < 0.01$). In step 2, the 3 bilingualism self-rated proficiency modalities (L2 speaking, L2 reading, and L2 writing) were entered into the regression equation. The change in variance accounted for (ΔR^2) was 1% and not statistically significant, $F(3, 41) = 0.20$, $P > 0.05$. Thus, the bilingual proficiency modalities (L2 speaking, L2 reading, and L2 writing) did not themselves significantly predict naming scores in L1.

We also investigated whether the age effect was quadratic, entering age^2 into step 3 of our analysis (Table 3). The quadratic effect of age was significant ($\beta = -0.30$, $P < 0.05$) as illustrated in Figure 1. Age X Education interactions were entered into step 4 of our analysis (Table 3). The Age X Education interaction was a significant ($\beta = 0.27$, $P < 0.05$) predictor of naming such that the advantages of greater education increased with advancing age. Age X L2 Speaking, Age X L2 Reading, and Age X L2 Writing interactions were then entered in step 5 of our regression analysis (Table 2). Only the Age X Speaking L2 interaction significantly predicted ($\beta = -0.55$, $P < 0.05$) naming such that the proficiency of L2 speaking contributed more to L1 naming with advancing age (Figure 2).

As well, we investigated whether lexical frequency affects KNT scores and if they are modulated by age, education, L2 speaking, L2 reading and L2 writing measures. A repeated measures ANOVA indicated that naming scores differed across different lexical frequencies, $F(2, 52) = 34.5$, $P < 0.05$. Pairwise comparisons revealed that naming scores were the lowest for the low frequency words. There was no significant interaction between lexical frequencies and age, education, or any of the L2 variables.

Additionally, we investigated whether participants' scores significantly improved after the use of phonemic cues. A mixed model ANOVA indicated that KNT scores improved after the use of phonemic cues $F(1, 45) = 26.47$, $P < 0.05$ for both the older and younger adults (see Figure 3). There was no interaction between age and KNT scores $F(1, 45) = 0.57$, $P > 0.05$ such that the phonemic cues did not differentially benefit one group more than the other.

4. Discussion

The BNT and its various versions are commonly used in cross-national studies to test confrontation naming in older adults (e.g., [8]). The BNT was developed for a North American population and cross-national studies using the BNT have found that some of the items are not culturally appropriate for other populations [34]. For example, items such as "unicorn" on the BNT are not culturally relevant to rural areas of Kashmir and thus it was not appropriate to include them. Thus, we devised a culturally appropriate 60-item naming test to address whether age, education, and bilingual modalities (reading, writing, and speaking proficiencies) affect confrontation naming.

Our study indicates that naming declines with advancing age in our population. The decline is curvilinear (Figure 1) in that confrontation naming scores increase in early adult years and then decrease with an accelerating decline, particularly after the age of 70 (as in [35]). Of course, since our study does not have confrontation naming scores for participants aged 29–59, the pattern our model estimates for that age range should be interpreted with caution. Nevertheless we note that our model provides striking parallels to the findings of the Language in the Aging Brain Laboratory for a higher-educated monolingual older-adult population (e.g., [15, 36]). In addition, the inflection point in our illiterate participants is similar to that of Goral et al. [4] for their higher-educated (16 years) and less-educated (12 years) participants alike, around age 36.

The age-related decline observed in our study can be explained by the Transmission Deficit Hypothesis [37]. Specifically, this model involves networks of processing units divided into lexical, phonological, and semantic nodes which are connected to each other. During the process of word retrieval, the concept of the word in the semantic system activates a lexical node which in turn primes the phonological node so that the correct word is produced. The amount of priming is dependent upon strength of connection between the nodes. If the connection between the nodes is weak, lexical retrieval of the words is difficult [4]. According to the TDH model, older adults face lexical retrieval difficulties due to a decreased amount of priming resulting from a weakening of connections between different nodes. Our results show that after the age of 70, naming decline is rapid, suggesting that the connection between lexical, semantic, and phonological nodes is rapidly weakening, consistent with the TDH model.

