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Bilingualism and Rapid Automatized Naming: effects of language switching on lexical access and reading speed

Bilinguismo e Nomeação Automática Rápida: efeitos da alternância de línguas sobre o acesso lexical e a velocidade de leitura

ABSTRACT

Purpose: To assess whether bilingualism, on a language switching experiment, is associated with higher or lower accuracy and speed of the rapid automatized naming of objects and investigate the influence of language switching on reading speed. **Methods:** The performance of 50 Brazilian bilingual children in the Rapid Automatized Naming Task, whose L1 was Brazilian Portuguese and who were exposed to English daily at school, was assessed. Forty-seven monolingual (Brazilian Portuguese) children were grouped according to age. **Results:** Language switching interfered with the performance of the bilingual children in the Rapid Automatized Naming Task in terms of speed and accuracy. No correlations were found between the performance in the RAN task and Reading Speed. **Conclusion:** Brazilian bilingual students showed poor performance in the rapid naming task on the switch trial when compared to monolingual students, showing higher rates of mistakes, especially hesitations. Only the performance of bilingual students in the rapid naming task in L2 correlated with L1 reading speed.
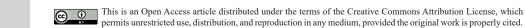
RESUMO

Objetivo: Verificar se o bilinguismo, na condição de alternância de línguas, associa-se à maior ou menor velocidade e precisão na nomeação rápida de objetos e se essa condição se relaciona com a velocidade de leitura de texto. **Método:** Analisou-se o desempenho de 50 crianças bilíngues sequenciais brasileiras, cuja língua materna era o Português Brasileiro, expostas ao Inglês diariamente no ambiente escolar. O grupo monolíngue, composto por 47 crianças, foi agrupado de acordo com a faixa etária. Foram analisados desempenhos em tarefa de Nomeação Automática Rápida (RAN) e velocidade (palavras lidas por minuto) em prova de leitura oral de texto. **Resultados:** Os resultados revelaram que a alternância de línguas se associou ao desempenho dos escolares bilíngues na prova de Nomeação Rápida no que diz respeito à velocidade e à precisão. Em condição de alternância de línguas, os escolares bilíngues despenderam mais tempo para nomear e cometeram mais erros. Somente se observou correlação entre o desempenho dos escolares bilíngues na prova de nomeação rápida em L2 e a taxa de leitura em L1. **Conclusão:** Escolares brasileiros bilíngues apresentaram pior desempenho em tarefa de nomeação rápida na situação de alternância de línguas quando comparados a escolares monolíngues, com maior número de erros, especialmente hesitações.

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INTRODUCTION

Bilingualism is an important communication tool and, with the advent of globalization, the ability to communicate in more than one language has become a necessary skill. Since it is a complex phenomenon influenced by several factors[1], the definition of bilingualism in the literature is varied. However, regarding the purposes of this study, we will follow the definition proposed by Grosjean (1992), who described bilingualism as the "regular use of two languages"[1].

Science has been trying to understand the effects of bilingualism on cognition for years. Initial evidence, presented from the 1960s, showed that bilingual children were exceptionally good at various cognitive tasks when compared to monolingual ones[2]. Recent research concluded that bilingualism has a significant impact on cognitive functions and that bilingual individuals develop better executive functions and metalinguistic skills[3]. On the other hand, other studies, which also studied the effects of bilingualism on cognition, pointed out that fluently bilingual children may present vocabulary restrictions[4], reduced scores in verbal fluency tests by semantic and phonological clues[5], in addition to a higher number of errors in picture naming tasks[6], which may indicate difficulties in lexical access[3], also, an important ability for the automatic recognition of words during reading[7]. Studies also pointed out that bilinguals had a disadvantage in naming tests even when these were performed in their dominant language[8].

According to the literature, both languages are activated in the brains of bilingual individuals when producing a word or utterance in either language, such as during speaking and reading[8,9]. The semantic representations of words are shared between the languages and are connected to lexical representations for each language separately[10]. Because of that, bilingual individuals differ from monolingual ones, since they process twice as much lexical information during any language activity[10]. Consequently, in tasks that emphasize the lexical level, such as the Rapid Automatized Naming (RAN)[11] test, we may expect different performances for bilingual and monolingual individuals, since the parallel activation of lexical representations in bilinguals may result in the phenomenon of competition between languages[12], with possible impairment concerning the performance of these individuals regarding speed and accuracy, with the probable appearance of the hesitations in the lexical access[13].

