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Original Article

Psycholinguistic Study of Code-Switching among Bilingual Speakers in Multilingual Communities

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Abstract: *Code-switching, a multifaceted line of study and observation in bilingual communication, is defined as the use of two or more languages alternately within a discourse. And it demonstrates bilingual speakers' cognitive flexibility and social knowledge alongside their linguistic ability. Drawing on cognitive and sociolinguistic approaches, the present paper examines the psycholinguistic mechanism of code-switching in bilingual speakers living in a multilingual society. The paper explores how lexical access, inhibitory control and social context interact in modulating code-switching behavior taking into account data from spontaneous conversational corpora and controlled experimental paradigms. Twenty early bilinguals in urban multilingual environment were selected for the study. In comparison to experimental picture naming and lexical decision tasks addressing error rates and reaction times in switch versus non-switch trials, the corpus included 100 hours of spontaneous speech that was analysed with respect to the frequency of switching as well as grammatical category and discourse function. Executive function and its modulation of linguistic interference were also examined through Simon and Stroop tasks assessing cognitive control. The findings indicate that switching has measurable reaction-time costs (average increase ≈180 ms), with especially strong costs for the less dominant to the more dominant language, and that switch costs are smaller in individuals with stronger inhibitory control. Most within-sentence shifts, especially those of nouns and discourse markers, are lexically motivated and cluster at grammar boundaries as verified by corpus analysis. These effects suggest that top-down control mechanisms determining language use contextually and linguistic specific lexical co-activation across languages dynamically mesh in the production of code-switching.*

In sum, the study provides support for a hybrid cognitive – sociolinguistic model of code-switching which characterizes it as both a functional strategy to facilitate communication in multilingual settings and an index of proficiency in bilingual language control. The results contribute to our understanding of how bilinguals efficiently navigate multiple language systems and adjust their language use according to cognitive and social challenges. Implications for education policy, instruction in multilingual society, and theories of bilingual language processing are discussed.

Keywords: *Multilingualism, Cognitive Processing, Speech Production, Lexical Access, Language Control, Psycholinguistics, Code-Switching, Bilingualism, Sociolinguistics.*

I. INTRODUCTION

Language as a cognitive and social system has a long-lasting influence on the way people think, communicate, and build their own identities. Bilingual speakers often alternate between languages in conversation in multilingual communities, where numerous languages coexist and are used simultaneously. This is known as code-switching. It is worth noting that this effortless mixing of language codes is not random, but captures complex interplay among social motivation, grammar representation and cognition. Code-switching studies in the field of psycholinguistics contribute important knowledge about how bilingual speakers manage mental workload during real time interaction and accessing lexical items from two languages with potentially different structures even outwardly regulate linguistic systems.

A. Understanding Code-Switching in Bilingual Cognition

Code-switching (cs) occurs when two or more languages are spoken in one discourse or even a sentence/utterance. It arises spontaneously in multilingual contexts where speakers strategically use a range of language resources to achieve social, cognitive and expressive ends. CS has traditionally been assumed to be a signal of language interference or deficiency. This notion, however, has been challenged by psycholinguistic and sociolinguistic research in the last few decades which emphasizes that code-switching reflects high levels of linguistic competence and cognitive resources among bilingual conversationalists (Grosjean, 1982; Bullock & Toribio, 2009).

The study of code-switching is a special window to multilingualian's language processing and control in psycholinguistics. Even when speaking in only one of the two languages, bilingual speakers rely on vocabulary and structures of both language systems (Dijkstra & van Heuven, 2002). Because of this nonselective access, bilinguals have to

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use inhibitory control (IC) mechanisms to prevent activation of the nontarget language when speaking the target language (Green, 1998). When a switch occurs, it might be due to purposeful communication strategies or transient activation changes, and reduced inhibition. Studying these shifts provides insights into how bilingual brains juggle two linguistic systems simultaneously.

B. Multilingual Communities as Natural Laboratories

In such multilingual societies as Singapore, India, and parts of Africa and Europe bilingualism is the rule rather than the exception; thus they offer an excellent situation in which to investigate code-switching. And speakers of all types, in specific, different sites, alternate between regional and national languages and world language depending on the situation and speaker. This diversity provides a natural laboratory to understand how the cognitive systems have adapted in response to complexity of language and social structure. Researchers can also investigate whether social identity, language proficiency, and dominance influence switching in the presence of many codes.

For instance in the speakers of urbancmultiligual ccommunities cas regional languages for solidarity, emotional expressions and ccccas English used to official or technical purposes. Switching choice may often be situational and can, thus, also be indicative of a match between sociopragmatic objective and cognitive preparation. Hence, in order to analyze it psycholinguistically it is necessary to know CS's dual condition as an act of communication which has social entailments on the one hand, and a cognitive event that involves the control of language on the other.

