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DELTA

Articles

Task effect on L2 rhythm production by Cantonese learners of Portuguese

O efeito de tarefa na produção do ritmo por estudantes cantonenses de português como L2

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ABSTRACT

This study examines L2 Portuguese speech produced by eight native Cantonese speakers from Macao, China. The aims of this study are to investigate (1) whether the speech rhythm in L2 Portuguese is more source-like (more similar to Cantonese) or more target-like (more similar to Portuguese), and (2) whether L2 speech rhythm differs across three different tasks: a reading task, a retelling task, and an interpreting task. Seven rhythm metrics, i.e., %V, ΔC, ΔV, VarcoC, VarcoV, rPVI_C, and nPVI_V, were adopted for comparison and investigation. The results showed that L2 Portuguese rhythm produced by Cantonese speakers differed from L1 Portuguese speakers' rhythm. R-deletion and vowel

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epenthesis were the reasons for the variabilities and instabilities of L2 Portuguese production by Cantonese learners, as they affect the duration and the number of vowel intervals and consonantal intervals. Moreover, in Cantonese learners' L2 Portuguese production, the semi-spontaneous tasks (retelling and interpreting) presented a significant difference from the reading task. The driving force for such a difference was the cognitive load behind the tasks.

Keywords: *L2 rhythm; Portuguese; Cantonese; task effect; cognitive load.*

RESUMO

Este estudo examina a produção oral em português como L2 produzida por oito falantes nativos cantonenses de Macau, China. Os objetivos deste estudo são investigar (1) se o ritmo da fala em português L2 se aproxima da língua de partida (i.e., cantonense) ou do da língua de chegada (português), e (2) se o ritmo da fala L2 difere entre três tarefas diferentes: leitura, recontagem e interpretação. Sete métricas de ritmo, i.e., %V, ΔC, ΔV, VarcoC, VarcoV, rPVI_C, e nPVI_V foram adotadas para comparação e investigação. Os resultados mostraram que o ritmo do português como L2 produzido pelos falantes cantonenses diferia do ritmo dos falantes cuja L1 é português. O apagamento de r e a vogal epentética são as razões para as variabilidades da produção de L2 português pelos falantes cantonenses, pois propriedades estas afetam a duração e o número dos intervalos vocálicos e consonantais. Além disso, na produção destes falantes, as tarefas semi-espontâneas (recontagem e interpretação) apresentaram uma diferença significativa em relação à tarefa de leitura. A força motriz de tal diferença é a carga cognitiva por detrás das tarefas.

Palavras-chave: *ritmo da fala L2; Português; Cantonense; efeito de tarefa; carga cognitiva.*

1. Introduction

L2 oral production has always been a focus in an educational context. The most discussed topics include, among others, accent and pronunciation (e.g., Celce-Murcia et al., 2010; Dao et al., 2021), and fluency (e.g., De Jong et al., 2012; Wright & Zhang, 2015). Language learners also strive to obtain "target-like" speech in their acquisition.

Since speech prosody is one of the most salient factors which affect listeners' judgement of non-native speakers' accent (Kang, 2010), speech rhythm can serve as an important indicator for how "target-like" L2 production is. However, L2 speech rhythm has not yet attracted sufficient research (Li & Post, 2014).

The current study is motivated by and situated in the multilingual linguistic background of Macao, a city located on the south-eastern coast of China. The native residents of Macao speak Cantonese Chinese as their native language. However, as it was formerly a Portuguese colony, Portuguese is also an official language. Given this region's historical and social background, a large number of Macao residents still study European Portuguese. Nevertheless, L1 Cantonese learners' Portuguese rhythm production has not been investigated. Therefore, in this study, we examine the speech rhythm production by L2 Portuguese learners whose L1 is Cantonese.

L2 speech rhythm manifestations are related to various factors, such as speakers, test materials, or elicitation tasks, among others (Arvaniti, 2012; Kawase et al., 2016; White & Mattys, 2007). For example, Arvaniti (2012) found that elicitation choices substantially affected all the metric scores in English, showing differences between the three tasks involved: sentence reading, story reading, and spontaneous speech.

Therefore, in the current study, our research questions (RQ) are:

RQ1: is the speech rhythm in L2 Portuguese more source-like (more similar to Cantonese) or more target-like (more similar to Portuguese)?

RQ2: does L2 speech rhythm differ across three different tasks: a reading task, a retelling task, and a sight interpreting task?

Sight interpreting, or more commonly known as *sight translation*, is a variant of simultaneous interpreting. The interpreters read a script written in the source language while simultaneously interpreting it into the target language.

We adopted seven metrics for analyzing speech rhythm, including five interval measures (ΔC, ΔV, %V; VarcoV and VarcoC) and two pairwise variability indices (rPVI and nPVI) in analyzing L2 Portuguese produced by Cantonese learners. Detailed definitions and formulae can be found under "Computation of rhythm metrics" in Section 3.

2. Literature review

Speech rhythm and rhythm measures

In recent years, researchers have adopted potentially objective and measurable metrics in an attempt to study the differences between the rhythms of different languages (Nolan & Jeon, 2014). The development of these metrics was also driven by the auditory impressions of the traditional isochronous view of speech (Abercrombie, 1967; Pike, 1945), which led to a putative hypothesis that languages fall into different rhythm classes, namely syllable-timed, stress-timed and mora-timed (Grabe & Low, 2002; Ladefoged & Johnson, 2011; Mok & Dellwo, 2008; Pike, 1945; Port et al., 1987; Warner & Arai, 2001). The first set of rhythm metrics were proposed by Ramus et al. (1999), including the standard deviation of consonantal intervals (ΔC), the standard deviation of vocalic intervals (ΔV), and the percentage of the sentences that was vocalic (%V). However, these interval measures were later challenged as they were considered to be heavily affected by speech rate (Dellwo & Wagner, 2003; Grabe & Low, 2002; Ramus, 2002). For instance, a number of studies (Barry et al., 2003; Frota & Vigário, 2001; White & Mattys, 2007) discovered that ΔC and ΔV were inversely related to speech rate.