Another important factor to be considered in the study of bilingualism is associated with the phenomenon of code-switching of the linguistic code. In natural communication situations, proficient bilingual individuals are capable of switching between their languages in a flexible way[14]. Language alternation is a process dependent on the individual's efficient ability to select the target language used during the moment of communication and inhibit the non-target language, maintaining the separation between both languages[14]. However, language alternation may result in negative effects on the performance of bilingual individuals, namely increased response time and number of errors in language tasks[14]. It is hypothesized that, during the process of language alternation, the selection of the previously inhibited language requires an extra time for its reactivation, resulting in negative costs on the performance of the bilingual individual[14].

The measurement of lexical access speed may be performed by applying the RAN test[11]. Concerning this test, the participants must quickly and correctly name familiar stimuli arranged in sequence[11,15]. The pertinent literature reports that the ability of rapid automatic naming is related to the reading performance[7,11]. Therefore, the performance in the RAN, assessed by speed and accuracy parameters of lexicon access, is considered one of the best predictors of reading fluency for all known orthographies[16,] and many of the processes required for its performance are also required for reading (such as saccadic eye movement and connection of representations, in the case of reading, orthographic and phonological processing[15]. The automaticity in each perceptual and linguistic process as well as the connection between them in serial visual presentation tasks is the major reason why the RAN can predict reading skills[15].

Although studies indicated that bilingualism may influence the ability to access the mental lexicon[3,6], the literature still indicated gaps when trying to clarify how the mechanisms underlying this process are affected by the ability to communicate in more than one language. Indeed, it is known that the RAN can assess two important aspects of lexical access: accuracy; and speed. However, it is not understood if bilingualism, in demand of alternating languages, was able to act differently on these two parameters, and how this occurs in comparison with monolinguals. In the present study, we investigated the performance of bilingual individuals in the RAN task considering two aggravating factors: the competition[12] between languages; and the language switching[14].

Thus, this study aimed to investigate the performance of bilingual and monolingual children in lexical access speed, naming accuracy, according to the type of the number of errors measured in words, and reading speed. The hypothesis is that bilingual children will spend more time and make more mistakes since they receive interference from the second language learned in the execution of the tasks, and that the language switching may interfere in the performance of the students. Moreover, hesitation is likely to be the most frequent type of error observed in RAN concerning bilingual children.

Thus, this research aimed to investigate whether bilingualism, regarding language switching, interferes with the speed or accuracy of rapid naming of objects, considering the type of error presented in the nomination, as well as verifying if the speed of access to the mental lexicon is related to the speed of text reading.

METHODS

Retrospective and cross-sectional study with quantitative analysis. This study received approval from the Research Ethics Committee of the *Universidade Federal de São Paulo* (number 1193/2017). The participants and their guardians signed the Informed Consent Forms (ICF) and all data were anonymized.

Sample selection

We studied assessment protocols from the database of the Center for Teaching, Assistance and Research in Writing and Reading (in Portuguese *Núcleo de Ensino, Assistência e Pesquisa em Escrita e Leitura* (NEAPEL)) of the *Universidade Federal de São Paulo* (UNIFESP). We selected assessment protocols of school children aged 7-9 years (n = 97, $\overline{X}$ = 8.0, SD = 0.5) regularly enrolled in different private schools in the municipality of São Paulo (SP). All participants were Brazilian and had Brazilian Portuguese as their mother tongue (L1).

The bilingual children were also Brazilian, being initially exposed to the English Language (L2) from three years old and had no familiarity with any languages other than Portuguese and English. The students had been exposed to the second language for at least 30 hours a week for at least three years and developed literacy in both languages.

We excluded protocols of children who presented complaints, indications, or diagnoses related to sensorial, auditory or visual (not corrected), cognitive, neurological, psychiatric, learning or communication alterations.

Information on the gender and age of the school children was collected from the evaluation protocols. However, information regarding the socioeconomic and education levels of the parents was not collected.

