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A COMPARISON BETWEEN FULL TIME EQUIVALENT AND LENGTH OF RESIDENCE AS MEASUREMENTS OF TIME IN BILINGUAL SPEECH RESEARCH: THE CASE OF FIRST LANGUAGE ATTRITION

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Abstract

Full Time Equivalent (FTE), a product of Length of Residence (LOR) in L2 contexts multiplied by an index of frequency of L2 use, has been considered to be an important factor in bilingual speech development (Flege & Bohn, 2021). This work, therefore, seeks to analyze changes in the Voice Onset Time (VOT) of Brazilian Portuguese-L1 (short lag) in contexts of English-L2 (long lag) as a function of LOR and FTE (N=44) through Bayesian linear regression models with mixed effects. As a result, the models showed a positive effect of time on VOT values, with VOT values increasing over LOR. However, the models that used FTE yielded greater effects with greater credibility. We conclude that LOR underestimates the effect of time, making FTE a more accurate metric since it incorporates both 'time' and 'language use'.

Keywords: Full Time Equivalent; Length of Residence; First Language Attrition; Complex Dynamic Systems.

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Introduction

To Schmid and Köpke (2007), first language (L1) development and knowledge hold privileged statuses at the core of the study on bilingualism. The L1 is usually considered stable and unchanging (Schmid & Köpke, 2007) and is affiliated to gain-oriented processes (Kupske, 2019). Moreover, it is known that developing the sounds of a nonnative language in adulthood is often challenging (Laurido & Evans, 2018), as the L1 sound system influences the development of the new languages (Best & Tyler, 2007; Flege, 1995; Flege & Bohn, 2021). However, changes in the L1 speech upon the development of a second language (L2) in adulthood have also been widely evidenced in the last decades (e.g., Kupske, 2016; Schmid, 2010), providing empirical support for the plasticity of the L1 systems across the lifespan. Research has then shown that the L1 sound system is adaptive, influenced by competition from new languages or dialects (de Leeuw, 2018), a process usually referred to as first language attrition (FLA, cf. Schmid & Köpke, 2007).

A recent angle to comprehend speech development may be noticed in complex, dynamic approaches (e.g., Beckner et al., 2009; de Bot, Lowie, & Verspoor, 2007; Larsen-Freeman & Cameron, 2008), in which language is seen as a Complex Dynamic System (CDS), and language development as being the result of "interrelated patterns of experience, social interaction, and cognitive processes" (Beckner et al., 2009, p. 2). In a CDS perspective on FLA (Kupske & Alves, 2016; Kupske, 2021b; Kupske & Lima Jr., 2022), alterations in the L1 speech production and perception are taken as an integral part of the bilingual development since the L1 and L2 sound systems are anchored by the same neural architecture (MacWhinney, 2002) and cohabit the same phonological space in the brain (Flege, 1995; Flege & Bohn, 2021). The L1 and the L2 are in constant interaction as they are seen as agents of a single language repertoire or a greater complex system. FLA then reflects the common dynamics of language development as bilinguals negotiate their way through different landscapes of language use (Linck & Kroll, 2019, pp. 91-92). In this perspective, FLA came to be unanimously characterized as a natural and expected part of bilingual development (Kupske et al., 2019; Linck & Kroll, 2019; Schmid & Köpke, 2019). In this vein, studies on bilingual development that only take into account what happens to the L2 or solely focus on the influence of the L1 may be underestimating a large part of the whole process (Kupske, 2021a; Schmid & Köpke, 2019).

Researchers have extensively investigated the main factors that affect this multidirectional crosslinguistic interaction, which triggers alterations in the L1 speech. Focusing on bilinguals who reside in the L2 community, some of the factors commonly investigated are length of residence (LOR) in the nonnative setting (Kupske & Alves, 2016), age of arrival (AOA), age at onset of bilingualism (AOB), language dominance (Köpke & Genevska-Hanke, 2018), L2 use (Kupske & Lima Jr., 2022), and L2 instruction (Piske et al., 2001). Three of these factors are somehow related to the effect of time, LOR, AOA and AOB, which show that time has been used as a measure and/or predictor for L2 experience and development, as well as L1 attrition. For instance, the Speech Learning Model (SLM - Flege, 1995), its revised version (SLM-R - Flege & Bohn, 2021), and the Perceptual Assimilation Model - L2 (PAM-L2 - Best & Tyler, 2007) are two of the most adopted models in L2 speech research that traditionally focus on L2 experience, which is typically measured by time (Gorba, 2023).

Time, in a broader sense, has always been a center for debate in bilingual studies. For example, one of the most prevalent and effervescent discussions in the area concerns AOB. It has been especially at the center of research on L2 sound development by immigrants, as most studies focus on late learners. Data in the literature point towards a negative correlation between AOB, which sometimes matches the AOA, and success and accuracy in the production of L2 sounds. This considered, the later a new language system is developed, the stronger the bilingual's accent will be (e.g., Flege et al., 2006). As pointed out by Hopp and Schmid (2013), AOB has thus been taken as the main predictive variable for the accuracy in the production of the nonnative sounds. This phenomenon, to Flege (2019), is generally interpreted as an indication that the L2 developmental capacity would decrease after the end of a Critical Period (CP). However, the limits to the success of L2 immigrants, even after years of regular use of the L2 in the host country, may not result from a neurocognitive maturation (Flege, 2019, p. 503). To the author, these limits can arise from differences in the quantity and quality of input that early and late learners normally receive. Following that angle, there is a robust body of research suggesting that it is possible for late bilinguals to attain native levels in their L2 speech production and perception, as in the studies conducted by Bongaerts, Summeren, Planken, and Schils (1997), Sancier and Fowler (1997), and Muñoz and Singleton (2007), in which late bilinguals yield L2 production within the same range of the L1 monolingual controls. Those studies validate Flege (1995, 2007), Flege and Bohn (2021) and Best and Tyler (2007), who propose that the cognitive mechanisms for language development remain intact during the lifespan, and that even late bilinguals would be able to reach L2 native-like levels.

There is a high number of impasses regarding this topic, since research conceptualizes the effects of age in the production of L2 sounds in a different way, the crucial question being whether AOB is the trigger of language transfer or whether it would only be associated to this process (Hopp & Schmid, 2013). Thus, while some, for example, interpret the effects of age as symptoms of a closure in the CP, as already pointed out, others interpret issues related to age as reflections of the level of L1 entrenchment in the process of L2 phonetic categorization (Zimmer & Alves, 2006). Models that advocate in favor of a cognitive entrenchment open up the possibility that factors other than age and time are related to L2 sound development. In this sense, several studies (e.g., Kupske, 2017; Opitz, 2011) already consider that other factors such as linguistic aptitude, education and attitudes towards the languages involved in the process have significant effects on the success of L2 and L1 attrition. Thus, Opitz (2011) indicates that the question of age is not limited to "the sooner the better under any circumstances" (Opitz, 2011, p. 73).