The TDH model has also been used to explain the Tip-of-the-Tongue (TOT) phenomenon which occurs in older adults due to weak connections between lexical and phonological nodes [3]. The TOT phenomenon occurs when individuals are certain that they know the name of the target or can either define or else provide partial phonology of the target but cannot retrieve the full name unless some sort of cue is provided [3]. Indeed, a mixed model ANOVA indicated that the phonemic cues improved scores of younger and older participants equally ($P > 0.05$, see Figure 3).

In contrast to aging, education per se did not have an effect on L1 naming in this study. This is consistent with a number of studies [9, 20, 38–40]. Furthermore, our results are not surprising, because we only included items on our confrontation naming test that were part of the culture and individuals of all educational backgrounds had acquired them in early life. According to Juhasz [36] and others (e.g., [41]) words learned earlier in life are processed with greater accuracy and faster than those learned later. Moreover, as a result of the way items were selected for the KNT, it is possible that the lexical target nouns were not the ones that were learned in schooling. Perhaps the education effect found in some but not all studies of naming and aging occurs only when school-learned items (e.g., protractor, compass) are among the targets.

However, we found an Age X Education interaction such that older illiterates performed worse than older educated adults, even though we had selected target items that are the ones learned not in school but in daily life. Our results were consistent with Welch et al. [16]. The interaction between education and age-related decline on naming in older adults could also be explained by a model developed by Capitani et al. [42]. They proposed three different possible outcomes for interaction between age-related decline and education on neuropsychological tests: (1) parallelism: the age-related decline runs the same course in different educational groups (i.e., no interaction); (2) protection: the age-related decline is attenuated in well-educated participants; (3) confluence: the initial advantage of well-educated groups in middle age is reduced in later life. Our results support the protection hypothesis, even though our better-educated older adults do not have the same degree of high education as those in the Capitani et al. [42] study.

With regards to whether bilingual proficiency affects naming, we did not find an individual bilingual modality effect. It is possible that individual bilingual modalities did not affect confrontation naming because our population was atypical of the bilingual populations generally studied in the bilingualism literature. Our bilingual participants did not read and write in their L1 but only spoke it. Also, the lexical items of their rural home environment may not overlap with the academic L2 taught at school, so perhaps there was no interference from being bilingual on the items tested in the KNT. Since the participants were dominant in their spoken L1, it is possible that there was no distraction from their L2 which could inhibit L1 production as Kroll et al. [43] posited that it should. However, we did find an Age X L2 Speaking interaction such that older bilinguals did better than older monolingual adults on L1 confrontation naming.

Though bilingualism has been found to attenuate other age-related cognitive decline (e.g., [44]), it has been reported to adversely affect picture naming in both younger and older adults (e.g., [25, 26]). Studies that found bilingualism impacted picture naming adversely (e.g., [26]) did not specifically investigate whether bilingualism interacted with age as we did here. Furthermore, in these studies, the effect of L2 speaking proficiency specifically on naming was not investigated. Our results suggest that speaking a second language may attenuate age-related decline in picture naming in the first language. We did not find an L2 reading or writing interaction with age, which suggests that it is L2 speaking ability that matters the most. Bialystok et al. [44]

found a bilingual advantage for working memory tasks in older bilingual adults compared to monolinguals. Our data suggest that it would be important to look at specific bilingual modalities to determine how proficiency in them affects different tasks. It is possible that speaking ability was a major determinant in Bialystok et al. [44] study. Nevertheless, our results further extend the bilingual advantage to age-related naming decline and refine our understanding to focus on L2 speaking proficiency.