Bilingual children were grouped according to the order in which the test was applied, as follows: PBG - 23 children took the test in Portuguese (first test) and then in English; EBG - 27 children took the test in English (first test) and then in Portuguese. When analysed together, the bilingual schoolchildren group was called BG only. The monolinguals were grouped according to age. The distribution of the total sample according to the group, age and gender is shown in Chart 1.

Instrument approach

To evaluate the schoolchildren, we used the RAN test proposed by Lúcio et al.[11], consisting of two test boards, called Part A and Part B, in which six colored figures (key, egg, ball, fork, sun, and bread) were distributed linearly, six times on each test board, totaling 36 appearances per board and following different presentation order for each of the test boards[14]. The vocabulary selected for the construction of the instrument was determined from a pilot study, in which the six chosen images were recognized by 100% of 15 monolingual Brazilian preschool children. For the assessment in the second language, the same instrument was used to approximate the length of the vocabulary between both languages, since the vocabulary in English is monosyllabic (key, egg, ball, fork, sun, bread) and in Portuguese is disyllabic (*chave, ovo, bola, garfo*), except for two items of the test, which, as in English, are monosyllabic (sun, bread).

Application procedures

For the assessment of monolingual schoolchildren, a training board was presented, containing the six colored figures, arranged sequentially on an A4 sheet, in landscape direction. The students were asked to name the pictures as quickly as possible. After becoming familiar with the stimuli, the test boards were presented and the students were instructed to name the figures as correctly and quickly as possible, without making mistakes, following the naming order from left to right, from the top to the bottom of the sheet. The test boards were applied in sequence, i.e., initially Part A and then Part B.

For evaluating the bilingual children, the same version of the instrument applied to the monolingual children was used and the evaluation process was identical, except for the language used during the test. The bilingual children took the test in both languages (Portuguese and English) and the order of application of the instrument was randomly drawn among the participants, comprising two distinct groups: PBG (Bilingual group that took the test first in Portuguese and then in English) and EBG (Bilingual group that took the test first in English and then in Portuguese). The instruments were applied consecutively, i.e., immediately after the application of tests A and B in the initial language (PBG: Portuguese; EBG: English), the same instruments (tests A and B) were applied in the final language (PBG: English; EBG: Portuguese). Participants received the instructions regarding the language in which they would be tested.

We also collected information on the rate values in the oral reading of texts carried out by the schoolchildren. For evaluating the monolingual schoolchildren, texts were taken from textbooks (in Brazilian Portuguese), being appropriated to the school grade. To evaluate the bilingual school-aged children, texts suitable for each grade were also selected (in English) and the evaluation process was the same for both groups. The texts were presented on A4 paper in portrait mode and the students were instructed to read the text aloud. The evaluator started the stopwatch at the beginning of the second paragraph and interrupted the reading of the student when he/she reached the one-minute mark, graphically recording in the protocol the last word read by the child.

All evaluations were digitally recorded and the files were stored for later analysis.

Data analysis

Initially, all recordings were listened to and errors were marked. In a second stage, errors were grouped and classified according to the following proposal based on and adapted from Kohn and Goodglass[17]: Hesitations: Response latency greater than two seconds; Repetitions: Duplication of the item immediately preceding the target item; Substitution: Exchange of the target item for another vocabulary item, present or not in

Chart 1. Distribution of the sample according to the group, age, gender, and education level.

Sample		Bilingual	Monolingual	Total
Age	7	06	12	18
	8	32	14	46
	9	12	21	33
	Total	50	47	97
Gender	Female	32	24	56
	Male	18	23	41
	Total	50	47	97

the naming list; Omission: Complete omission/exclusion of the target item; Intrusion: Intrusion of the other language during the naming test; Self-correction: Immediate correction performed by the schoolchild when an error occurs in the emission of the target item.

We recorded the total value and types of errors, as well as the total time spent (in seconds) in naming the two boards, on an excel spreadsheet.

The reading tests were also analyzed and the number of words read was computed on an excel spreadsheet.

For the descriptive analysis, we calculated the means and standard deviations of the values of the answers of the school children, by year and group.

The inferential analysis was obtained using the Student *t*-test for the comparison of two groups, and the Analysis of Variance (ANOVA), which is indicated to compare three or more groups of information, to identify possible differences between the performances of the groups. In cases of non-normality, the Mann-Whitney U test was used. Spearman's correlation coefficient was also calculated to investigate possible associations between the variables studied. The significance level adopted for the tests was 5%.

