Acquisition and Discrimination of Language in Simultaneous-Bilingual Infants

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This review examines the neurocognitive correlates of simultaneous language acquisition, primarily focusing on children under the age of 14. It will examine the associated linguistic and neurological processes including the following: discrimination and selection, prosodic classification, inhibitory control, and code switching. These processes employ cognitive systems unique from those of monolingual communication and even cause alterations in neuroanitomical structure. Analysis of these alterations will be presented in the forms of functional magnetic resonance imaging (fMRI) and near infrared spectroscopy (NIRS). Additionally, the review will also investigate the presence of a developmental disparity between monolinguals and bilinguals, considering several major hypotheses regarding causation and seeking to determine long-term impact.

1 Introduction

Code-switching refers to the practice of alternating between two or more languages or varieties of language in a single utterance.(Yow, Tan, and Flynn, 2017). Although there has been research analyzing the relationship between code-switching, language discrimination, and the cognitive linguistic mechanisms employed by bilingual individuals, the field remains relatively unexplored with a great deal of the literature highlighting some of the flawed models that are commonly accepted for evaluating linguistic development and literacy. Contemporary research is presenting alternative theories on the manner in which the minds of bilingual individuals operate with respect to language discrimination.

As asserted in (Werker and Byers-Heinlein, 2008), one of the current flaws within the study of bilingualism and phenomenon of code-switching lies in the dominance of studies dealing with *sequential* bilingualism, while simultaneous-specific studies represent a comparatively minor portion of the field and hypergeneralize two entirely distinct cognitive processes. Similarly, (Yow, Tan, and Flynn, 2017) points out the erroneous hypotheses of early studies on children's language alternation behaviors which asserted that code-switching occurs as a result of confusion or linguistic incompetence. The reality is that code-switching can oftentimes be a sign of greater linguistic competency. Despite the flaws of research within the field, novel and critical data is emerging from studies such as (J. Abutalebi et. al, 2007), refining scientific understanding of the processes at work within the bilingual brain. This review will examine these cognitive processes through review of the aforementioned studies, aiming to provide a cohesive and analytical synthesis of the most current consensuses within the field in relation to cognitive cost and developmental compensation.

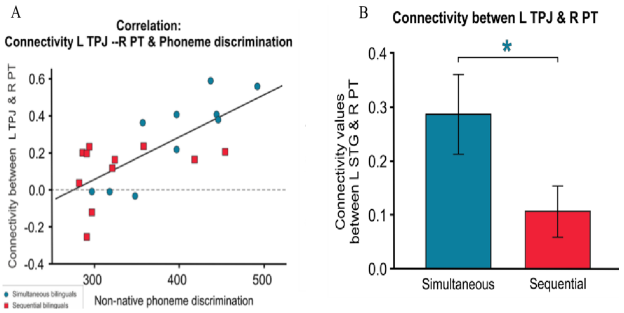

Figure 1: *Simultaneous vs Sequential Discrimination of Phonemes (D. D'Souza, 2018)*