Various measures were then adopted to constrain the impact of speech rate. Ramus et al. (1999) used utterances with similar syllable counts and durations. Dellwo (2006) proposed rate-normalized metrics (Varcos), and Grabe and Low (2002) quantified differences in adjacent intervals using the Pairwise Variability Index (PVI). PVI was argued to be a better indicator for speech rhythm than the previous metrics since it was "cumulative, controls for changes in speaking rate within intonational phrases, and contains an articulation rate normalization component" (Low et al., 2000, p. 396) and it could capture the vowel duration and amplitude better (Low, 1998; Nolan & Asu, 2009). In addition to these commonly used measurements, other methods have been proposed for investigating rhythm (Barbosa, 2000; Cummins & Port, 1998; Dellwo & Wagner, 2003; O'Dell et al., 2007; Van Maastricht et al., 2019).

Metric-based methods are also employed in the research for second language rhythm acquisition (e.g., L2 English by L1 Punjabi and Italian speakers: Ordin & Polyanskaya, 2014; L2 English by L1 Chinese learners: Zhang & Lee, 2019; L2 Portuguese by Chinese Mandarin learners: Zhou et al., 2017). A number of studies (e.g., Li & Post, 2014; Van Maastricht et al., 2019; Yuan, 2010) have found substantial L1 transfer of speech rhythm to L2 production. However, it has also been observed that the higher the L2 proficiency level, the greater the proximity of L2 rhythm to L1 productions (Zhou et al., 2017).

Previous studies have also examined the task effect on L2 rhythm, including reading (e.g., Gut, 2003; Low et al., 2000; White & Mok, 2019; White & Mattys, 2007), retelling (e.g., Gut, 2007; Mok & Dellwo, 2008), and spontaneous speech (e.g., Lai et al., 2012; Lin & Wang, 2008; Mok, 2009). For instance, Topintzi et al. (2009) compared the rhythm of Kozani Greek and Standard Modern Greek and found that, for PVI values, the reading task presented more variability in Kozani Greek, for both vowel (61.15) and consonant (59.15). However, for quasi-spontaneous speech (picture-description task), more consonantal variability was indicated in Standard Modern Greek (54.65).

In the current study, we selected seven most well established and most commonly used metrics (%V, ΔC, ΔV, VarcoC, VarcoV, rPVI_C, and nPVI_V). The traditional interval measures allow us to compare the metrics for L1 Portuguese and L1 Cantonese reported in previous studies, while the PVIs allow us to capture more variance since they are reported to be relatively more robust measures.

Portuguese and Cantonese as L1

Most existing speech rhythm research of Portuguese focus on comparing rhythmic and intonational properties of L1 Portuguese varieties (e.g., European Portuguese in Frota et al., 2002, and Frota & Vigário, 2000, 2001; Brazilian Portuguese in Barbosa, 2000; Cagliari, 1981; Cagliari & Abaurre, 1986) or on examining their speech rhythm typology using acoustic measures (e.g., Frota & Vigário, 2001). Within European Portuguese, the rhythmic variation has been investigated diatopically (e.g., Cruz, 2013; Cruz et al., 2017; Cruz & Frota, 2014; Oliveira et al., 2015) and diachronically (e.g., Frota et al., 2012). Frota and Vigário (2001) tested European Portuguese (EP) and measured the variability of interval duration relative to sentence duration, i.e., standard deviations of the vocalic and consonantal intervals (Δ%V and Δ%C). The authors concluded that EP shows mixed rhythmic properties. It is close to syllable-timed languages concerning the vocalic proportion (%V), and it resembles stressed-timed languages according to their consonant variabilities (ΔC, Δ%C).

Cantonese is a dialect of Chinese (Duanmu, 2007). Only a small number of studies investigated Cantonese rhythm (Mok, 2009, 2011; Mok & Dellwo, 2008). For instance, Mok and Dellwo (2008) investigated Cantonese, Beijing Mandarin, L2 English by Cantonese speakers and L2 English by Mandarin speakers, together with languages in BonnTempo Corpus. They found that speakers may change their rhythmic patterns according to different tasks. As for %V, they found that retelling in Mandarin and Cantonese presented higher values than reading (around 57 and 55, respectively). However, this difference was not revealed by the PVIs.

In the current study, we aim to compare the rhythm metrics of L2 Portuguese speech with the metrics of L1 Portuguese and L1 Cantonese reported in the literature. As a first-step comparison, we consider that the metrics in the literature are sufficient to serve as a baseline for an indication of whether L2 Portuguese is more source-like or target-like (RQ 1). We acknowledge the differences between the tasks and materials used in the current study and the previous studies, and plan to address this issue by investigating L1 Portuguese speech using the same tasks and materials in future studies. Not including L1 control groups was also partially due to the practical difficulties of lacking access to L1 Portuguese speakers during the Covid-19 pandemic.