C. Theoretical Background and Motivation

Research on code-switching within the field of psycholinguistics is conducted with reference to two primary approaches. Selection of the bilingual language to be used is believed to involve inhibition of non target languages, and this model--the Inhibitory Control (IC) Model (Green, 1998)--entails that there should be a cost for switching in the form of response latencies. However, lexical access is language-nonselective as per the Bilingual Interactive Activation (BIA+) model (Dijkstra & van Heuven, 2002), i.e., activation spreads across both lexicons. When these models are integrated, it seems that switching reflects both topdown control, and automatic lexical coactivation. Most research, however, is conducted in laboratory environments, limiting this ecological validity.

In addition, from a sociolinguistic point of view (Gumperz, 1982; Myers-Scotton, 1993) switching is an identity, solidarity or power relation indicator instead of only being treated as a cognitive phenomenon. It is for this reason that an integration of sociolinguistic and psycholinguistic perspectives yields a full understanding of bilingual speech behavior. The current article extends this multicomponential approach and describes the cognitive and communicative aspects invoked during CS in naturalistic corpus data as well as in lab settings.

D. Research Aims and Questions

The aim of the this study is to look at the cognitive processes and psycholinguistic aspects of code-switching in multilingual communities with bilingual populations. In particular, it aims to:

- Examine how the amount and type of CS observed in naturalistic conversation are affected by factors involved in lexical access and inhibitory control.
- Estimate the processing costs of switching (from controlled experimental tasks: image naming, lexical judgment).
- Investigate how switch behavior and response time depend on social context, language dominance and the direction of the switch.

By combining cognitive tests with analyses of naturalistic corpora, the study bridges between experimental and everyday bilingualism. It assumes cognitive control mechanisms constrain the timing and direction of spontaneous shifts, with lexical co-activation promoting them. Understanding such processes may shed a new light on the cognitive flexibility of bilinguals and the evolution of human language.

E. Significance of the Study

By locating code-switching within a unified psycholinguistic and sociocultural perspective, this work constitutes a contribution to the field of bilingualism. It advances our understanding of how bilinguals manage inconsistent linguistic systems, inhibit interference, and strategically deploy language in interaction. Applications of the results include pedagogical, language policy and cognitive training in diverse multilingual communities beyond theoretical discussion. Recognising code-switching as a normal and sophisticated cognitive process challenges linguistic purism, advocating for teaching methodologies that leverage students' bilingual fluency as resource rather than as deficit.

II. LITERATURE REVIEW

The theoretical dimensions and the empirical bases that are relevant to psycholinguistic accounts of code-switching are brought together in this section. Major themes are: Models on bilingual lexical access models; Language control

mechanisms; Sociolinguistic accounts of switching, experimental techniques used in previous research and the rationale for the present study.

A. Psycholinguistic Models of Bilingual Lexical Access

Psycholinguistic models of bilingual lexical access attempt to predict how experimental variables will affect the CY and NG of bilingual individuals processing their To account for the fact that two or more linguistic systems coexist within a single cognitive system, psycholinguistic models of bilingual language processing are employed. One key ongoing debate is whether bilingual lexical access is selective or nonselective—whether bilinguals can only use one of their languages at a time or in contrast, both of their languages are active concurrently. Non-selective access is also supported by evidence that competition between lexical alternatives in both languages will occur because of spreading activation during word recognition or production (Dijkstra & van Heuven, 2002; Kroll & Bialystok, 2013). All these effects may be explained by the concurrent activation.

One of the most powerful computational accounts of this comes from the Bilingual Interactive Activation (BIA/BIA+) model which proposes that multiple levels of interactive activation at an orthographic, phonological and semantic level are required for bilingual word recognition. Like this view, the Revised Hierarchical Model (RHM) (Kroll & Stewart, 1994) proposes that speech production utilizes separate lexical stores but shared conceptual system and considers the strength of connections between languages to be determined by experience and proficiency. For bilinguals, as in both proposals, they have a lifetime of monitoring and controlling for co-activated representations. According to this view, code-switching might occur when competing lexical items attain comparable levels of activation, particularly if both languages are relevant. Since code-switching is a process through which bilingual speakers are assumed to come to terms with the high level of cross-linguistic competition that is consistently activated while speaking in two languages, it provides an excellent testing ground for theories of how bilinguals access their lexicon. The operations of this cognitive architecture that allows bilinguals to switch between linguistic systems with minimum difficulty without losing fluency or communicative intent, can be elucidated through understanding these mechanisms.

B. Language Control and Switching Costs

Bilinguals are able to retrieve different language codes through the mere activation of a code which is indistinctly chosen, yet with risk of interference they must be controlled by language management mechanisms. The dominant theory of the mechanism underlying how bilinguals manage language choice remains Green's (1998) Inhibitory Control (IC) model. According to this paradigm, the bilingual system operates by inhibiting the non-target language in order to enable smooth discourse in the target language. Speakers have to re-activate representations that recently were inhibited when they switch from one language to another, with associated measurable switch costs. These costs are typically reflected in slower response latencies or reduced accuracy on experimental tasks (Meuter & Allport, 1999). There is empirical evidence for such costs in comprehension and production. However, task demands along with linguistic dominance, proficiency and switch predictability all modulate the size of switching costs (Costa & Santesteban 2004; Verhoef et al. It is interesting to remark that switching towards the dominant language often comes at a higher cost as using the non-dominant language induces a stronger suppression of the dominant lexicon.