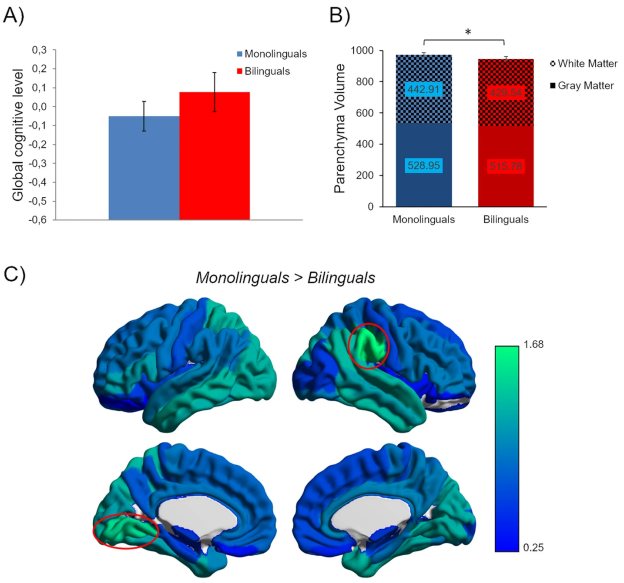

Figure 2: *Cross-Sectional MRI From (V. Costumero et. al, 2020)*

2 Findings

A seminal work backing the separation of simultaneous and sequential bilingualism in linguistic research is (D. D'Souza, 2018). As distinguished by cross-sectional FMRI analysis, there is a significant difference in the neurological mechanisms employed for acquisition, storage, discrimination, and code-switching between simultaneous and sequential bilinguals (See Fig. 1), along with differing overall developmental patterns and distribution of cerebral matter (See Fig. 2).

2.1 Discrimination and Selection

Monolinguals are able to treat all speech as components of a single language, whereas multilinguals require the additional step of discrimination and selection of languages prior to both input and output. As shown in (Bosma and Pablos, 2020) and further proven by (Han, Li, and Filippi, 2022), there is a measurable cognitive cost associated with this process.

2.2 Prosodic Classification

Among the distinguishing characteristics of language, prosodic features such as rhythm, intonation, stress, and tempo provide a significant majority of the information required for interlingual discrimination. As such, languages are divided into the following isochronic classifications: Syllable timing, Stress timing, and Mora timing.

Syllable-timed languages, such as Mandarin Chinese, tend to give syllables approximately equal prominence and generally lack reduced vowels, depending instead on intonation. Stress-timed languages, such as English, depend on syllable emphasis through changes in stress, sonority, duration, and vowel reduction.

Despite the relative simplicity of the aforementioned classifications, languages do not fit quite so easily into such precise categories in real-world applications. Languages exhibit degrees of durational variability both in relation to other languages and to other dialects of the same language. For example, there can be varying degrees of stress-timing within the various dialects of a language. Some southern dialects of Italian, a syllable-timed language, are effectively stress-

timed (M. Grice, M, D'Imperio, et. all, 2010). English, a stress-timed language, has become so widespread that some regional standards tend to be more syllable-timed than their British or North American counterparts, an effect that comes from the influence of other languages spoken in the relevant region.

The creation of the Mora class was a result of this incongruous conformity to the aforementioned classes. Mora timing is essentially a subcategory of syllable timing, relying on phonemes rather than syllables, a smaller unit of sound. Its exact definition has undergone several revisions in response to a variety of dissenting experimental findings, but nonetheless, provides a valuable framework for determining the prosodic fit of a nonconforming language or dialect.

	Teachers' ratings of English competency (T2)			
Predictor (T1)	R^2	ΔR^2	F	β
Step 1:	.25**		9.20**	
Age				.50**
Step 2:	.36*	.11*	7.40**	
Age				.41*
Percentage of code-switched utterances				.34*
Step 3:	.70***	.34***	14.01***	
Age				.29*
Percentage of code-switched utterances				.36*
English NDWR per minute				.60***
PPVT standard scores				.21

Figure 3: *Hierarchical Regression, Competency Prediction (English) (Yow, Tan, and Flynn, 2017)*

	Teachers' ratings of Mandarin competency (T2)			
Predictor (T1)	R^2	ΔR^2	F	β
Step 1:	.08+		4.00+	
Age				.28+
Step 2:	.27**	.19**	8.47**	
Age				.12
Percentage of code-switched utterances				.46**
Step 3:	.51***	.24***	15.68***	
Age				.05
Percentage of code-switched utterances				−.15
Mandarin NDWR per minute				.80***

Figure 4: *Hierarchical Regression, Competency Prediction (Mandarin) (Yow, Tan, and Flynn, 2017)*

2.3 Developmental Impact

Early studies of bilingual infants raised concerns regarding potential adverse developmental effects of simultaneous acquisition. Most notably, (Genesee, 1989) found observable and measurable delays in the development of simultaneous bilinguals in early infancy. Known as the Unitary Language System Hypothesis, this discovery rightfully caused significant concern. While the data is legitimate and affirmed, the temporal scope was limited (ages 0-2), leaving long-term effects misunderstood.