Task effect and cognitive load

Cognitive load research focuses on the relationship between working and long-term memory and how they affect learning and problem solving (Diao et al., 2007). L2 studies based on cognitive load in writing tasks found that thinking in L2 and using L2 lexis and syntax directly present a reduced cognitive load than having a conception in L1 and then translating it into L2 (Nawal, 2018). When it comes to listening performance, Diao et al. (2007) found that a full script or simultaneous subtitle should be eliminated when the learning objective is on practicing listening. Although the two types of texts seem helpful, they may "impose an unnecessary cognitive load" (Diao et al., 2007, p. 251). In our study, the retelling task has been shown to require more cognitive effort than a reading task (e.g., Mok, 2009), but involves less cognitive load compared to the interpreting process (Goldman-Eisler, 1967; Setton, 1999).

3. Methods

Participants

Eight native Cantonese speakers (three males and five females), aged 24 to 33 (mean 27.4), participated in the current experiment. They were born and raised in Macao, and their parents were also Cantonese speakers. No one reported extended exposure to Portuguese during early childhood. Their age of onset for Portuguese learning was between 17 and 21. All eight participants were graduates of the Master of Translation and Interpreting Program at Macao Polytechnic University, who had reached a minimum of C1 level[3] at admission.

3. Common European Framework of Reference for Languages (Council of Europe, 2021)

Materials

We divided the recording materials into three parts: (1) *read*: read the text in L2 Portuguese; (2) *retell*: retell the same story in L2 Portuguese; (3) *inter*: interpreting the text from L1 to L2, i.e., Cantonese to Portuguese. For the reading and the retelling task, we used the same story in Portuguese, "The North Wind and the Sun". Since the original Portuguese version (Cruz-Ferreira, 1999) was published a few decades ago, in a pilot session, speakers had difficulty reading the script due to the infrequent words. Therefore, the first author proposed a more modern and participant-friendly version by adjusting the lexicon and sentence style (see Appendix). This version was better geared towards the age group and the style of expressions of the participants recruited in the current study. A native EP speaker, who held a master's degree in Translation and Interpreting, also checked and gave advice on the proposed version. This version was then tested on two Cantonese master students of Portuguese language who did not participate in the final recordings. The materials were well received and the readings were smooth. For the interpreting task, we adjusted a news article into "written oral Cantonese", a form of writing used in everyday life by native Cantonese speakers. A professional Chinese-Portuguese translator, whose mother tongue is Cantonese, modified the script to be more suitable for this task. The script was printed on a piece of paper for the speakers to read while interpreting it into Portuguese.

Since we use previously published research as our L1 baseline, we present the differences between previous studies and our current study in terms of the tasks, materials, and the number of speakers in Table 1 for clarity and readability.

Table 1 – Number, gender, age, and L1 of speakers, tasks used, recording materials, and metrics of L1 Portuguese speech in Frota and Vigário (2001), L1 Cantonese speech in Mok & Dellwo (2008) and Mok (2009), and L2 Portuguese speech by Cantonese speakers in current study

	Speakers			Task(s) & Materials	Metrics
	Number & Gender	Age	Language(s)		
Frota & Vigário (2001)	5 female	20s-30s	L1 Portuguese	reading short sentences	%V, ΔC, ΔV, Δ%C, Δ%V
Mok & Dellwo (2008)	6 (3 male+3 female)	under-graduate/postgraduate students	L1 Cantonese; L2 English	"The North Wind and the Sun" reading and retelling in L1; reading the English version	ΔC, ΔV, %V, VarcoC, VarcoV, rPVI_C, nPVI_V*
	6 (3 male+3 female)		L1 Mandarin; L2 English		
Mok (2009)	6 (3 male+3 female)		L1 Cantonese	"The North Wind and the Sun" reading and retelling in L1	
	6 (3 male+3 female)		L1 Mandarin		
Current study	8 (5 female+ 3 male)	24-33	L1 Cantonese; L2 Portuguese	reading "The North Wind and the Sun" (version proposed by the authors); retelling the same story; sight interpreting news passage	ΔC, ΔV, %V, VarcoC, VarcoV, rPVI_C, nPVI_V

* Mok & Dellwo (2008) and Mok (2009) also used ΔS, VarcoS, rPVI_S, nPVI_S in their study. They are not included in the table since they are not examined in the current study.

Recording procedures

Due to Covid-19, face-to-face interactions were restricted. The recording sessions were therefore conducted remotely. We used the procedures and settings reported in Zhang et al. (2021) and asked the participants to record themselves using Awesome Voice Recorder (henceforth, AVR; Newkline, 2020) on mobile phones. The recordings were recorded as mono-channel .wav files at a bit rate of 256 kbps and a sample rate of 44.1kHz. Detailed instructions for recording set-up and all materials were sent to the participants prior to the recording sessions. The authors held video chat sessions to train the participants in conducting the recording sessions on their own, including setting up the device, adjusting the settings in AVR, familiarizing themselves with the test materials, naming and sending files, etc. The participants were then asked to record a few test sentences and send the test files to the authors. The authors examined the quality of the test files before asking the participants to proceed with recording the speech materials. The quality of the final recordings was also examined before analysis.

Participants were instructed to read the text as many times as they needed to familiarize themselves with the materials prior to recording the reading and retelling tasks. Before recording the interpreting task, they read the scripts again, and they were allowed to look up any words they needed or prepare notes to ensure the highest possible quality output in sight interpreting.