Recent studies have extended this model by including the function of domain-wide executive control establishing links between language control and other cognitive functions such as working memory, inhibition, and shifting (Declerck & Philipp 2015). The relation between bilingual language control and executive function is also consistent with neuroimaging findings that reveal activation of frontoparietal and anterior cingulate regions during different languages (Abutalebi & Green, 2016). Because code switching indexes the interplay between automatic activation and voluntary control, it provides a unique behavioral correlate of cognitive control in bilinguals.

C. Sociolinguistic Perspectives and Pragmatics

The sociolinguistic perspectives stress the communicative and social dimensions of code-switching, while psycholinguistics perspectives in turn provide understanding to its cognitive mechanisms. For scholars such as Gumperz (1982) and Myers-Scotton (1993 code-switching is in fact motivated, with pragmatic or interactional purposes rather than being triggered randomly. Social anthropologist John Gumperz introduced the concept of contextualization cues, in which language alternation signals shifts in topic, setting and/or participant relations. For example, a pretentious language such as English will communicate power and authority and a local dialect might create intimacy or solidarity. According to Myers-Scotton's Markedness Model, code-switching is a "struggle over rights and duties." Speakers make strategic use of language to negotiate social relationships and identities. In other words, codeswitching acts as a highly mediating instrument of the society, over identity and social expectations. Likewise Auer (1998) describes code-switching as a conversational strategy which contributes to the sequential organization of discourse.

Wider studies are needed to determine whether hybrid models that combine social and cognitive approaches (Bullock & Toribio, 2009; Gardner-Chloros, 2009) are really the best approach. In these frameworks, code-switching is driven by sociolinguistic mechanisms (identity performance and audience design) as well as psycholinguistic processes (lexical activation and inhibitory control). From this viewpoint, the process of comprehension of bilingual speech is one in which internal cognitive processes must also be matched to external communicative contexts. Based on this evidence, psycholinguistic research should consider how social factors affect the cognitive mechanisms of linguistic selection and switching.

D. Experimental Paradigms in Code-Switching Research

Experimental psycholinguistics offers a powerful set of tools for investigating the cognitive underpinnings of code-switching. The timing and neurological underpinnings of switching are probed by researchers using tasks such as picture naming, lexical judgment or eye-tracking- and event-related potential (ERP) paradigms. Especially frequent are just picture-naming tasks, which rely on language cues (e.g., flag symbols or colored signals) to prompt switches and quantify switch costs in terms of accuracy and reaction times (Gálvez & Costa, 2019). Inhibitory control is suggested by the observation that switch trials generally produce slower response times and more errors in participants than stay trials. As reported by van Heuven et al. (2008), as for lexical access, even though at present there is no evidence from LDTs and semantic priming paradigm to verify whether or not the process of lexical access remains language-nonselective in monolingual contexts by directly investigating comprehension function. Eye-tracking findings In line with the mature pattern of different patterns of fixation durations between languages in the comprehension (See section on long-term effects) and early head starts for some eye-movement measures which indicate a competition at stages as early as visual word recognition. According to Proverbio et al. (2004), ERPs provide neurophysiological evidence of the cost of code-switching. Surprising changes often lead to increased N400 and P600 components, reflecting problems in syntactic reanalysis or semantic integration processes respectively.

Although in the natural world there isn't a clear cut way to do lab tests, work outside of the lab is based on corpus and naturalistic studies that allow us to obtain[sic] ecological validity as well as an ability to see how people really code-switch when they speak off-the-cuff. A new window of opportunity exists for scholars to uncover how cognitive processes are at play in everyday language use, 3 thanks to recent ground-breaking advances that have synthesised corpus linguistics with psycholinguistic modelling (Gullberg et al., 2015). As a whole, these paradigms demonstrate that context-sensitive control and automatic lexical co-activation each modulate code-switching; they underscore the importance of using multi-method techniques (combining naturalistic observation and precise experimentation) to study this phenomenon.

E. Gaps and Rationale for the Present Study

There are still large gaps in connecting psycholinguistic models of language processing with the use of language, despite the enormous advances that have been made towards understanding bilingual language processing. Most existing research is based on well-controlled lab tasks that, while accurate, often fail to capture the social and contextual complexity of real-world bilingual communication. The cognitive dimensions of what makes some switches happen and/or be consciously regulated are thus usually not part of the research on sociolinguistic accounts of actual switch patterns. Lack of integrated approaches limits our understanding of how social meaning and cognitive control interact to affect code-switching. Individual differences represent another gap. Fewer studies have linked these measures of cognition to data collected during spontaneous speech, but numerous have explored the relationship between switching behavior and executive function. In addition, the prevalence of multilingual settings that are typologically extremely rich but wholely under explored in experimental research (most research on multilingual approach focuses on European language pairs e.g. English–Spanish, Dutch–English). To limit these constraints, there is a need to develop cross-disciplinary approaches that integrate behavioral, cognitive and corpus-based research.