Discussing the question above, although the structures responsible for the relationship between perception and production in language acquisition are not explicit, Flege (1995, 2007) points out that the mechanisms and processes applied to the development of the sound system of the first language (L1), including the formation of categories, for example, remain intact throughout the life of an individual and are applied not only to L2 development, but, as Evans and Iverson (2004) reveal, also to dialect accommodation. In the same direction, Best and Tyler (2007) point out that speakers continually refine their perceptions of speech sounds, including their own L1s. Following this angle, even late bilinguals would be able to reach native-like L2 levels. The relationship between age and proficiency is not as simple as it is generally taken in the area (e.g., Kupske, 2019; Flege, 2019). In our view, this fact may also be understood from a complex, dynamic account of development, according to which a wide range of factors accounts for the learning process. This considered, what can be said to be the so-called effect of "age" by itself may be the result of an interplay of factors whose presence or exposure might be correlated with age.

For immigrants in an L2-dominant setting, the focus of this study, one of the factors that explicitly has an effect on L2 speech development and FLA is the LOR in the host country (e.g., Kupske, 2016; Kupske & Alves, 2016; Rasinger, 2005; Stevens, 2006), as it correlates with L2 proficiency (e.g., Birdsong, 2005; Johnson & Newport, 1989), and is also associated with better speaking and reading skills in the L2 (Chiswick & Miller, 2001; van Tubergen & Wierenga, 2011). However, according to van Tubergen (2010), the effect of LOR is prone to be no longer representative after ten years of immigration. In addition, LOR is not an accurate measure for language development and attrition, specifically in the context of immigration. In fact, not always are immigrants fully exposed to the target language of the host country, either by lack of opportunity, social identification or other social/sociolinguistic factors. Once again, we assume that it is the complex interactions among speakers, not LOR taken by itself, that account for dynamic changes in the first and additional languages.

To Flege (2019), LOR in the L2-dominant community is an imprecise, and sometimes even misleading, index about the L2 input quantity and quality immigrants receive. This is because not all immigrants start using the host language right after the immigration (e.g., Flege et al., 1995) or use it regularly (Moyer, 2009). According to Flege and Liu (2001), LOR would thus be a valid indication of the amount of L2 input only for immigrants who have had both the desire and the opportunity to use the L2 regularly. In this sense, favorable and unfavorable attitudes towards the L1 and the L2 play a significant role in acculturation and language development, as, for instance, positive attitudes towards the host language and culture – integrated acculturation attitudes/integrative motivation – would facilitate learning (Yilmaz & Schmid, 2015). On the other hand, Ellinger (2000) reveals a negative correlation between L2 proficiency and L1 language and culture adherence, as the L1 use and the preservation of robust connections with the first language and culture are recognized to hinder L2 cultural and linguistic integration (Chiswick & Miller, 2001; Yilmaz & Schmid, 2015) and, as a consequence, L2 development and FLA. As for language attrition, Kupske and Lima Jr. (2022) have investigated alterations in the L1 by integrated and nonintegrated immigrants immersed into an L2 context. The study revealed that the changes in the L1 are more accentuated by those who are affiliated to the new environment compared to those who are not.

For reasons such as the ones discussed above, Flege and Bohn (2021) redesigned the SLM - now called Speech Learning Model Revised (SLM-r). In this recently revised version of the model, Flege and Bohn (2021) highlight the significance of differences among individuals, and introduce a novel factor as the most pertinent in L2 speech development (Gorba, 2023) and, as a consequence, to FLA, namely Full-Time Equivalent (FTE). It is a compound variable calculated by multiplying LOR (time) by an index/value of L2 use (experience). To Flege & Bohn (2021), it would be a more extensive and, therefore, more accurate metric. Even though the impact of LOR on multidirectional crosslinguistic interaction has been observed (e.g., Kupske, 2016), additional factors may potentially have a significant influence.

We conceive that the FTE conforms with a complex, dynamic account of L2 development and FLA. As the FTE takes L2 experience into account, it implements two aspects that we consider to conform with CDST, as (i) it may reflect a wide variety of complex interactions among speakers in different sociolinguistic contexts, with different communicative goals depending on the emergent relationships that take place in the interaction; (ii) it considers 'time' as a relevant variable in development, as one's experience to date is the result of multiple interactions that are developed throughout time, thus reflecting a process that emerges from complex interactions and experiences in different communicative scenarios.

In this paper, we investigate how the FTE may be taken into consideration when accounting for phonetic-phonological L1 attrition data. By investigating the production of Voice Onset Time (VOT) in Brazilian Portuguese (BP) by first-generation Brazilian immigrants residing in the United Kingdom, the present study consists of a reanalysis of the speech production data presented in Kupske (2016) and Kupske and Lima Jr. (2022). These works explore the interaction between distinct VOT categories, since VOT in word-initial voiceless plosives in BP is significantly shorter (short lag) than in Standard Southern British English (SSBE, long lag). Even though FLA has been already tested and evidenced in the previous analyses of the corpus, this study seeks to analyze if a change in time measure (LOR X FTE) will yield alterations in the results in terms of FLA. In this context, although FTE is experimented here with FLA data (which, in this paper, is regarded as a natural consequence of L2 development), one of the aims of this work is to test it as a measure of time that can be applied for studies on speech development in more general terms.

Method

Participants

For this work, data from 44 participants were considered. 34 Brazilian volunteers (17 for each gender) from the greater Porto Alegre region (RS - Brazil) were recruited, 10 of whom were part of a control group of monolingual speakers of BP and 24 first-generation immigrants (age of arrival > 18 years) residing in Greater London, United Kingdom. In addition to the Brazilians, data from 10 SSBE monolinguals were considered. The data were taken from the corpus created by Kupske (2016). For the experimental group (EG), only Brazilians who had emigrated directly from Brazil to the United Kingdom were considered. At the time of data collection, participants were between 19 and 45 years old (Mean = 27.8; SD = 8.2) and had lived in London for different periods of time (Mean = 5.7; SD = 3.3). Although proficiency in the dominant L2 is influenced by age variables (e.g., AOB, AOA, etc.) and age at testing, these factors correlate with the LOR variable (Schmid, 2011) and are not controlled or tested, as the longer the time of immigration, the higher the age at testing. All immigrants were advanced English language users, tested by a C-test (Keijzer, 2007). Participants answered a sociolinguistic questionnaire (Kupske, 2016) to ensure that they had not been in the UK before immigration, and that the L2 had been developed in the new context.