Data annotation

The speech data were annotated and extracted in *Praat* (Boersma & Weenink, 2021). The onsets and offsets of utterances, words, and all vowels and consonants were annotated. The consonants and vowels were first forced aligned using the "*Align interval*" function for *Portuguese (Portugal)* in *Praat*. All boundaries were manually corrected according to the criteria set in Turk et al. (2006). A trained phonetician then double-checked 20% of the annotation. Any inter-annotator discrepancies were discussed and revised. We also designed a set of additional criteria for the current study following the criteria set in Frota and Vigário (2001), e.g.:

i. The glide in a falling diphthong is included as a part of a vocalic interval (e.g., /aj/ in /majʃ/),

ii. The glide in a rising diphthong is included as a part of a consonantal interval (e.g., /dj/ in /imɨdjɐtɐmẽtɨ/);

iii. The pauses are labelled “p” when it is less than 250 ms and are labelled “pause” when more than 250 ms (the reasons are detailed below).

Computation of rhythm metrics

In Table 2, we present the formulae and definition of five interval measures and two pairwise variability indices used in the current study.

Table 2 – Rhythm metrics used in this study, their formulae and definitions

Metrics		Formula & Definition	Source
Interval Measures	%V	$\%V = \frac{sum\ V}{utterance\ durantion}$ the proportion of vocalic intervals within the sentence, that is, the sum of vocalic intervals divided by the total duration of the sentence	Ramus et al. (1999)
	ΔV	$\Delta V = \sqrt{\frac{1}{n}\sum_{i=1}^{n}}\ (V_i - mean\ V)^2$ the standard deviation of total duration of vocalic intervals within each utterance	
	ΔC	$\Delta C = \sqrt{\frac{1}{n}\sum_{i=1}^{n}}\ (C_i - mean\ C)^2$ the standard deviation of total duration of consonantal intervals within each sentence	
	VarcoC	$VarcoC = \frac{\Delta C}{mean\ C} \times 100$ (C is the duration of consonantal intervals) the normalized standard deviation of consonantal interval durations divided by the mean consonantal duration, multiplied by 100	Dellwo & Wagner (2003)
	VarcoV	$VarcoV = \frac{\Delta V}{mean\ V} \times 100$ (V is the duration of consonantal intervals) the normalized standard deviation of vocalic interval durations divided by the mean vocalic duration, multiplied by 100	

Pairwise Variability Indices	rPVI_C	$$rPVI = \frac{(\sum_{k=1}^{m-1} \quad \lvert d_k - d_{k+1} \rvert)}{(m-1)}$$ (*m* is the number of intervals in the text; *d* is the duration of the *kth* item/interval) the mean of the differences between consecutive consonantal intervals, which is not normalized for speech rate	Grabe & Low (2002)
	nPVI_V	$$nPVI = 100 \times \left[\frac{\sum_{k=1}^{m-1} \quad \left\lvert \frac{d_k - d_{k+1}}{\frac{(d_k + d_{k+1})}{2}} \right\rvert}{(m-1)} \right]$$ (*m* is the number of intervals in the text; *d* is the duration of the *kth* item/interval) mean of the differences between consecutive vowel intervals divided by the sum of the same intervals, then multiplied by 100	

In the reading task, an utterance is well defined by punctuations. However, the two semi-spontaneous tasks involved many instances of disfluencies, such as silent or filled pauses. We, therefore, segmented the utterances by intonational phrases. One of the cues for intonational phrase boundaries was silences longer than 250ms since this is a threshold frequently used in L2 fluency research (e.g., De Jong et al., 2012; Wright & Zhang, 2015).

Statistical analysis

We built linear mixed effect models using *lme4* package (Bates et al., 2015) in R (R Core Team, 2021). For the full models, Task (read, retell, interpret) was used as the fixed effect, with Task as random slope for the random intercept of Speaker. Then we compared the full model with a reduced model without the random slope of Task. All models performed better without the random slope. We calculated the degree of freedom, F statistic, and p-values using the *anova* function in *lmerTest* package (Kuznetsova et al., 2017) . Confidence intervals and effect sizes were acquired using sjPlot package (Lüdecke et al., 2021).

When the fixed effect was significant, further pairwise comparisons were done using the *emmeans* package (Lenth et al., 2022). Based on the analysis and plotting procedures used in this article, an R package, *rhythm.metrics*[4], was built for producing the descriptive data and visualisation (Zhang, 2022).

3. Results

L2 vs L1 speech rhythm

Recall that we use previously published research as our L1 baseline, i.e., L1 Portuguese speech in Frota and Vigário (2001), L1 Cantonese speech in Mok & Dellwo (2008) and Mok (2009). Apart from these studies, Bond et al. (2008) also studied speech rhythm in L1 Portuguese production. They used ΔC, ΔV, %V, rPVI_C, and nPVI_V to compare the rhythm of reading of proses and poems. However, values in Bond et al. (2008) were approximately several hundred times lower than the other studies (e.g., ΔC: 0.16 for prose reading in Bond et al., 2008 *vs* 55.40 for reading in Frota & Vigário, 2001). This could be because the unit used in this study was seconds, while other studies, including ours, used milliseconds. Although Bond et al. (2008) offers an interesting comparison between reading prose and poems, due to the lack of sufficient details reported, we could not make any useful comparisons between our study and theirs. We made further comparisons in Table 3, detailing the mean scores and standard errors of the seven metrics used in this study.