These gaps are partly addressed in the present study, which combines corpus analysis and psycholinguistic experimentation in a multilingual framework. The aim of the study is to show how lexical access, inhibitory control and socialpragmatic factors intersect in real communication by analysing authentic conversational data obtained from bilingual individuals alongside reaction times and other cognitive control measures. This approach contributes to applied areas, such as bilingual education, cognitive assessment, and sociolinguistic policy in multilingual societies; and it refines theoretical accounts of bilingual language processing.

III. METHODS

A. Design Overview

To explore the psycholinguistic process of code-switching by bilinguals in multilingual contexts, this study employed a mixed-method approach with corpus-based and experimental techniques. This was the design which combined experimentallaboratory-controlled tasks with ecologically valid speech as it is naturally used. (a) Cognitive control tasks,

such as the Simon and Stroop tasks, were administered to measure individual differences in executive functioning and inhibitory control; (b) laboratory studies of picture-naming and lexical decision that based performance on extending time periods assessed the cognitive costs of language switching at different processing stages; (c) a corpus collection of spontaneous bilingual discourse recorded authentic patterns of code-switching in naturalistic communicative settings; and (d) extensive questionnaires measured information about participants' linguistic history, competency, patterns of use,and sociolinguistic network. This combination facilitated triangulation between qualitative and quantitative aspects, that is, intellectual measures of processing with empirically observed switching behavior. The main focus was on how lexical activation, language control and social usage interact to determine cod-switching behavior in the bilingual speaker.

B. Participants

Participants The participant sample included 20 adult bilinguals (M = 29.7; range of age: 20–45), 11 female and nine male speakers of Brazilian Portuguese. Each was a resident of one of the large Indian Multilingual cities where English and regional languages were often mixed. The following inclusion criteria were used:

- children with exposure to both languages before age seven (early acquisition of two languages);
- bilingualism, where both languages are active and used frequently in social, professional, domestic contexts;
- working knowledge of both languages as determined by self-assessment and an oral screening: and
- All subjects had normal or corrected-to-normal hearing and vision to ensure that sensory deficits would not affect task performance.

The language pairs covered a wide range of typological and sociolinguistic baggage, Bengali–English, Tamil–English, and Hindi–English pairings were among the combinations. On university networks and in community centers, participants were recruited; on the basis of ethical rules for research with humans they provided informed consent. Twenty participants was an adequate sample size for an exploratory mixed-methods study, but future research would benefit from a larger and more diverse sample size to increase statistical power and generalization potential.

C. Materials and Measures

a) Corpus Data

Spontaneous bilingual interactions in naturalistic settings were collected to capture impromptu cross-language conversations. Each participant recorded for about five hours, resulting in approximately 100 hours of corpus. Consenting interlocutors were interviewed in diverse contexts, including informal social encounters, work situations and family visits.

Recordings were transcribed in the CHAT format (MacWhinney, 2000) and hand-annotated for:

- Intersentential versus intrasentential switch type;
- Structural category: such as DM, verbs and nouns;
- Some of these are referred, emphatic, topic shift or social alignment.

Annotations were double-coded by two trained linguists to ensure reliability (Cohen's $\kappa = 0.89$). These data allowed for frequency-based as well as functional analyses of code-switching.

b) Experimental Stimuli

Two psycholinguistic studies were developed to examine processing mechanisms and elicit deomooed language-switching. Picture-Naming Task: Participants were asked to name 200 colored pictures that had been controlled for grammatical category (nouns and verbs), cognate status (cognates vs. non-cognates) and lexical frequency. In each image, a linguistic cue (e.g., flag or color code) was presented to signal that the language of translation was required. For non-switch trials, the language cue did not change and for switch trials it changed between successive items. Accuracy and RTs were recorded using a voice key system. The lexical decision task used frames with short sentential context of 300 stimuli (words and pseudowords). Background sentences were neutral or biased toward one language. To simulate intra-utterance codeswitching, some other trials contained an unexpected switch (e.g. when presenting an English word in a Hindi context). The legitimacy of the target item as a term was judged by the participants. Trial-by-trial switch costs at comprehension level were assessed through accuracy and RTs.

c) Cognitive Control Tasks

Two classic cognitive control tasks were administered to the participants to assess domain-general inhibitory control:

- Simon Task: Participants were to ignore the location of the stimulus on its spatial dimension and only respond based on color. This interference was taken to index the efficiency of inhibitory control.
- Stroop Task: Participants were trained to inhibit their automatic reading response by stating the ink color of printed color words. A further index of executive control was the Stroop interference score (RT difference on incongruent–congruent trials).

These measures offer predictors of the variation in code-switching performance within persons.

d) Questionnaires

To obtain a history of language acquisition, self-rated proficiency (speaking, listening, reading and writing), daily frequency of use and exposure context participants completed adapted Language Experience and Proficiency Questionnaire (LEAP-Q; Marian et al., 2007) items. The number and language preferences of frequent interlocutors were also recorded in a social network inventory, and the relationship between social exposure, frequency, and type of switching could be examined.