FLA has already been tested and evidenced in previous analyses of the corpus (Kupske, 2016; Kupske & Alves, 2016; Kupske & Lima Jr., 2022). However, this study seeks to analyze if a change in time measure (LOR vs. FTE) will yield alterations in the results of the analysis. In order to do that, the LOR in years and the FTE of the participants were taken into consideration separately in the analyses carried out for this paper. The FTE values were obtained by multiplying LOR (in years) by a value of L2 use according to the questionnaire. Participants should choose, for the L2 frequency of use, one of these options: (i) only L1. never L2 (value = 0.0); (ii) more L1 than L2 (value = 0.25); (iii) L1 and L2 equally (value = 0.50); (iv) more L2 than L1 (value = 0.75); (v) only L2. never L1 (value = 1.0). Thus, a participant with ten years of LOR and an L2 use value of 0.50 will have an FTE of 5.0. In the same line of thought, a participant with five years of LOR and an L2 use value of 1.0 will also reveal an FTE of 5.0. When completing the questionnaire, immigrants should list their main interlocutors in different contexts, indicating whether the L1 or the L2 was used. This information was used to validate the frequency values assigned for the calculation of FTE.

Data collection and acoustic and statistical analysis

In addition to the number of syllables of the target word and speech rate, the height of the next vowel can influence the VOT rates of voiceless plosives. Thus, the choice of targets for this study took into account the vowel contexts. Following Kupske (2016), BP items containing (i) voiceless plosives preceding the high back vowel and (ii) preceding the mid back vowel were selected[1]. Table 1 presents the BP targets used. For more details about the procedures, refer to Kupske (2016).

Table 1: Targets

Vowel	/p/	/t/	/k/
High back	*Puma*	*Tudo*	*Cujo*
	Puro	*Tufo*	*Cume*
	Pulo	*Tusso*	*Cura*
Low-mid back	*Poça*	*Toca*	*Cola*
	Posso	*Toque*	*Copa*
	Pote	*Tosa*	*Copo*

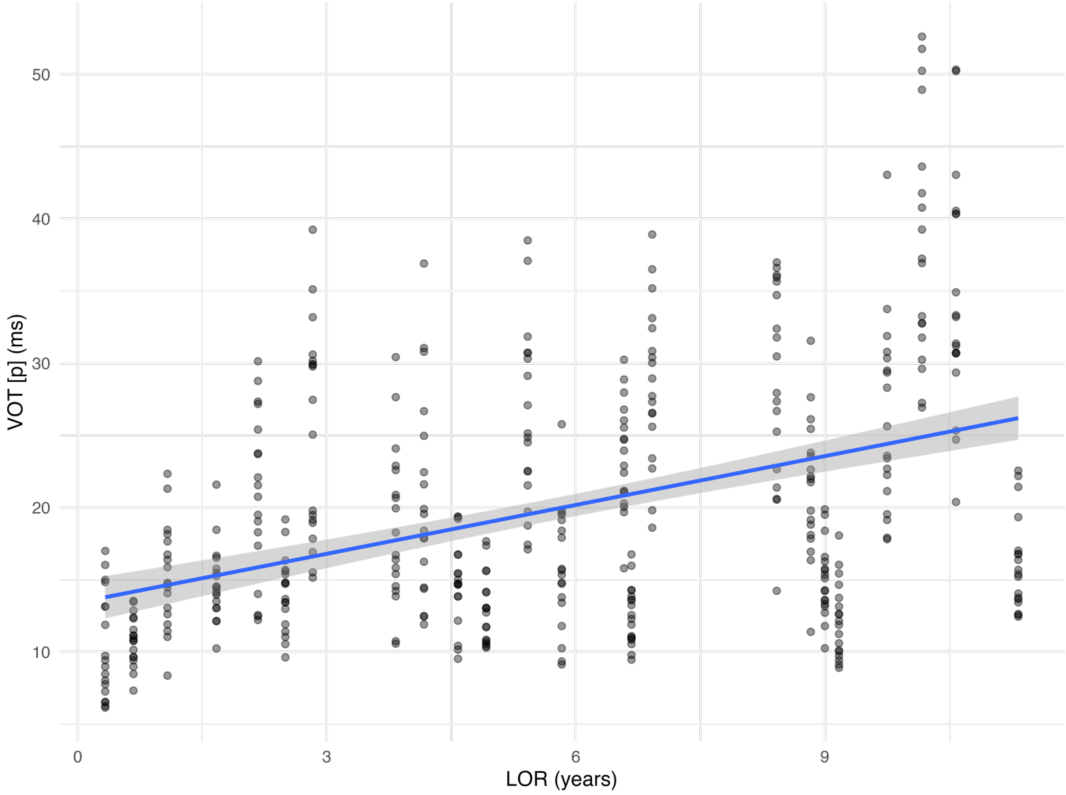
The absolute VOT values were measured in Praat (Boersma & Weenink, 2023), considering the duration in milliseconds between the burst of the stop and the first regular pulse of the following vowel[2]. In addition, production of high back and low-mid back vowels was considered an inclusion/exclusion criterion for participants. Participants with other production patterns were disregarded[3]. Participants were instructed to try to maintain a natural speech rate throughout the task, and 50% of the distracting items were placed on each edge of the data collection blocks, attenuating order effects in the presentation of stimuli.

For the inferential statistical analysis, two Bayesian linear regression models with mixed effects were fitted for each consonant, one looking at VOT values as a function of LOR and another as a function of FTE. The coefficients of the posterior distributions, as well as graphs with predicted values, were used for the inference.

Results and discussion

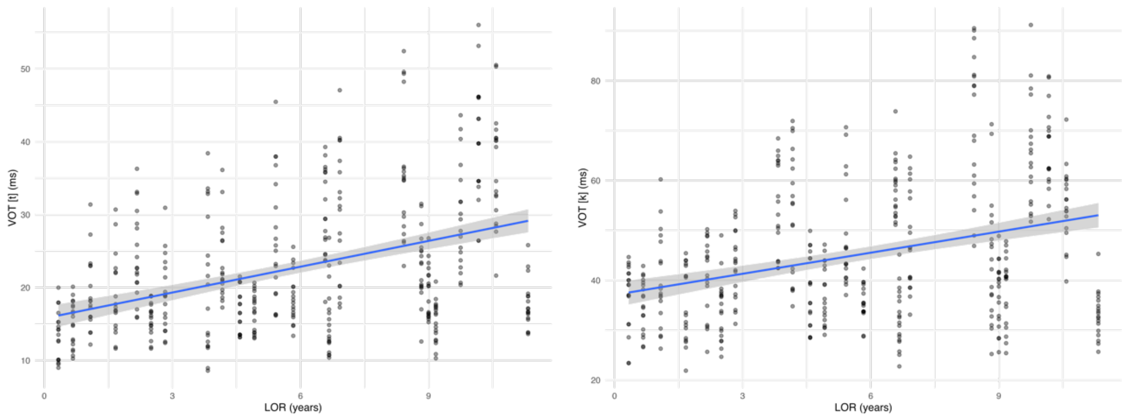
In a traditional study investigating the effect of time on FLA, in this case, on VOT values of BP, the first step would be to look into how LOR correlates with VOT values, as the graph in Figure 1 shows.