RESULTS

Comparison of the performance of the PBG and EBG groups for total time spent in L2 rapid naming showed that the PBG was slower in naming both test boards compared to the EBG. On the other hand, in Portuguese naming, the EBG showed higher averages for naming only test board A, showing similar performance in naming test board B (Table 1).

Regarding the comparison between PBG and EBG for each type of error in RAN (Table 2), we observed that the PBG presented more hesitations than the EBG on test board A. However, the performance of the groups was similar for the same variable on test board B. Concerning the repetition error, we observed higher averages for the PBG on test board A, but similar performance on test board B. There was no difference in performance between the groups for the other variables.

Table 1. Comparison of total time spent on Rapid Naming in English and Portuguese between PBG (n= 23) and EBG (n= 27)

| | | English | | | | Portuguese | | | |
| | | Test board A | | Test board B | | Test board A | | Test board B | |
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
BG	**PBG**	44.83	9.47	41.17	10.88	31.69	6.37	38.91	7.18
	EBG	31.96	4.31	35.00	6.63	43.81	8.28	41.63	8.2
	p-value	0.00*		0.018*		0.00*		0.22	

*Statistical significance: p=0,05 - Test ANOVA
Caption: BG = Bilingual Group; PBG = Portuguese Bilingual Group; EBG = English Bilingual Group; SD = Standard Deviation

Table 2. Analysis of means and standard deviations for each type of error in Rapid Naming in English for PBG and EBG

					p-value
HESITATION	**Test board A**	**PBG**	Mean	0.78	0.006*
			SD	1.166	
		EBG	Mean	0.04	
			SD	0.192	
	Test board B	**PBG**	Mean	0.39	0.094
			SD	0.839	
		EBG	Mean	0.07	
			SD	0.267	
REPETITION	**Test board A**	**PBG**	Mean	0.74	0.008*
			SD	1.137	
		EBG	Mean	0.04	
			SD	0.192	
	Test board B	**PBG**	Mean	0.61	0.059
			SD	1.27	
		EBG	Mean	0.07	
			SD	0.267	
SUBSTITUTION	**Test board A**	**PBG**	Mean	0.26	0.438
			SD	0.619	
		EBG	Mean	0.41	
			SD	0.694	
	Test board B	**PBG**	Mean	0.48	0.639
			SD	0.73	
		EBG	Mean	0.37	
			SD	0.884	

*Statistical significance: p=0,05 - Test ANOVA
Caption: PBG = Portuguese Bilingual Group; EBG = English Bilingual Group; SD = Standard Deviation

Table 2. Continued...

					p-value
OMISSION	**Test board A**	**PBG**	Mean	0	-
			SD	0	
		EBG	Mean	0	
			SD	0	
	Test board B	**PBG**	Mean	0	-
			SD	0	
		EBG	Mean	0	
			SD	0	
INTRUSION	**Test board A**	**PBG**	Mean	0.35	0.043*
			SD	0.775	
		EBG	Mean	0	
			SD	0	
	Test board B	**PBG**	Mean	0.09	0.328
			SD	0.417	
		EBG	Mean	0	-
			SD	0	
SELF-CORRECTION	**Test board A**	**PBG**	Mean	0.13	0.364
			SD	0.458	
		EBG	Mean	0.26	
			SD	0.526	
	Test board B	**PBG**	Mean	0.39	0.93
			SD	0.656	
		EBG	Mean	0.41	
			SD	0.636	

*Statistical significance: p=0,05 - Test ANOVA
Caption: PBG = Portuguese Bilingual Group; EBG = English Bilingual Group; SD = Standard Deviation