4. https://github.com/congzhang365/rhythm.metrics

Table 3 – Means (standard errors) of rhythm metrics for L2 Portuguese reading, retelling, and interpreting tasks, compared with L1 Portuguese sentence reading from Frota and Vigário (2001) and with L1 Cantonese (reading, retelling) from Mok and Dellwo (2008) and Mok (2009)

	Current study			**Frota & Vigário, 2001**	**Mok, 2009; Mok & Dellwo, 2008**	
	L2 Portuguese reading	**L2 Portuguese retelling**	**L2 Portuguese interpreting**	**L1 Portuguese sentence reading**	**L1 Cantonese reading**	**L1 Cantonese retelling**
Interval measures						
ΔC	55.40 (27.2)	55.17 (32.2)	59.88 (34.3)	54.6 (14.55)	41	40
ΔV	89.09 (47.2)	105.4 (65.0)	93.83 (64.1)	40.2 (14.10)	-	-
%V	62.04 (10.6)	66.59 (15.3)	60.73 (16.0)	48.0 (5.04)	55	57
VarcoC	50.91	51.91	52.71	-	48.5	49
VarcoV	51.76	55.42	55.31	-	-	-
Pairwise variability indices						
rPVI_C	19.21	30.21	30.61	-	49	45
nPVI_V	9.01	20.60	17.60	-	43	48

In Table 3, the mean ΔC values in the current study are very similar to that of L1 Portuguese speech reported in Frota and Vigário (2001), and are higher than L1 Cantonese. The mean ΔV values are also higher in L2 Portuguese than in L1. The difference was much more substantial than ΔC. ΔV was not reported for L1 Cantonese in the literature. These results allow us to have an initial observation about the variability of the vowel duration produced by Cantonese learners of L2 Portuguese in different tasks. For %V, in all three tasks, the current L2 Portuguese study reported higher mean values than L1 Portuguese. The mean values for L1 Cantonese are also higher than L1 Portuguese. In this sense, the L2 Portuguese is more source-like. Varcos for L1 Portuguese were not inspected by Frota and Vigário (2001). VarcoC values in L1 Cantonese are on a similar level to that of L2 Portuguese speech by Cantonese speakers.

For the PVIs, values of nPVI_V (39 for prose reading and 51 for poem reading) reported in Bond et al. (2008) were higher than that of all our three tasks in the current study (9.02, 20.6 and 17.6), while Bond et al.'s (2008) rPVI_C score for poem reading (24) is between reading

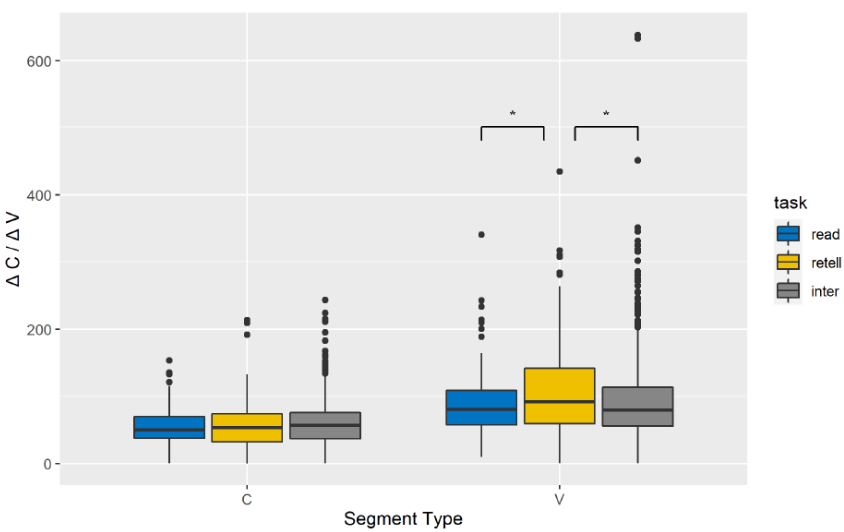
(19.21), and spontaneous speech (retelling 30.21; interpreting 30.61). However, as previously reported, the results in Bond et al. differ from other studies substantially. As for L1 Cantonese speech, the PVI values are also much higher the PVIs in the current study.

Task effect[5]

ΔC and ΔV

Figure 1 shows the ΔC values and ΔV values by task. The ΔV values show a more obvious difference between tasks. The statistical analysis results showed that the effect of the task was not significant in predicting ΔC ($\chi^2(2) = 2.24$, $p = 0.107$, $R^2 = 0.01$). However, for ΔV ($\chi^2(2) = 4.80$, $p = 0.0084$, $R^2 = 0.027$), there was a significant task effect. The post hoc test indicated that for ΔV, there was a significant difference: the score was higher in the retelling task than in the reading task by 17.49 ($p = 0.0193$), and the ΔV score of interpreting was lower than retelling by 12.56 ($p = 0.0193$).

Figure 1 – Variability of intervals by task: ΔC and ΔV

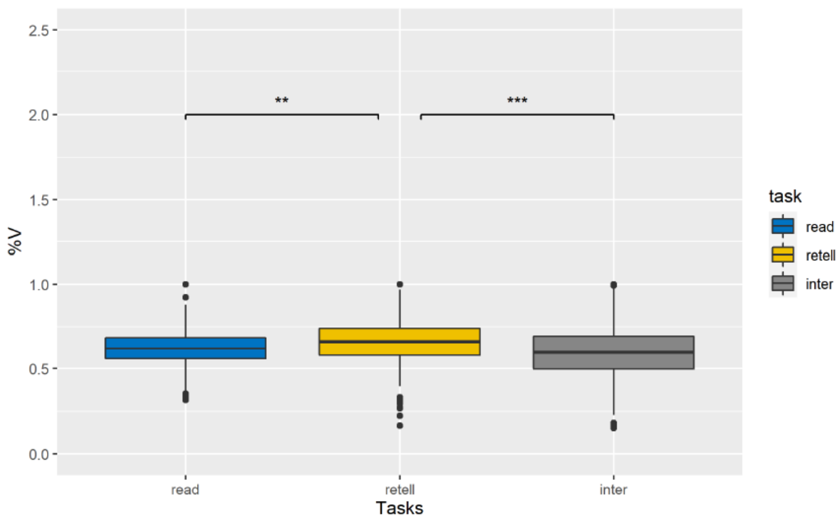


5. The data and scripts used in this study are available here https://osf.io/47jnf/. More detailed results such as confidence intervals and random effects can be found in the full data analysis.