Figure 1: Graph showing effect of time in LOR on VOT values for [p]



The graph features LOR in years in the x- axis and VOT values in ms for [p] in the y- axis, with a linear model tendency line showing a positive correlation between the two, showing that VOT values tend to increase as LOR increases. The same occurs with the VOT values of [t] and [k], as seen in the following graphs.

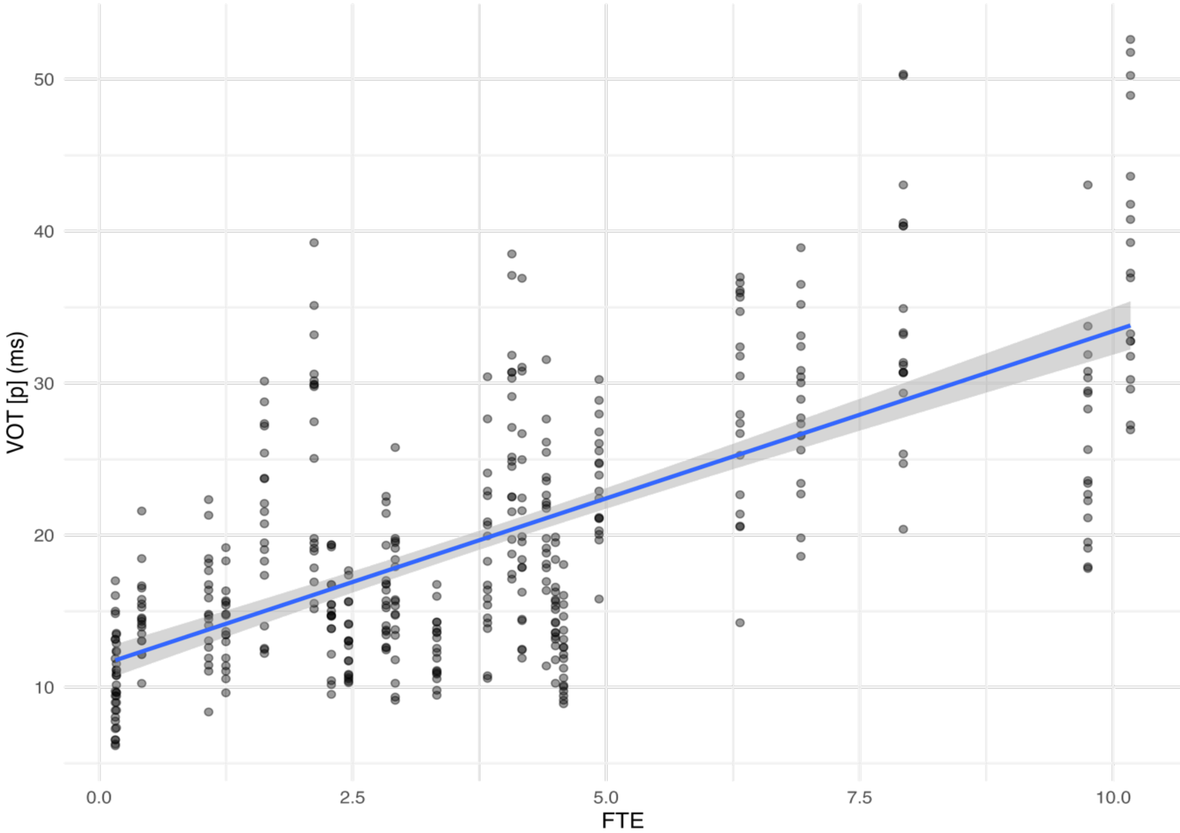
Figure 2: Graphs showing effect of time in LOR on VOT values for [t] (left) and [k] (right)



These data go in the direction of the hypothesis in FLA studies, which assume that the longer one has been living in the L2 country, the stronger the rate of attrition. This is reflected in the increase of VOT values for immigrants with higher LOR values, showing that Brazilians living longer in the UK tend to have longer VOT values in their L1 stops. Despite the clear correlation, there is a lot of variability in the data, with participants with lower LOR values producing long VOTs and, more remarkably, with the data points of the highest LOR producing very low VOT values. Variability is expected in research that sees language development as a dynamic process (Verspoor, Lowie, & De Bot, 2021; Verspoor & Lowie, 2022), but it may also, as in this case, inform that other variables might be in play.