Both the Age X Education interaction and Age X L2 Speaking interaction that we found could be explained by the cognitive reserve hypothesis. The cognitive reserve hypothesis states that individual differences in how tasks are processed reflect differences in how the brain copes with brain injuries and age-related changes [45]. According to this hypothesis, educated individuals and bilinguals may have greater neural reserve (brain or cognitive networks) as a result of engagement of cognitive processes in acquiring new information and in using more than one language. The increased neural reserve in these individuals serves to protect them against the negative effects of aging and potential brain injuries [46, 47]. It is possible that being educated and being proficient in a second language increased the older individuals' neural reserve and this benefited them in their old age.

Our study also addresses the suggestion of Gollan et al. [48] that the benefits of bilingualism may only be conferred on those with low education. Gollan et al. [48] found that higher degrees of bilingualism delay the onset of Alzheimer's disease only in individuals with less than 12 years of education. The authors suggest that higher-educated individuals did not benefit from bilingualism because at higher educational levels the power of cognitive reserve has reached its upper limit and thus there is no further benefit of bilingualism on cognitive reserve. Our study is consistent with this claim in that none of our participants had greater than 10 years of education and the combination of bilingualism and education appears to have benefited them in picture naming in their first language because they had not reached the posited upper limit of cognitive reserve. However, it is important to keep in mind that further studies are needed to better understand the nature and limits of cognitive reserve.

As others have observed (e.g., [21]), it is challenging to test illiterate populations because the participants may not understand the concept of testing and may never have been in a testing environment. We dealt with this challenge by testing individuals in their homes and providing substantial training on the task before testing began. Moreover, we created a culture-appropriate set of photographs of items whose names ranged from high to low frequencies to permit success on the task yet provide the opportunity for variable performance. Our test also included only those items whose names would have been acquired outside of school, thus eliminating the possibility of having educationally biased items.

A conceptual challenge we faced was the confounding of education and bilingualism in our study, although we were fortunate that even individuals in the same education brackets ranged in their L2 proficiency. Further indication of the confounding of education and bilingualism in our study

Table 4: Kashmiri Naming Test.

Item name	
(1) "Bael"	Shovel
(2) "Khrav"	A type of wooden slipper
(3) "Nadur"	Lotus stem
(4) "Bugin"	A type of earthen piggybank
(5) "Rabab"	A guitar-like musical instrument
(6) "Traam"	A special plate on which four people can eat
(7) "Kukur"	Chicken
(8) "Pheran"	Woolen cloak worn in winter
(9) "Wukhul"	A small stone pestle
(10) "Hangul"	Kashmiri stag
(11) "Phot"	A large wooden basket
(12) "Tsong"	Earthen lamp
(13) "Kangir"	Earthen fire-pot to keep warm in winter
(14) "Balteen"	Bucket
(15) "Tsery"	Dried apricots
(16) "Radio"	Radio
(17) "Aal"	Gourd
(18) "Booni"	Chinar tree
(19) "Grayti"	A large stone grinder used in farms
(20) "Bushkaab"	A type of plate in which men and boys eat
(21) "Daan"	A specific type of clay hearth with an oven
(22) "Latsul"	Broom
(23) "Muhul"	A large pestle used in farms
(24) "Doyn"	Wooden churner
(25) "Takar"	Basket
(26) "Martoor"	Claw hammer
(27) "Birbatayn"	Wooden toy
(28) "Haak"	Kale
(29) "Tsuchwur"	A type of bagel
(30) "Dandabrush"	Toothbrush
(31) "Dukaeer"	Scissors
(32) "Naaw"	Boat
(33) "Haaput"	Bear
(34) "Yander"	Spinning wheel
(35) "Karakuli"	A type of hat worn by men
(36) "Kang"	A clay pot for used for burning coal
(37) "Tsestan"	Needle
(38) "Pambach"	Lotus seed head
(39) "Tash"	A utensil used for draining water when washing hands
(40) "Chumta"	Tongs
(41) "Aalbayn"	A specific type of plow
(42) "Zoon"	Yolk
(43) "Pulhor"	Grass slipper
(44) "Hayr"	Ladder
(45) "Haydar"	Mushroom

Table 4: Continued.