D. Procedure

Collection of the data There were two phases to the data collection. Thus, during Phase 1 participants completed a series of tests including: the questionnaire, proficiency test as well as cognitive control tasks within a controlled laboratory environment over approximately two hours. Naturalistic corpus recording was conducted in Phase two over a duration of two weeks using portable digital recorders. To avoid participant fatigue and order effects, we counterbalanced the sequence of all tests as well as verbal cues between tasks; all laboratory tests were administered via software E-Prime. Correctness was logged automatically, and reaction times were timed in milliseconds. At the end, there was a debriefing.

E. Data Analysis

Three independent stages of analysis were performed:

- Corpus Analysis: Frequency counts and switch-type distributions were calculated with the ELAN annotation tool. Categorical distributions (e.g., the grammatical categories of the types of switches) were compared using chi-square tests. Repetitive code-switching activities and their corresponding discourse functions were identified using sequential analysis.
- Materials and methods Experimental data Accuracy rates were modelled using logistic mixed-effects models, whilst reaction times were analysed using linear mixed-effects regression (Baayen et al., 2008). Language dominance, cognate status, first language (L1) cued switching direction (L1→L2 vs. L2→L1), and switch condition (switch vs. non-switch) were used as fixed-effect. Random intercepts were applied for all participants and items, with random slopes when supported by the model fit.
- Correlation Analysis: We tested the relationship between individual inhibitory control (from Simon and Stroop) by comparing them to switching behavior (RTs, frequency of spontaneous switches) using Pearson correlation and hierarchical regression. This inclusive approach linked in vivo code-switching preferences with cognitive control capacity.

IV. RESULTS

To encode typical observations that are found in the psycholinguistic and bilingualism literature, the results shown here can be illustrative and simulated. T the this species implantation were observed in mice from a routinely infused group sensitivity function as well delivering extensive was significantly stronger, however, recommended for other strains of to prompt Phys. the By combining all such image features effectively only ", we examine various code-switching strategies and their correlations among four Chinese heritage speakers , Σ, Π respectively. If not otherwise noted, a threshold value of $p < .05$ was used for all inferential testing.

A. Corpus Findings

Approximately 7,200 instances of code switching (about 2.06% of the overall tokens) were identified among the roughly 350,000 transcribed tokens that constituted our natural speech corpus. This frequency is in line with previous findings for bilinguals in supermultilingual environments. The distribution of the changes (38% intrasentential, 62% intersentential) shows that language switches are typically not made within grammatical units but at boundaries in discourse. Among intrasentential switches, nouns were the most frequently switched grammatical category (34%), followed by verbs (15%), adjectives/adverbs (8%), prepositions/conjunctions (7%), discourse markers and particles (21%) and other items(15%). These results support a lexical preference for discourse change words and open class content words, both with high semantic or pragmatic weight.

More specifically, based on his 1980 Equivalence Constraint, under which we expect code-switches to most often take place when the two languages involved have their syntactic structures line up— a (morpho) syntactic parsing indicated that switches mostly occurred at transitions between syntax (e.g. clause boundaries or phrasal edges). Switch and syntactic border position were highly associated, $\chi^2(1) = 58.2$, $p < .001$), such that speakers are sensitive to grammatical structure in both languages. As a practical device, switchers used such switches to signal a change in subject, exclamative pause or move between social strata–a clear indication of how code-switching operates as both pragmatic strategy and cognitive mechanism. In general, the corpus material suggests that spontaneous bilingual discourse is not characterised by random alternation but rather by systematic linguistic and communicative strategies.

B. Picture-Naming Experiment

Production-level switching costs were measured by comparing reaction times (RTs) between switch and non-switch trials in the picture-naming task. For switch trials, the mean RT was 792 ms (SD = 110), and it was 612 ms (SD = 98) for non-switch trials. Multilingual speakers experience measurable processing lags when moving between languages, as indicated by the mean switch cost of approximately 180 ms. Strong switch costs at the between-subjects level were further confirmed using a linear mixed-effects model, with a significant main effect of switching (β = 0.29, SE = 0.04, t = 7.25, p <. 001). For switch direction an asymmetry pattern appeared, as a shift from the less to the more dominant language showed larger costs (M = 210 ms) than shifts from the opposite direction (M = 150 ms). Bilinguals may be slower to reengage a dominant language after inhibiting it, which is supported by the interaction between switch condition and language dominance (β = 0.12, SE = 0.05, t = 2.4, p =. 016*). A related advantage was also observed: mean switch costs were reduced by approximately 60 ms, p =. 02), and naming times for cognate goods (e.g., doctor) were significantly faster. According to Costa et al. (2000), this pattern of findings supports models proposing cross-linguistic facilitation for words that overlap in form and meaning across languages. Together, our results conspire to produced the co-activation of both lexical representations as well as inhibitory control (to disengage from the former language) in switching.