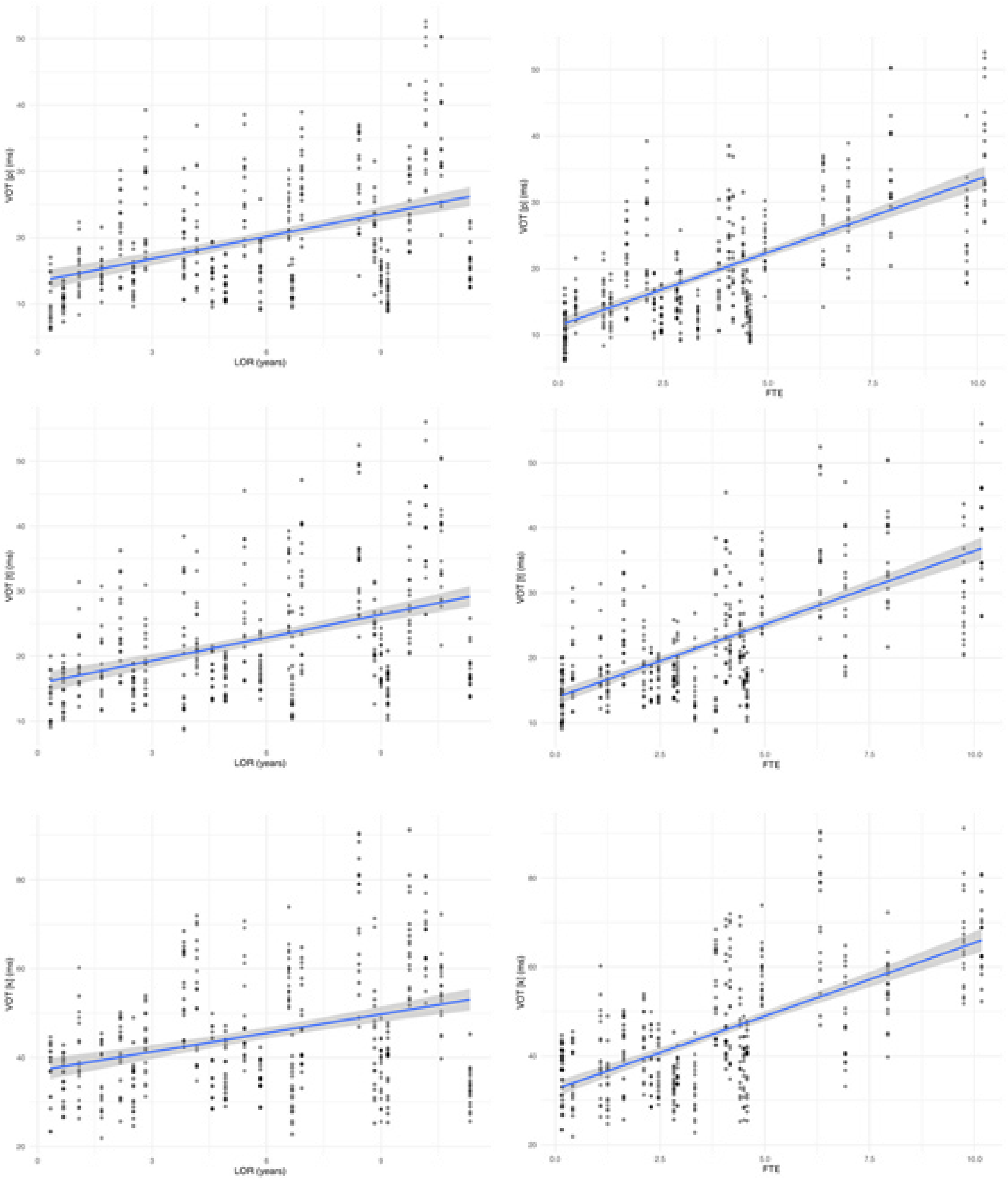
The next graph shows the same VOT values for [p], but now correlated with FTE values.

Figure 3: Graph showing effect of time in FTE on VOT values for [p]



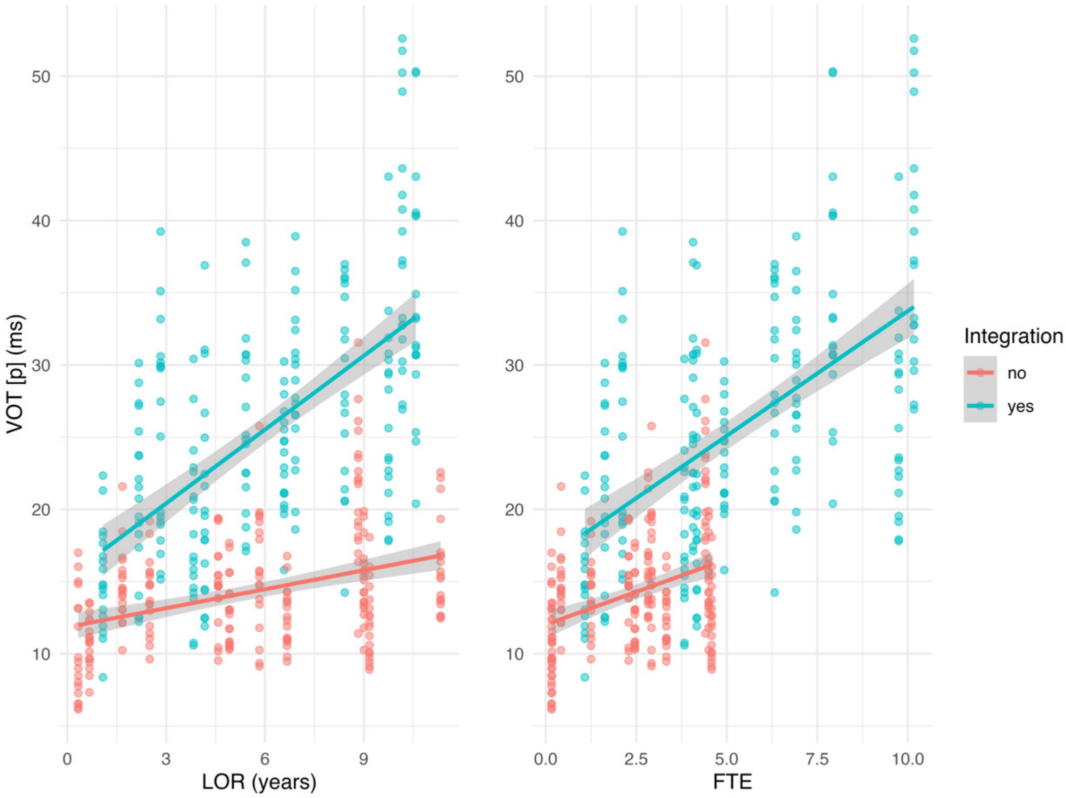
FTE also positively correlates with VOT values. One can notice, though, that now there are more data points on the left portion of the graph, showing that some of the immigrants with long LOR values do not use the L2 as much, causing their equivalent time to be lower. This reduces variability, especially on the right portion of the graph. This reduction of variability, in turn, makes the linear model tendency line steeper for FTE than for LOR, and more confident about its direction, portrayed by the thinner gray shadow around the line, which stands for the 95% confidence interval of the model. The thinner error shadows and the steeper lines for FTE can be clearly seen when LOR and FTE graphs are placed side by side, as in the following Figure.