Table 3. Analysis of means and standard deviations for each type of error in Rapid Naming, in Portuguese, for MG and BG

					p-value
HESITATION	**Test board A**	**MG**	Mean	0.234	0.003*
			Standard Deviation	0.519	
		BG	Mean	10.88	
			Standard Deviation	1.349	
	Test board B	**MG**	Mean	0.38	0.772
			Standard Deviation	0.768	
		BG	Mean	0.34	
			Standard Deviation	0.688	
REPETITION	**Test board A**	**MG**	Mean	0.128	0.069
			Standard Deviation	0.494	
		BG	Mean	0.46	
			Standard Deviation	1.163	
	Test board B	**MG**	Mean	0.4	0.551
			Standard Deviation	1.313	
		BG	Mean	0.56	
			Standard Deviation	1.248	
SUBSTITUTION	**Test board A**	**MG**	Mean	0.17	0.09
			Standard Deviation	0.433	
		BG	Mean	0.4	
			Standard Deviation	0.833	
	Test board B	**MG**	Mean	0.45	0.856
			Standard Deviation	0.686	
		BG	Mean	0.42	
			Standard Deviation	0.758	

*Statistical significance: p=0,05 - Test ANOVA
Caption: BG = Bilingual Group; MG = Monolingual Group

Table 3. Continued...

						p-value
OMISSION	Test board A	MG	Mean	0.021		0.442
			Standard Deviation	0.145		
		BG	Mean	0.06		
			Standard Deviation	0.313		
	Test board B	MG	Mean	0.04		0.748
			Standard Deviation	0.292		
		BG	Mean	0.06		
			Standard Deviation	0.24		
INTRUSION	Test board A	MG	Mean	0		0.182
			Standard Deviation	0		
		BG	Mean	0.06		
			Standard Deviation	0.313		
	Test board B	MG	Mean	0.06		0.083
			Standard Deviation	0.247		
		BG	Mean	0		
			Standard Deviation	0		
SELF-CORRECTION	Test board A	MG	Mean	0.787		0.399
			Standard Deviation	0.931		
		BG	Mean	0.62		
			Standard Deviation	1.007		
	Test board B	MG	Mean	0.79		0.865
			Standard Deviation	1.02		
		BG	Mean	0.82		
			Standard Deviation	0.873		

*Statistical significance: p=0,05 - Test ANOVA
Caption: BG = Bilingual Group; MG = Monolingual Group

Table 4. Spearman's correlations between the variable Time spent on Rapid Naming and Reading Speed for the BG (N=50)

			Reading Speed
BG	Time spent	Correlation Coefficient	-0.454**
	Rapid Naming English	Sig. (p)	0.001
		n	50
	Time spent	Correlation Coefficient	-0.069
	Rapid Naming Portuguese	Sig. (p)	0.633
		n	50

**Statistical significance: p=0,05 - Spearman's Correlation Coefficient Test
Caption: BG = Bilingual Group

Regarding the comparison between Bilingual Group (BG) and Monolingual Group (MG) for each type of error in RAN (Table 3), we observed that BG presented more hesitations than MG in the naming of test board A, but showed similar performance to the monolingual, on test board B, for the same variable. No performance differences were observed between the groups for the other variables.

The investigation of correlations between lexical access and the number of words read per minute was carried out by analysing the time spent on naming and the total number of errors found in the RAN test for each group.

No correlations were found between the total number of errors and the number of words read per minute for either the English or the Portuguese BG.

On the other hand, a significant (negative) correlation was found for the analysis of the time spent on rapid naming and the number of words read per minute for the BG in the English test (Table 4). However, no significant correlation was found for the analysis in Portuguese.

DISCUSSION

Language switching is a behavior naturally observed in bilingual individuals. The efficient bilingual speaker can identify the communicative context and control the use of his/her languages, keeping them completely separate or allowing more flexibility in communication[18]. When considering the mechanisms of lexical access of the bilingual individual's brain, in which occurs the parallel activation of the lexical representations of both languages, we could understand that the process of language switching is complex and demands control over several cognitive processes[9] and, sometimes, the language alternation may negatively interfere on the speaker's performance[19].

The comparison between the time spent in the nomination by the bilingual groups revealed worse performance for the second nomination tasks performed (Table 1), regardless of the language used in the second nomination, i.e., bilingual group students spent more time to perform the RAN test in language alternation condition. These results showed that, in bilinguals, linguistic performance in lexicon access may be negatively impacted by language alternation in rapid naming tasks. In fact, researches have pointed out that bilinguals make more mistakes and are slower when submitted to activities involving language alternation when compared to the performance in production activities in only one language[20-22].