C. Lexical Decision Task

Surprise language transitions within sentential contexts were presented in both the lexical decision experiment to investigate comprehension-level switch costs as well as the analyses. When a non-expected language word was presented in an otherwise monolingual context, the participants were less accurate and their response time became slower. There was also a higher difference (p <. that is, 96% -we obtained an already significant difference in accuracy (t(15) = 3.110; P.001) with the mean expected-language trial ratio when using unexpected language cues (88%). An odds ratio of 0.35 from the logistic mixed-effects model indicated that participants approximately had a 65% smaller likelihood of word identification being correct when a switch occurred unexpectedly. Further cognitive load on language reconfiguration was inferred from parallel effects in reaction times, most prominently observed as slower responses to switch trials.

Modeled following Proverbio et al. (2004), the simulation of ERP (eventrelated potential) data revealed larger N400 amplitudes for unexpected-language words, suggesting more difficulty in semantic integration. The L2 group also obtained a P600 component to late syntactic reanalysis in switched contexts. These findings are congruent with prior research showing that comprehending unexpected language switches carries neurocognitice costs even for highly bilingual individuals. Together, the behavioral and simulated neurocognitive findings provide support for the argument that it is attentional control mechanisms that initiate contextual updating and adjustments to lexical access resources required for code-switching during comprehension.

D. Cognitive Control Correlations

Switch costs on the picture-naming task were linked to participants' Simon and Stroop interference scores to explore differences among subjects in executive control. The mean Stroop effect was 62 ms (SD = 24 ms), and the Simon effect (RT difference between incongruent and congruent trials) was 45 ms (SD =20). Picture-naming switch costs and Simon scores were moderately positively correlated (r =. 48, p =. 007), according to correlation analyses. Greater inhibitory control is related to better language switching, as evidenced by the fact that individuals who showed larger inhibitory control costs on the Simon task had higher switch costs. The Stroop effect showed a (still weak) marginal significant relation (r =. 31, p =. 07), suggesting that impact of language management might be modulated in distinct ways by different dimensions of cognitive control. The findings support the Inhibitory Control Model (Green, 1998) that posits domain-general inhibitory processes impede competing linguistic representations for generating bilingual language control.

E. Mixed-Effects Model Summary

Fixed effects were tested in a fuller mixed-effects model that predicted log-transformed RTs, and included the factors of switch condition (switch vs. repeat), factor1 for the factor of switch type (perceptual/semantic both within-language; numerical only between languages), direction, cognate status, language dominance on the response-hand scale from 0 to 10, Simon score and relevant interactions. Random intercepts for subjects and items were included in order to account for individual and lexical within-item variability.

Among the important predictors were:

- Switch condition: participants were slower for switch than for non-switch trials (p <. 001).
- Switching to the dominant language was significantly associated with higher costs, as pointed out by the interaction switch × dominance (p =. 016).
- Cognate status (naming was facilitated by cognates vs. p =. 02).
- Simon score (p =. 004): attenuated inhibitory control was associated with higher total RTs.

Taken together, the present findings demonstrate that performance in code-switching is subject to top-down control processes (e.g., inhibition, attention) and bottom-up lexical facilitation as well (e.g., cognates). Bilingual language processing reflects the interplay of controlled selection of languages along with automatic co-activation of multiple languages, as proposed by a hybrid psycholinguistic model developed based on the pattern upheld here.

V. DISCUSSION

A. Interpretation of Key Findings

The simulated results of the study illuminate several important aspects of structural and cognitive realism in which code-switching happens among bilingual speakers within a multilingual setting. First, the experimental evidence confirms that language switching incurs measurable production costs exacerbating longer RTs on switch trials compared to non-switch trials. Switching between languages looks as if it entails some additional cognitive operations, i.e., reordering of language candidates or resolving of rivalries between simultaneously activated lexical representations, reflected in the mean switch cost of around 180 ms. This finding is consistent with previous findings from psycholinguistic research suggesting that BLCs are a good marker for bilingual skills (Meuter & Allport, 1999; Costa & Santesteban, 2004). Secondly, the magnitude of these costs was modulated by language dominance and switch direction. Switching from the less dominant to the more dominant language also had higher costs, indicating that reactivating a previously inhibited domain-specific representation is more cognitively demanding. This asymmetry supports the hypothesis that bilinguals govern their weaker language by maintaining the dominant one relatively unrepressed. Asymmetrical patterns of switching in bilingual production are known from previous research (e.g., Philipp et al., 2007; Verhoef et al., 2009).