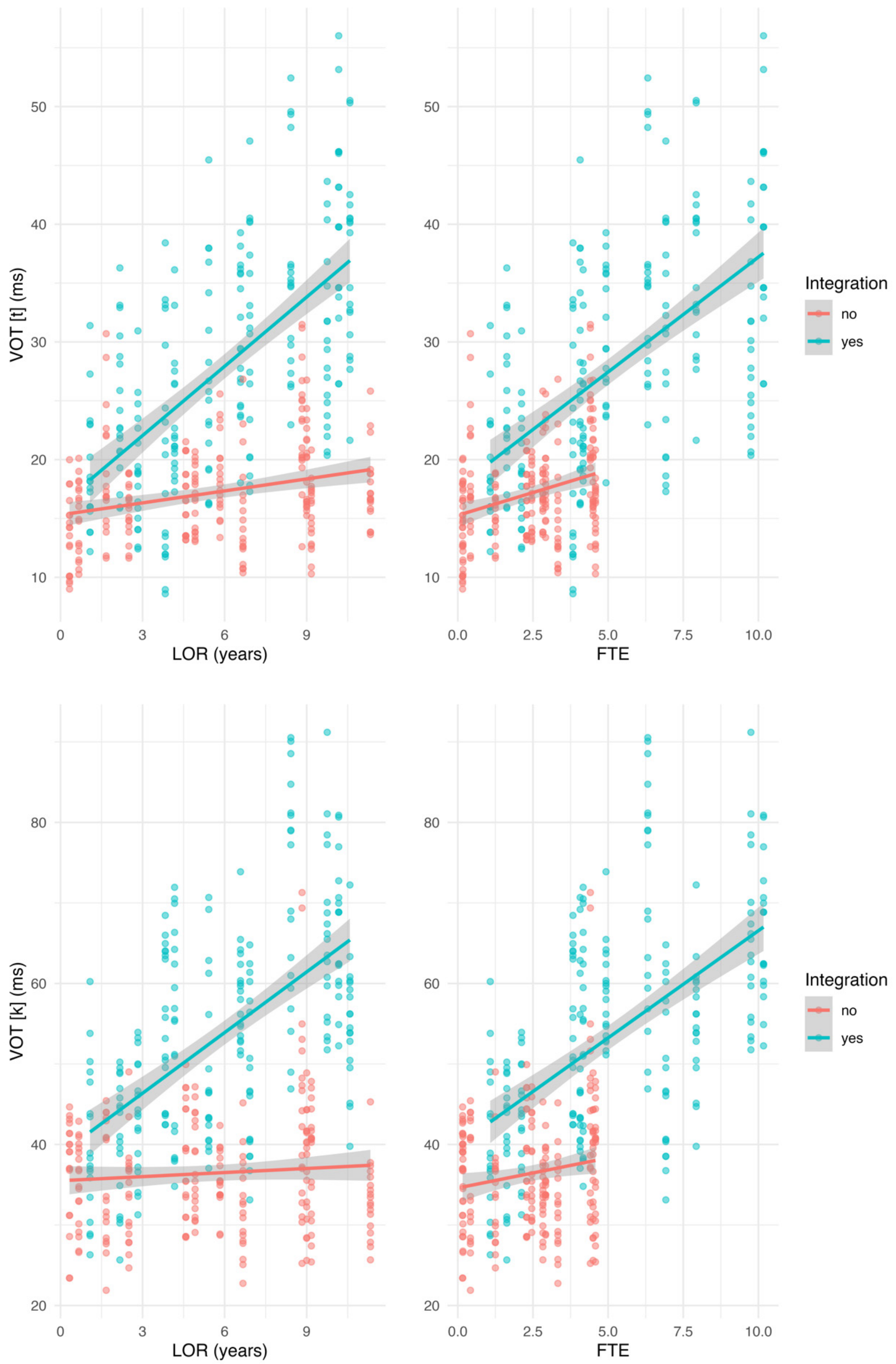
Figure 4: Graphs comparing the effect of time in LOR (left) and in FTE (right) on VOT values for [p] (first row) for [t] (second row) and for [k] (third row).



All graphs on the right of Figure 4, which show FTE on the x axis, have a steeper linear model tendency line with a thinner error shadow than the ones on the left, which show LOR on the x axis. Note that a researcher using the traditional LOR measurement would underestimate the time effect, since the lines on the LOR axis are less steep and present larger standard error shading. This happens because in graphs with LOR there are data points in the lower right portion, which disappear in the FTE graphs because they are shifted to the left, allowing the FTE line to become steeper and with more certainty of its direction (less standard error shading). These individuals are people who, despite living in England for more than six years, have not shown high rates of use in the L2. Thus, their FTE is lower. In other words, they cannot be equated to full-time L2 users. This becomes even clearer by subdividing the immigrants into integrated and non-integrated to the new country, as shown in Figure 5. As mentioned in the Methods section, questions on a Likert scale related to attitudes towards the L1 and L2 (cultures and languages with which participant felt most comfortable, preferred language, etc.), as well as frequency and scenarios of use of the L1 and L2, were used to categorize participants into integrated and non-integrated immigrants.

Figure 5: Graphs comparing the effect of time in LOR (left) and in FTE (right) on VOT values for [p] (first row) for [t] (second row), and for [k] (third row), separating immigrants in those integrated to the new country (blue) and those not integrated to the new country (red).





As shown in Figure 5, the models with LOR underestimate the effect of time by ignoring the amount of L2 use. Even though non-integrated immigrants show lower VOT values in all graphs, their tendency lines are slightly steeper when considering time as an equivalence to amount of language use (graphs on the right).

A natural question that arises is how the linear models would differ with the two measurements of time, LOR and FTE. In order to answer these questions, we started by fitting two Bayesian mixed-effects (random slopes and intercepts for participants) linear regression models, one for the VOT of [p] as a function of LOR and another as a function of FTE. The advantages of Bayesian models are that they do not estimate point coefficients or the probability of the data given a null hypothesis (p-value), but rather estimate a probability distribution of the coefficients given the data. In addition, Bayesian models can include prior knowledge of the field through prior distributions. In this analysis, we used information on typical VOT values for BP stated in the literature (Kupske, 2016; Barbosa & Madureira, 2015; Cristófaro-Silva et al., 2019) to define our prior distributions. We used a normal distribution with mean 13 and standard deviation 3 for the prior distribution of /p/; a normal distribution with mean 18 and standard deviation 3 for the prior distribution of /t/; and a normal distribution with mean 31 and standard deviation 7 for the prior distribution of /k/. Table 2 presents the coefficients estimated by the models for [p], as well as their 95% credibility intervals, with the model with LOR on the left and the one with FTE on the right.

Table 2: Results of two Bayesian mixed-effects (random slopes and intercepts for participants) linear models for VOT values of [p] as a function of LOR (left) and FTE (right). Models: VOT ~ LOR_year + (LOR_year | participant); and VOT ~ FTE + (FTE | participant)

	/p/ ~ LOR		**/p/ ~ FTE**	
Predictors	*Estimates*	*CI (95%)*	*Estimates*	*CI (95%)*
Intercept	12.68	8.52 – 17.06	11.57	8.02 – 14.42
LOR_year	1.04	0.17 – 1.83		
FTE			1.97	1.03 – 2.82
Random Effects				
τ_{00}	18.05 $_{participant}$		15.38 $_{participant}$	
τ_{11}	1.06 $_{participant.LOR\_year}$		0.81 $_{participant.FTE}$	
Observations	432		432	
Marginal R^2 / Conditional R^2	0.156 / 0.683		0.398 / 0.682	

Bayesian models return probability distributions for each coefficient, also known as posterior distributions. The intercept of the LOR model has a probability distribution with 95% of its highest density between 8.52 and 17.06 (95% credible interval, "CI" in the table). In other words, the model predicts a VOT between 8.52ms and 17.06ms (with 95% of credibility) for the [p] of an immigrant with LOR equal to zero, with 12.68ms ("Estimate" in the table) being its most probable value (median of the probability distribution). The model also predicts an increase of 1.04ms (with a 95% credibility of being between 0.17ms and 1.83ms) per year increased in LOR.