%V

Figure 2 shows the % V values. While the task difference was not easy to see in the figure, the statistical analysis results also showed a significant task effect for %V ($\chi^2(2) = 15.11$, $p < 0.001$, $R^2 = 0.036$). The post hoc test showed that the %V score was higher in the retelling task than the reading task by 0.0446 ($p = 0.0079$); interpreting was lower than retelling by 0.0578. ($p < 0.001$).

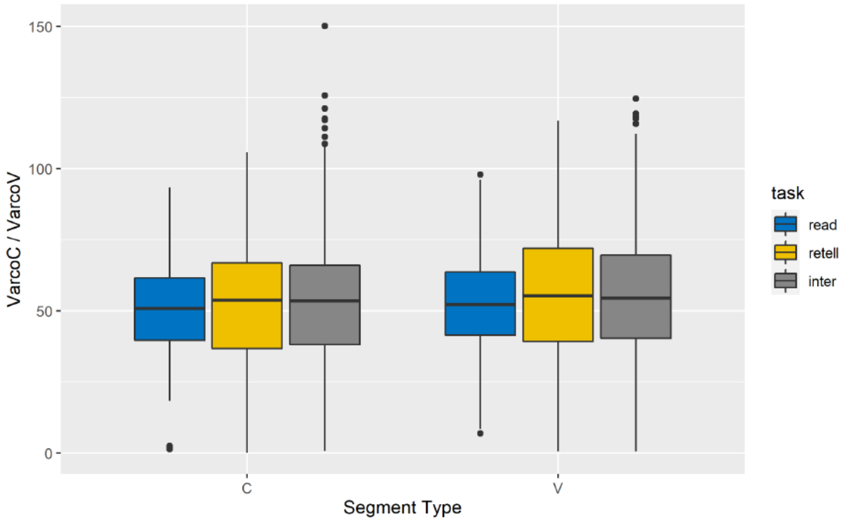
Figure 2 – Variability of intervals by task: %V



VarcoC and VarcoV

Figure 3 exhibits the differences between tasks in terms of VarcoC values and VarcoV values. Different from the ΔC and ΔV results, here the task was not a significant predictor for either VarcoC ($\chi^2(2) = 0.4686$, $p = 0.626$, $R^2 = 0.004$) or VarcoV ($\chi^2(2) = 1.720$, $p = 0.1795$, $R^2 = 0.012$).

Figure 3 – Variability of intervals by task: VarcoC and VarcoV



rPVI_C and nPVI_V

The results in Figure 4 show that the effect of the task is significant in predicting rPVI_C (χ^2 (2) = 6.09, p =0.0023, R^2 = 0.029). The post hoc test showed that the rPVI_C score was higher in the retelling task than in the reading task by 11.282 (p = 0.011). Interpreting also showed a higher score than reading by 12.106 (p=0.0017).

Figure 5 shows that the effect of the task is significant in predicting nPVI_V (χ^2 (2) = 8.05, p=<0.0003, R^2 = 0.034). The post hoc test showed that the retelling task had a higher nPVI_V score than the reading by 11.85 (p = 0.0004). The interpreting's score was also higher than the reading by 9.33 (p = 0.0009).

Figure 4 – Variability of PVI by task: rPVI_C

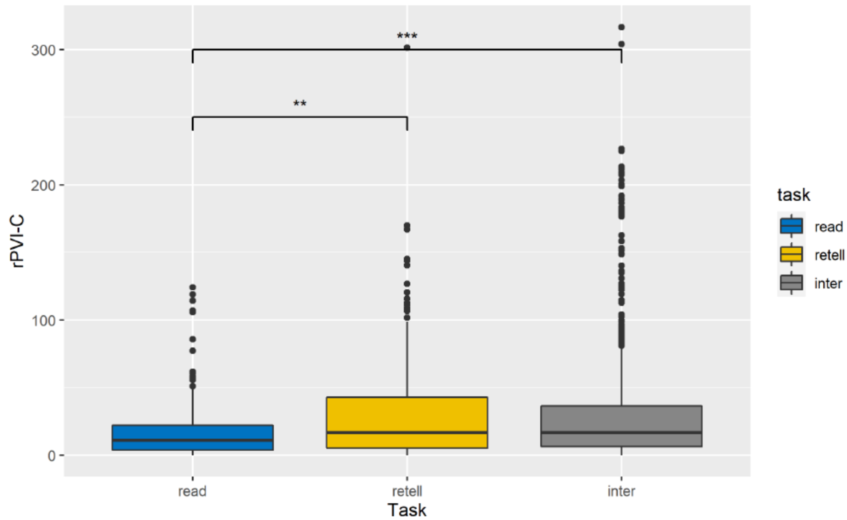
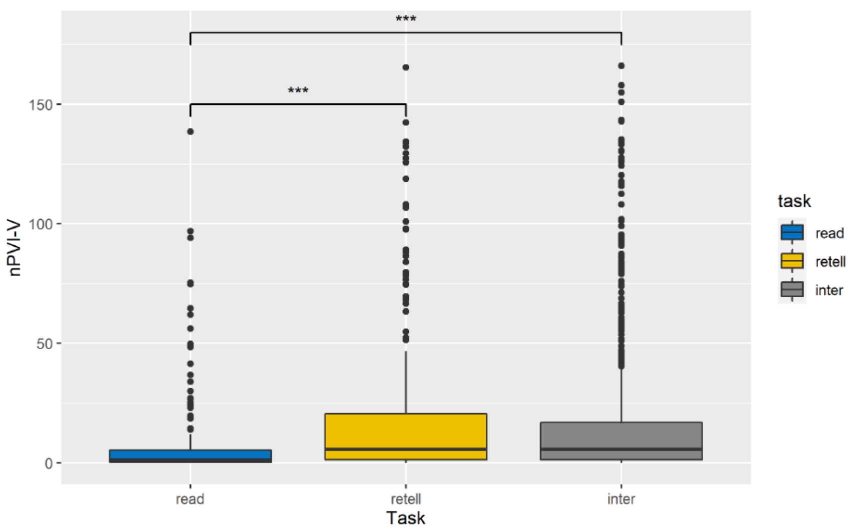