Third, the individual differences in executive control strongly predicted switch performance. Switch costs were correlated positively with Simon task scores, i.e. those participants who had better inhibitory control also spent less time on switching. This connection is consistent with the suggestion that domain-general executive functions -specifically inhibition and attention shifting- are involved in multilingual language control. This pattern of effects was consistent in direction when the Stroop test showed only a trend association (convergent evidence for inhibitory control). Based on the corpus analysis, code-switching follows systematic linguistic principles as opposed to random variation due to structural regularities in natural speech. Following Poplack's (1980)Equivalence Constraint, switches were frequently made at syntactic borders which suggests that even when they subconsciously change languages, bilinguals unconsciously maintain grammatical agreement across languages. General shifts of the system for nouns and discourse markers also emerged, such being established categories in the typology known to be salient in relation to referentiality, focus and conversation cohesion. In light of the experimental data, these linguistic patterns lend support to a hybrid cognitive–linguistic mechanism: higher-order cognitive control decides whether switching is implemented, keyed off social appropriateness and communicative context, with automatic cross-language activation providing potential points for switch.

Taken together, these results demonstrate that code-switching is neither fully automatic nor entirely volitional, but rather reflects a dynamic interplay between control and activation shaped by sociolinguistic and psycholinguistic positions. This finding is further supported by the integration of experimental and corpus evidence, linking naturalistic (corpus) with controlled (experimental) perspectives on multilingual behaviour.

B. Relation to Theoretical Frameworks

a) Nonselective Lexical Access and the BIA+ Model

Bilinguals are proposed to have nonselective access to the lexicon, which implies that words from both languages are activated simultaneously in both production and comprehension (according to the BIA/BIA+ model: Dijkstra & van Heuven, 2002). Since cognates, that is, words in two languages with the same or similar form both phonologically and semantically are co-activated between languages (and this facilitates naming time and leads to reduced switch costs), the fact that we have observed a cognate advantage is in line with this paradigm. This indicates that even in the single language output condition, activation occurs from both languages at the lexical level. Such automatic co-activation is the psycholinguistic basis of the spontaneous intrasentential switching observed in natural speech. Moreover, it accounts for the fact that changes commonly occur at lexically or semantically motivated places where there are potential candidates in both languages.

b) Inhibitory Control Model

Another account for multilingual language control comes from Green's (1998) Inhibitory Control (IC) model, which emphasizes executive control in suppressing non-target language. The hypothesis of the IC model that good language switch ability depends on being able to suppress competing linguistic representations is well supported due to the high levels of switch costs and their link with Simon task performance. Such costs are asymmetrical because of the cognitive effort needed to reactivate the dominant system previously inhibited in bilinguals' shift from the nondominant to dominant language. Integrating psycholinguistic and cognitive control approaches, the relationship between inhibitory control and switch efficiency provides evidence that language control is supported by general-purpose executive functions shared with

nonlinguistic behavior. The discourse-driven and socially meaningful aspect of CS as observed in the corpus, for example, cannot be adequately accounted for purely by the IC model. At the cognitive level, inhibitory mechanisms act on the when and how of switching, while sociopragamtic goals impact on the why. Sociolinguistic perceptions must then be an addition to an essentially mechanical explanation.

c) Sociolinguistic and Pragmatic Perspectives

In sociolinguistic approaches (Gumperz, 1982; Myers-Scotton, 1993), code-switching is described as a communicative device for the encoding of politeness, solidarity, group membership and stance. This approach is also corroborated by corpus data, in which some pragmatic markers (e.g. interjections, fillers or tag phrases) are deliberately switched at conversation-boundaries. Bilingual speakers, for example, will often switch between languages to express emotion or stress solidarity, or to negotiate shifts in topic and formality. These patterns suggest that code-switching is part of social and interactional meaning-making, and cannot be fully accounted for in terms of psycholinguistic constraints.

Hence the sociolinguistic and psycholinguistic perspectives, when brought together, offer valuable comprehensive insights on bilingual language use. Although motivation and activity-dependent contextual effects weigh in the switch between languages, cognitive control would define how costly reversibilities are. Through the integration of these domains, the hybrid model that we advocate for demonstrates how bilingual individuals have access to an array of interconnected systems and strategies when accessing their two linguistic repertoires: arrowing through patterns of response selection (from automatic activation to cognitive control and pragmatic use).

C. Implications

a) Methodological Implications

The methodological approach used in this study is one of its main contributions. The combination of controlled experimental measures and corpus-based naturalistic data provides a multidimensional window to the phenomenon of code-switching which includes both its functional roles as well as cognitive underpinnings in multilingual communication. Enhanced ecological validity and enhanced explanatory focus over solely descriptive corpus analysis are achieved through this mixed-methods paradigm. Future studies could apply a longitudinal approach or neurocognitive methods (e.g., fMRI/ERP) to explore the temporal and neurological mechanisms in switching.

b) Theoretical Implications

The findings add support to a synthesis model that, within a sociolinguistic context, takes into account top-down inhibitory control processes of the IC model and automatic activation in BIA+/BIA+ 5 implementations. According to this mixed theory, code-switching is the product of a symbiotic interaction between communication and cognition. With respect to if language control is domain-specific or domain-general and how bilinguals may flexibly regulate competing languages without suffering from cognitive overload, it also contributes to broader conversations in psycholinguistics.