Likewise, the FTE model predicts a VOT of 11.57ms for [p], with a narrower 95% credible interval than that of the LOR model (that is, more certain of this value), besides an increase of 1.97ms (95% CI [1.03 – 2.82]) for each year increased in FTE. Notice that the slope (that is, the effect of time on VOT values) of the FTE model is higher than that of the LOR model; its 95% credible interval is farther away from zero, meaning the FTE model is more certain about the positive effect of time on VOT values. The random effects also display the superiority of the FTE model since it shows a lower variance of individual intercepts around the group intercept (τ00) and a lower variance of individual slopes around the group slope (τ11).

The results of the models fitted with [t] and [k] values, shown in Table 3, lead to the same inferences.

Table 3: Results of Bayesian mixed-effects (random slopes and intercepts for participants) linear models for VOT values of [t] as a function of LOR and FTE and for VOT values of [k] as a function of LOR and FTE. Models: VOT ~ LOR_year + (LOR_year | participant); VOT ~ FTE + (FTE | participant)

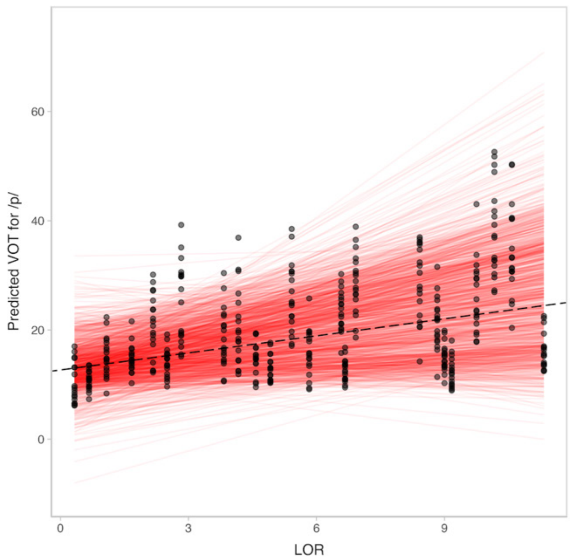
	/t/ ~ LOR		**/t/ ~ FTE**	
Predictors	*Estimates*	*CI (95%)*	*Estimates*	*CI (95%)*
Intercept	15.52	12.46 – 18.89	14.66	11.46 – 17.24
LOR_year	1.11	0.37 – 1.78		
FTE			1.89	0.99 – 2.76
Random Effects				
τ_{00}	9.71 $_{participant}$		9.39 $_{participant}$	
τ_{11}	1.13 $_{participant.LOR\_year}$		0.97 $_{participant.FTE}$	
Observations	432		432	
Marginal R^2 / Conditional R^2	0.161 / 0.609		0.344 / 0.608	

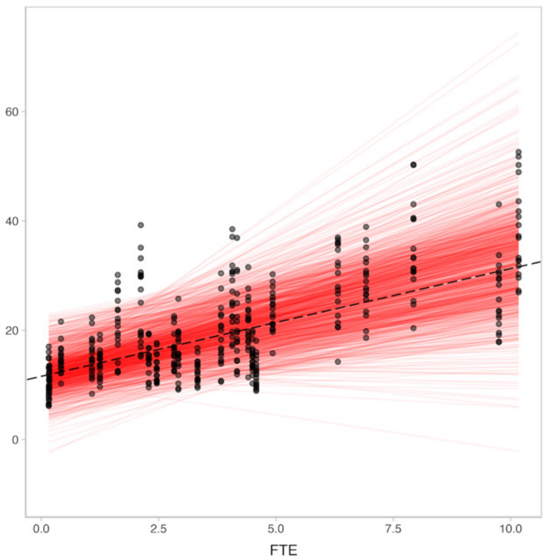
	/k/ ~ LOR		**/k/ ~ FTE**	
Predictors	*Estimates*	*CI (95%)*	*Estimates*	*CI (95%)*
Intercept	35.95	31.91 – 40.04	34.57	30.56 – 37.44
LOR_year	1.40	0.26 – 2.50		
FTE			2.36	0.97 – 3.73
Random Effects				
τ_{00}	11.01 $_{participant}$		7.37 $_{participant}$	
τ_{11}	3.43 $_{participant.LOR\_year}$		4.15 $_{participant.FTE}$	
Observations	432		432	
Marginal R^2 / Conditional R^2	0.112 / 0.640		0.254 / 0.640	