Item name	
(46) "Tumbaknar"	A drum-like musical instrument
(47) "Khat"	Sheep
(48) "Chilim"	Clay pipe for preparing tobacco
(49) "Kaynz"	A type of plate from which women and girls eat
(50) "Nalka"	Tap
(51) "Satut"	Hoopoe
(52) "Palas"	Plier
(53) "Droot"	Grass sickle
(54) "Dul"	A type of earthen pot for liquids
(55) "Kangin"	A type of wooden comb
(56) "Manzul"	Wooden crib
(57) "Watne-gur"	Wooden baby walker
(58) "Nai"	Flute
(59) "Gantebayr"	Kite
(60) "Anyut"	A type of earthen lid

is seen in the result from HMR reported in Table 2. Note that when the Age X L2 proficiency interaction was added at step 5, the Age X Education term was no longer significant, strongly suggesting that L2 proficiency and education, not surprisingly in this population, measure similar things. Only a study in a population where L2 proficiency and years of education can be dissociated could resolve the question of the relative contributions of each to naming in aging and, one would hope, to cognitive reserve more generally.

Our efforts at confronting the challenges permit us to report on naming in younger illiterates whereas prior studies have only found illiterates among older adults (e.g., [9]), showing that illiteracy along with monolingualism does not result in poorer L1 naming accuracy in 18–29 year olds. These results support the claim that naming declines most precipitously after age 70 and permit us to argue that young illiterates and monolinguals are not at a disadvantage compared to their age-matched educated and bilingual counterparts when it comes to lexical retrieval. However, it is possible that younger illiterates are slower in naming than their younger educated and bilingual peers. Further investigation is needed to understand whether education benefits naming latencies at any age.

In light of the challenges of testing a low-educated rural population among whom age must be estimated based on memory for salient historical events, it is all the more impressive that our results revealed age-related naming declines very similar to those reported among higher-educated Western populations. Furthermore, our study was also unique in that even our educated participants had low ranges of education (1–5 and 6–10 years) and thus we were able to determine that even in a population with few years of education by Western standards, more education and L2 proficiency offset naming decline in older age.

We note that even though KNT was designed for a healthy population, it could also be employed or adapted (e.g., by reducing the number of items or by excluding the low frequency items) to investigate the naming performances of individuals with aphasia and individuals suspected of having dementia. Furthermore, since the KNT has items of varying frequency, one could also investigate how errors in different types of aphasia and dementia might be related to word frequency levels.

Appendices

A.

See Table 4.

B. Proficiency Questionnaire

Please select your level of education:

Grade 1: ☐
Grade 2: ☐
Grade 3: ☐
Grade 4: ☐
Grade 5: ☐
Grade 6: ☐
Grade 7: ☐
Grade 8: ☐
Grade 9: ☐
Grade 10: ☐

Please select your language of education:

Urdu: ☐
Kashmiri: ☐

Spoken language:

Urdu: ☐
Kashmiri: ☐

What was the age of acquisition of your languages?

Kashmiri__________ Urdu__________

What language do you speak the most? __________

Where do you speak Urdu? __________

Do you read Urdu? __________

How much Urdu do you read? __________

Do you write in Urdu? __________

How much Urdu do you write? __________

When is the last time you spoke in Urdu? __________

When is the last time you read in Urdu? __________

When is the last time you wrote in Urdu? __________

Please rate your spoken Urdu proficiency (0 = no ability, 1 = poor, 2 = functional, 3 = good, and 4 = excellent).

Please rate your written Urdu proficiency (0 = no ability, 1 = poor, 2 = functional, 3 = good, and 4 = excellent).

Please rate your reading proficiency in Urdu (0 = no ability, 1 = poor, 2 = functional, 3 = good, and 4 = excellent).

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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