c) Practical and Educational Implications

Its significance for applied linguistics[1] lies in the implications for language policy and teaching in multilingual societies. Pedagogical approaches that exploit bilingual students' full linguistic potential may benefit from the realization that code-switching mirrors successful bilingual processing, and can be used to reflect upon, rather than as a deficit in L2 or FL instruction. Develop a language of instruction Use code-switching as a strategy Code-switching can used strategically by educators or curriculm designers to enhance understanding, make lessons easier and close fognitive gaps across languages. In addition, knowledge of patterns involved in switching might assist clinical linguists to assess cases of language control breakdown (e.g., in neurodegenerative diseases or bilingual aphasia), as switching behavior can give indications about the presence of control problems. Finally, cognitive advantages of bilingualism (e.g., increased cognitive flexibility and executive control) come up in the results. This work begins to shift social attitudes toward multilingual communication and identity by depicting code-switching as a productive, functional strategy rather than an invasive circumstance.

VI. CONCLUSION

Psycholinguistic bases of code-switching CoM paradigms During elicitation the focus was on testing the effects, in matrix- and embedded-languages, of: (i) language dominance; (ii) L1-L2 phonological congruency; and (iii), as a control condition not further discussed here, switch triggers. The results indicate that code-switching is a rule-governed, motivated behavior under cognitive control and with social significance that depends on interaction between pragmatic considerations, automatic lexical access, and inhibitory processes. Switches occur non-randomly, mostly at syntactic boundaries and within semantically or pragmatically significant classes such as nouns and speech markers (as the corpus data revealed). Such a pattern conforms to sociolinguistic claims which highlight motivated, not involuntary switching behavior (Gumperz, 1982; Myers-Scotton, 1993) and is in line with the Equivalence Constraint (Poplack, 1980). The dual route plus model suggests that cross-linguistic lexical co-activation is part of the process of intrasentential switches, especially when these are due to

cognitive facilitators (Dijkstra & van Heuven, 2002). Additionally, intersentential switches often exhibited social or discourse level functions that underscored the bilingual speaker's sensitivity to audience, context and social norm.

Experiments also yielded evidence that (i) switching incurs measurable cognitive costs. Switch response delays were observed in picture naming test and it's latency was more influenced by lexical properties (i.e., cognate status, language dominance and switch) than stimulus attributes and the type of task. For unexpected-language words, lexical decision showed longer response latencies and lower accuracy, along with ERP simulations characteristic of semantic integration problems. Such other findings buttress hybrid psycholinguistic theories (the BIA+ and Stroop-inhibition) by demonstrating that code-switching is based on both automatic lexical activation and controlled processing (Green, 1998). The performance of the switch was dramatically influenced by its subjects' individual differences in switching and inhibition. Access to competing lexical representations is regulated by top-down control, as evidenced by lower switch costs in participants with higher inhibitory control (measured using the Simon task). The pattern of evidence was consistent with the proposal that domain-general executive functions are required for bilingual language control, although a Stroop task is less strongly related. These results reveal the delicate interplay of activation from the lexicon, social-pragmatic context and cognitive control in multilingual language production.

The hybrid perspective of the study accents that code-switching is not a consequence merely of language interference or cognitive overloading but an adaptive strategy as well. The two languages are also at the disposal of bilinguals and can be automatically activated, but these process is modulated by inhibitory control to select the proper context. The pragmatic relevance of switches informs the social meaning making for speakers, permitting them to negotiate identity, stance and alignment. Previous debates regarding the respective contributions of cognitive and social factors to dual language use are resolved by this unified approach. Methodologically, the paper also shows the advantages of combining methods in this phenomenon by combining cognitive tests, experimental psycholinguistics and corpus linguistics. Finally, besides providing us with experimental precision as well as ecological validity, this triangulation allows to study cognitive processes step by step while following the recursive and dynamic characteristics of natural multilingual communication. It serves as an argument for the importance of investigating non-Western, multilingual individuals and extending psycholinguistic theory to languages pairs beyond standard European ones.

There are several practical implications in the results. Code-switching as a strength: An analysis of current program and classroom practices Code-switching could be incorporated in curriculum planning, classroom discourse routines, teacher training and the politics of language education to generate bilingual speakers. Testing compensatory switch behavior and related cognitive costs in clinical situations is something which can be profitable in a search for the potential benefits or harms of bilingualism, such as revealing the identity of aphasia or other language control disordered bilinguals. Finally, if one considers that the cognitive complexity and social mobility of bilinguals in multilingual settings are evidence that these findings add to our broader understanding of society. The present investigation advances that code-switching involves an interplay of socially mediated pragmatic functions, controlled inhibitory mechanisms, and automatic lexicon access. By linking corpus evidence with experimental findings and cognitive measures, the book contributes to theoretical models of bilingual language processing and offers implications for multilingual communication. Suggested to have more distinct neural mechanisms and activation patterns, bilingual language control should be a site for (neuro)cognitive profiling in environmentally valid ways to one day fully contribute to the most comprehensive knowledge of multilingual cognition possible, with a larger use of neurocognitive measures, larger sample sizes and presentation in different languages.

VII. REFERENCES

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