Figure 5 – Variability of PVI by task: nPVI_V



3. Discussion and conclusions

For RQ1, we compared the metrics in the current study with L1 Portuguese data reported in Frota and Vigário (2001) and L1 Cantonese data in Mok (2009) and Mok and Dellwo (2008). The consonantal variance in L2 Portuguese by Cantonese learners, as shown with ΔC, is similar to that of L1 Portuguese and higher than L1 Cantonese, i.e., more target-like. The variance of vowels in L2 Portuguese, as shown with %V and ΔV, is much higher than L1 Portuguese and is comparable to the values for L1 Cantonese, i.e., more source-like. For Varcos and PVIs, we do not have data from both L1s so it is not possible to be compared. The level of VarcoC in L2 Portuguese is similar to that of L1 Cantonese. L1 Cantonese speech presented much higher PVI values than the three types of speech in L2 Portuguese by Cantonese learners.

Regarding task effect (RQ2), different tasks influenced the values of ΔV and %V (the retelling task had a higher score than the reading task and the interpreting task in the post hoc test), rPVI_C and nPVI_V (for both metrics, retelling and interpreting showed higher score than reading task in the post hoc test), but not ΔC, VarcoC, or VarcoV.

L2 Portuguese rhythm

The vocalic variability in our corpus is possibly due to the simultaneous presence of rhotic deletion and vowel epenthesis, which echoes the findings in Zhou et al. (2017) for L2 Portuguese by Mandarin speakers. Rhotic deletion is likely to be the cause of small consonantal changes, and large vocalic changes, while vowel epenthesis largely contributes to the vocalic variance.

Rhotic deletion, which is common in Brazilian Portuguese (BP) and frequently noted in EP (Mateus & Rodrigues, 2003; Oliveira et al., 2018; Serra & Callou, 2015), was also observed in our data. The deletion resulted in a higher percentage of the vowels and increased the number of CV syllables. For example, in Table 4, "ɾ-deletion" in "por um lado /puˈũˈɫa.du/", and "por exemplo /puiˈzẽplu/" caused new vocalic clusters and instability in the duration of vocalic intervals.

Table 4 – Rhotic deletion examples in our data

word	meaning	IPA	canonical pronunciation in L1
por [um lado]	in one hand	pu[ũˈła.du]	puɾ [ˈũ ˈła.du]
por [exemplo]	for example	puiˈzẽplu	puɾ iˈzẽplu
reproduzir	reproduce	ʀəpruduˈzi	ʀəpruduˈzir
tirar	remove	tiˈra	tiˈrar
reduzir	reduce	ʀəduˈzi	ʀəduˈzir

Vowel deletion is a common characteristic of EP (Frota & Vigário, 2001; Mateus & Andrade, 2000; Silva, 1994), which also contributes to the differences in terms of rhythmic properties between EP and BP[6]. In other languages, such as English, Dutch, Catalan or Kozani Greek, vowel reduction is frequently the reason for vocalic variability (Dauer, 1987; Ramus et al., 1999; Topintzi et al., 2009) which leads to L2 phonological deviations from the target language (e.g., L2 English by Taiwanese speakers in Chen & Chung, 2008). L2 Portuguese by Cantonese speakers also did not present much vowel deletion/reduction. On the contrary, vowel epenthesis occurred, i.e., epenthesis in the "right edge" of a word (see examples listed in Table 5).

Epenthesis in consonant clusters, which was not found in literature, also contributed to the high score of %V and the higher value ΔC in L2 Portuguese by Cantonese speakers. This type of epenthesis challenged the established Portuguese consonant clusters, namely, the "branching onsets" constructed by plosive and alveolar flap /ɾ/ (Freitas, 2003; Mateus & Andrade, 2000). Therefore, the number of consonantal intervals increased, and the duration of the consonantal intervals was affected. Some examples are reported in Table 5.

6. For instance, in L1 Portuguese, "*pequ*eno [small] can be pronounced as [pˈkenu] (Davies & Elder, 2016) instead of [pəˈkenu]; "sa*be b*em [knows well]" as [sáb:ɐ̃j] (Mateus & Andrade, 2000). For BP, Frota and Vigário (2001) gave an example of "*objective* [goal]" pronounced as [obiʒɛˈtʃivu], showing that vowel epenthesis applies in BP, instead of vowel deletion.