This study also investigated the influence of the language switching on the accuracy of rapid naming, based on the analysis of the number and nature of errors committed. We identified a performance difference for the PBG and EBG groups in the naming of Test board A in English, only found for hesitation, repetition, and intrusion errors. When performing naming in English, the PBG group showed a higher number of errors than the EBG group in the same activity.

This result corroborates the hypothesis that language switching affects the linguistic performance of the bilingual individual[19]. When the language switching was performed, the students spent more time to name and presented a higher number of errors.

The nature of the mistakes found was also an interesting fact. Compared to the MG, the BG also showed differences in performance for the types of errors committed in the Portuguese naming task. The BG showed a higher number of hesitancy errors, however, showed similar performance to the MG for all other errors analyzed.

The pattern of errors observed in the comparison between PBG and EBG may be explained by the language switching, as referred to by the pertinent literature[19,22]. On the other hand, the hesitations identified in the comparison between MG and BG raise the hypothesis that the performance of BG may have been impaired by losses in access to the mental lexicon[23].

It is known that, in the brains of bilingual individuals, both languages are activated when productions are made in both languages[8,9] and the lexical representations are different for each of them[10]. Thus, the bilingual individual needs to select the relevant language and inhibit the other one, which, throughout life, would conciliate the improvement of his/her executive skills[12,24,25]. Good inhibitory control and a well-established attentional mechanism are necessary skills for bilinguals to be able to perform linguistic activities that demand the use of only one language[26].

However, although executive control benefits are reported for the bilingual individual[12,24,25], lexical access deficits are also found, especially in tasks of rapid access of lexical items[23], as occurs in the RAN. In addition to demanding attentional mechanisms, there is also a relevant verbal demand during the performance of RAN tasks, since bilingual individuals access twice as many lexical representations.

Thus, we hypothesize that the difficulties in lexical access presented by bilingual individuals may have been reflected in a higher number of hesitations and self-corrections in their performance in rapid naming.

On the other hand, the hesitations and self-corrections presented in the RAN do not necessarily reflect losses for more generalized linguistic processing situations[23]. Hesitations, or pauses in speech, may be present to a greater or lesser extent in the speech of individuals, and, for bilinguals, these breaks may even be a necessary resource when speaking a second language[13].

Although it is an activity of a different nature, researchers who have examined the role of these ruptures (hesitations, repetitions, self-corrections or reformulations, automatisms) of spontaneous speech have suggested that even highly fluent bilingual individuals produce more hesitations when speaking in their second language[27]. The literature indicates that when the bilingual individual is speaking in L2, his/her speech becomes less automatic, which may result in increased planning time and number of corrections. In this way, speech hesitations may be a positive strategy, since they help to increase planning time and facilitate communication[28].

We also verified the existence of correlations between lexical access and the number of words read per minute by analyzing the performance of students in the RAN test regarding the time spent and errors found.

The lexical access speed and the number of words read per minute were correlated in the BG group, but not in the MG group. The analysis showed, only for the EBG, a negative correlation between the time spent on English Rapid Naming and the number of words read per minute, i.e., the shorter the time spent in English naming was, the higher was the number of words read per minute in Portuguese.

The results showed that the types or quantity of errors found in rapid naming were not related to the performance in the number of words read per minute in the other groups. These findings disagree with the literature[29], according to which the ability of rapid naming is a significant predictor of reading speed for both monolingual and bilingual groups.

Regarding the limitations of the study, it is important to emphasize that the methodology determined the reading of sentences for the inclusion of children in the sample. Thus, cognitive skills related to the interpretation and understanding of sentences may have interfered with the performance in reading speed, which may have influenced the results regarding the relationship between the reading rate and the ability of rapid automatic naming. In addition, the absence of information regarding the socioeconomic level of the students was also an important limitation of this study.

CONCLUSION

Brazilian bilingual schoolchildren showed worse performance in rapid naming tasks regarding language switching in time and accuracy. They also showed worse performance in the task of rapid automatic naming when compared to monolingual students, showing a higher number of errors, especially hesitations. Only the performance of bilingual schoolchildren in the rapid naming test in L2 could be correlated with the reading rate in L1.

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Author contributions

ES was responsible for the research design, data collection, data analysis, and final writing of the article; CRBA was responsible for the research design, data analysis, and interpretation, final approval of the version to be published; ATHB collaborated on the methodological design, data collection, and analysis.