Several studies have attempted to replicate (Genesee, 1989) and determine long-term validity of the Unitary Language Hypothesis, yet almost all have determined it to be incorrect. While studies like (Yow, Tan, and Flynn, 2017) have affirmed the presence of a developmental delay between ages 0-2, continuation of analysis to early adolescence found evidence suggesting a significant increase in linguistic competency. The study postulates that this increase is heavily dependent on the frequency of code-switching during infancy, due to the close correlation between teacher-reported competency scores and recorded switching frequency in individual subjects. (See Figure 3, Figure 4)

Furthermore, there is strong evidence that early bilingualism and code-switching create structural, functional, and neuroanatomical adaptations that increase reading fluency as cross-linguistic literacy develops. Especially when encountering irregular lexemes, Functional near Infrared Spectroscopy analysis from (Jasińska, 2017) shows "hyperactivation in left posterior temporal regions associated

with direct sound-to-print phonological analyses" and "hypoactivation in left frontal regions associated with assembled phonology analyses" (See Figure 5).

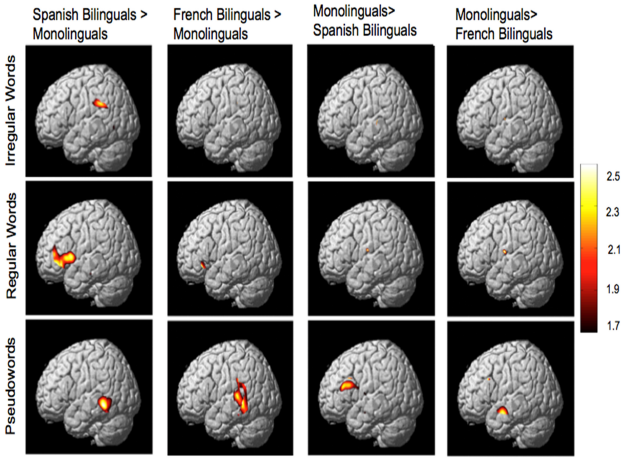

Figure 5: *differences in brain activation during the English reading tasks (Jasińska, 2017)*

3 Discussion

The main goal of the present review was to examine the cognitive processes associated with early simultaneous bilingualism and its developmental impacts, simplifying the available research and reporting on the overall consensus within the field. Among the reviewed articles, the most frequent age group studied was preschool children (2-6 years), followed by school-aged children (6–14 years).

Across all age groups examined, significant cognitive and neurological differences in language processing were observed, a trend that parallels the adult bilingual literature. Beyond, these cognitive differences, there is a consistent exhibition of delayed development in preadolescent stages, followed by higher levels of linguistic competency in adolescence after reaching operational literacy in both languages. Additionally, the usage of code-switching was observed in nearly every single individual subject of the reviewed publications and is very likely a key factor in linguistic development.

4 Conclusion

Due to the intricacy of the field and variation in experimental findings, few conclusions can be accepted with absolute certainty. All of the reviewed publications call for further investigation of their respective findings and struggle to agree on exact methods and metrics for quantifying such complex cognitive functions.

Notwithstanding these circumstances, three core differences in language processing between monolinguals and bilinguals can be understood through the synthesis of data from these publications. First, the requirement for discrimination amongst bilinguals comes with a measurable cognitive cost throughout the entire age range. Second, the influence of simultaneous bilingualism, both on cognition and developmental timeline, comes in varying degrees of magnitude, depending on the proximity of the languages with respect to their rhythmic classifications and their proportional levels of exposure. Third, there are definite structural neuroanatomical differences between monolinguals and bilinguals, some possibly advantageous in the process of learning to read. Likewise, these differences come in varying degrees of prevalence and likely depend on comparative exposure in early childhood as a product of heightened neuroplasticity.

Progress in the understanding of these differ-

ences has raised critical questions about their roles in development and sparked an ongoing discussion in regard to suppression of code-switching and tailoring of content in early and primary education. While these questions cannot be answered here, this research provides an essential framework and background of data to evaluate these quandaries.

Citations

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