Table 5 – Vowel epenthesis in L2 Portuguese productions

position	word	meaning	IPA	canonical pronunciation in L1
at the right edge of a word	passar	to pass	pɐˈsarɨ	pɐˈsar
	obrigar	to force	ɔbriˈgarɨ	ɔbriˈgar
	reconhecer	recognize	ʀəkuɲəˈserɨ	ʀəkuɲəˈser
	matar	to kill	mɐˈtarɨ	mɐˈtar
	transmitir	transmitting	tr ɐ̃ʒmiˈtirɨ	tr ɐ̃ʒmiˈtir
in consonant clusters	reproduzir	reproduce	ʀəpɨruduˈziɾ	ʀəpruduˈziɾ
	proteína	protein	pɨrɔtɐˈinɐ	prɔtɐˈinɐ
	primeiramente	firstly	pɨrimɐjrɐˈmẽtɨ	primɐjrɐˈmẽtɨ
	encontrar	to meet	ẽkõtɨˈraɾ	ẽkõˈtraɾ
	Brasil	Brazil	bɨrɐˈziɫ	brɐˈziɫ

Zhou et al. (2017) found that Mandarin L2 Portuguese speakers at the proficiency level C2 produced speech with identical %V value with L1 Portuguese speech (see also L2 advanced-level Chinese by American learners in Zhang & Lee, 2019); only speakers of a relatively lower L2 proficiency level (B1) presented %V values closer to that of L1 Mandarin. However, in the current study, our speakers had a minimum of C1 level, but they still presented source-like vocalic variance. This reflects the difference between the prosodic properties of Mandarin and Cantonese. In Mandarin, syllables with neutral tones are reduced and often have half of the duration of a full-toned syllable. These syllables resemble unstressed syllables in languages such as English. However, in Cantonese, neutral tone does not exist (Mok & Wong, 2010); hence, it does not have any reduced syllables. Vowel epenthesis is therefore a common L1 transfer in Cantonese learners (Chan & Li, 2000).

Task effect

Recall that the task effect was significant in ΔV, %V, rPVI_C, and nPVI_V.

For ΔV and %V, retelling had a significant difference from both reading and interpreting, which means in the retelling task, vowel epenthesis and r-deletion were likely to have happened more frequently.

Regarding rPVI_C and nPVI_V, retelling and interpreting had similar results while they both significantly differed from the reading task. This indicates that the more spontaneous tasks, i.e., retelling and interpreting, had larger variance than reading for both metrics.

These results allow us to deduce that vowels varied between tasks since three out of four metrics reported significance, and consonants showed less variability between tasks since only one out of three metrics showed significance. Moreover, the significant differences between the more spontaneous tasks and the reading task were expected, since the vowel epenthesis, and lengthening happen in the more spontaneous speech. This is because the speakers' attention tends to be drawn by processing the information rather than the production. Levelt's (1989) speech production model depicted three general stages: conceptualizer, formulator, and articulator. The retelling and interpreting tasks both involved extra processing in the conceptualizer and formulator stages, while the reading required less effort in the conceptualizer stage. Moreover, retelling and sight interpreting also required the speakers to have good working memory or multitasking ability. Therefore, the cognitive load in the two semi-spontaneous tasks was higher than the reading task. This explains why the PVI metrics differed between the reading and the other two tasks. However, the retelling task generally seemed to have higher variability across the metrics. It is possibly because the participants were highly trained for interpreting since they were master's students in Translation and Interpreting, while retelling was not a task that they performed regularly. The fact that retelling requires more effort related to working memory may also have contributed to the difficulty of the task since the interpreting task in this study is a sight interpreting task that did not require much effort in remembering information.

Limitations and future studies

We acknowledge that the current study is only a first step towards understanding the speech rhythm produced by L1 Cantonese-L2 Portuguese speakers. There are many more things to be done in future studies: First, we acknowledge the differences between the L1 data and our L2 data. Since the tasks and speech materials were not the same, it was not ideal to compare our study with the values in the literature. We plan to record our own L1 speech and follow up from this perspective. Second, we investigated the seven most commonly used rhythm metrics in this study in order to compare our data with the reported values in the literature. However, as these metrics receive increasingly more criticism, we plan to look at other methods of measuring speech rhythm. Third, tasks which require even more cognitive load, such as simultaneous interpreting, will be investigated in order to further understand how cognitive load impacts L2 speech production.

For data analysis, the outliers in the current study also reminded us that measures could be taken in future studies to normalize the L2 speech data. For instance, any ungrammatical or semantically incomplete utterances could be discarded to exclude the potential outliers.

As an extension, we also plan to examine the same eight speakers' L1 Cantonese oral production and compare the results with their L2 Portuguese speech. This will allow us to understand whether each speaker's L1 rhythm relates to their L2 production.

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Conflict of interests

The authors declare they have no conflict of interest.

Credit Author Statement

Yuqi Sun: conceptualization, methodology, study design, data collection, formal data analysis, writing, and editing.
Cong Zhang: conceptualization, methodology, study design, statistical data analysis, software, writing, and editing.

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Appendix 1.

New Portuguese version of *The North Wind and the Sun*

O vento norte e o sol

O vento norte e o sol discutiam qual dos dois era o mais forte, quando sucedeu passar um viajante envolto numa capa. Ao vê-lo, desafiam-se um ao outro em como aquele que primeiro conseguir obrigar o viajante a tirar a capa seria considerado o mais forte. O vento norte começou a soprar com muita fúria, mas quanto mais soprava, mais o viajante se aconchegava à sua capa, até que o vento norte desistiu. O sol brilhou então com todo o esplendor, e imediatamente o viajante tirou a capa. O vento norte teve assim de reconhecer a superioridade do sol.