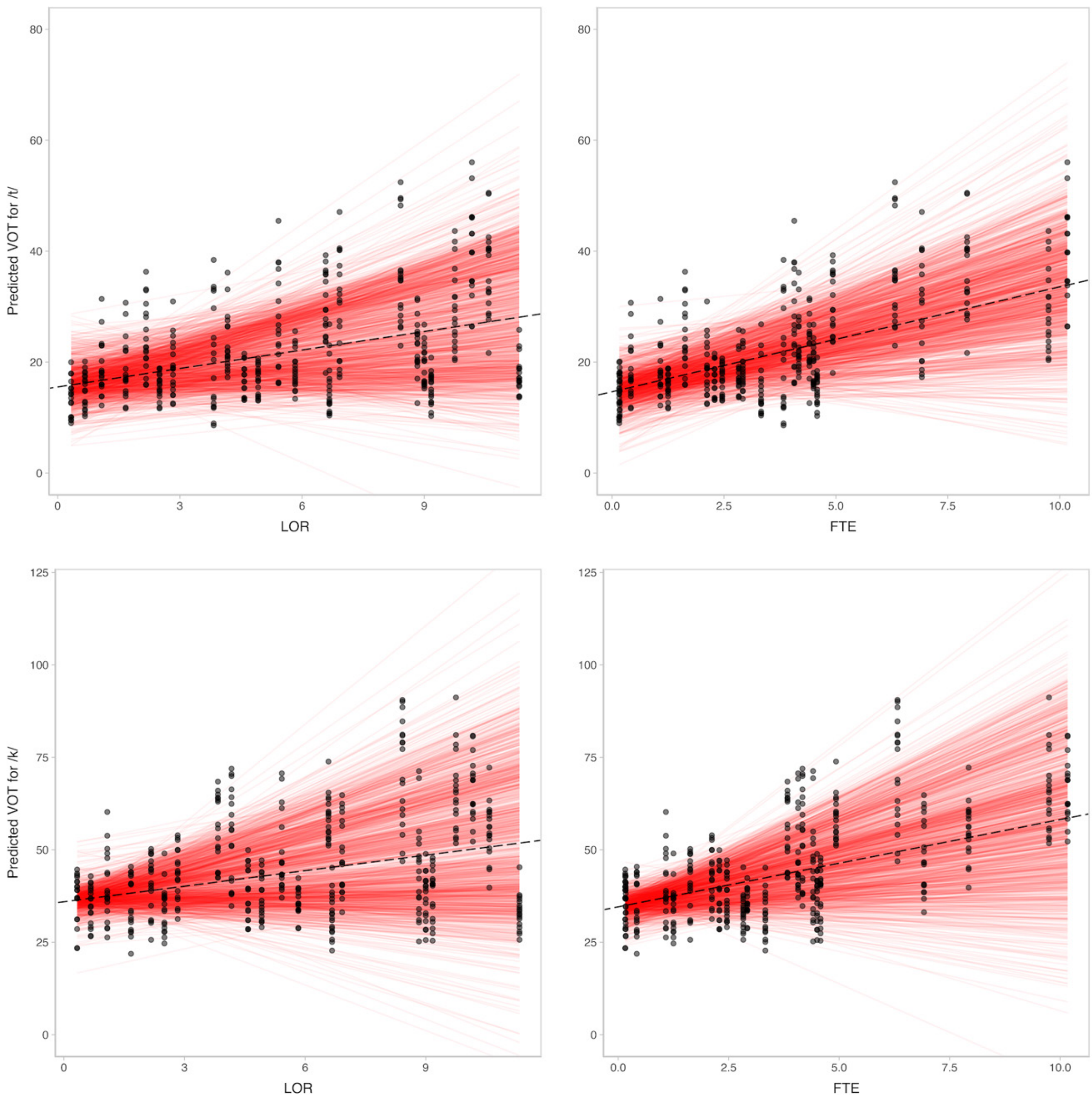
The results of the models with [t] and [k] followed the same pattern found in [p], already discussed in detail. Both the FTE models present higher slopes than the LOR models, with their 95% credible intervals farther from zero, showing that the FTE models are more certain about the increase in VOT values as time increases. The FTE models also present a strong tendency of having a lower variance in the random effects.

One way to visualize this stronger certainty of the FTE models is by looking at values predicted by the models. Each graph in Figure 5 presents the actual collected data points (black dots); a group tendency line (black dashed line), which was drawn using the median for the intercepts and slopes ("Estimates" in the previous tables); and 50 probable regression lines for each participant sampled from their posterior distributions. Since a Bayesian model does not result in point estimates but in probability distributions, it estimates an infinite number of probable lines. In each graph that follows, we randomly sampled 50 of those lines from the estimation for each participant, resulting in 1200 probable regression lines in each graph, which illustrate the tendency of the participants as predicted by the model. The first two graphs come from the models for [p], with the LOR model on the left and the FTE one on the right. The next two graphs from the [t] models and the bottom ones from the [k] models also show the LOR models on the left and the FTE ones on the right.

Figure 6: Predicted regression lines drawn from the posterior distributions (50 lines per participant, 1200 lines in each graph) revealing credible correlations of VOT of [p] (first row), of [t] (second row) and of [k] (third row) as a function of LOR (left) and of FTE (right).







Note that, for the three consonants, the LOR graphs (left) have more dispersed lines, going farther away from the central group line, with more extreme lines going to extreme values, and without forming one dark red pattern. On the other hand, the FTE graphs (on the right), though also displaying variability, show less dispersion of the lines, with a clear dark red pattern around the group tendency line created by the high number of individual lines going from a similar value in a similar slope. This shows the stronger certainty that the FTE models present concerning the positive effect of time on VOT values.

Final considerations

'Time' is a core construct in L2 development (de Bot, 2015). However, the notion of time may be elusive in L2 studies, as it has received many different labels (such as AOA, AOB and LOR) whose operationalizations may affect the discussion on the role of this variable. One typical construct to account for the effects of time is LOR, which tends to be commonly used in the studies on the development of L2 sound systems (Gorba, 2023). However, as suggested in this paper, LOR does not account for the different individual opportunities for L2 usage that each participant experiences.

In this paper, based on a complex, dynamic view of language development (e.g., de Bot, Lowie, & Verspoor, 2007; Larsen-Freeman & Cameron, 2008; Beckner et al., 2009), we carried out a study on L1 attrition and compared the different effects played by LOR and FTE, a recently-proposed metric (Flege & Bohn, 2021). The FTE is a construct that combines L2 use and time. In other words, as the FTE proves able to encapsulate 'time' and 'L2 usage' in a single construct, it has shown that the Brazilian participants' length of residence in Britain proves a relevant variable provided that opportunities for L2 use are taken into account.

We therefore argue that the FTE is a measure of time that conforms with a complex, dynamic account of language development, as it encompasses a multitude of factors that may emerge as an individual experiences life in another country and in another culture. 'L2 usage' is a fundamental construct in a complex, dynamic account (cf. Beckner et al., 2009; Larsen-Freeman, 2017), and the FTE proves a nice step in aiming to account for L2 use and time in a single metric. In other words, we assume that the FTE shows great epistemological coherence under a CDS account, as we are able to consider the role played by the emergent scenarios that take place in development in view of the learners' interactions and experiences in the L2.

The Bayesian models we carried out in this study with both measures of LOR and FTE have shown that the latter led to a better fit in these models. In fact, as we compare the models carried out with each one of the constructs, it is noticeable that the LOR by itself might mitigate the effect of 'time' in language development, as it does not seem to reflect the complexity and affordances that may come into play with L2 usage. By implementing usage into its formulation, the FTE conceives 'time' as a complex construct that accounts for the learners' individual experiences, which characterize the process of L2 development (and, as a consequence, the process of L1 attrition, as both L1 and L2 subsystems should not be regarded as disconnected entities). The models with FTE estimate a greater effect of time since time in this metric is more realistic by including L2 use. In other words, L2 use should always be present in immigration studies, and using FTE instead of LOR is one elegant way to achieve this.

Additional studies in the field of bilingual development (whether on L2 learning or L1 attrition) should prove necessary to account for the strengths and weaknesses of the FTE construct. The results we have shown in this paper not only suggest the FTE accounts for a better fit in the regression models that aim to show the effect of time and language experience, but also conforms with a view of language development and change that takes the complexity of language interactions into account.

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Notes

1. Items with the high back unrounded vowel were discarded from this analysis since it creates a context for complementary distribution in BP, leading, in some of its varieties, to palatalization of the alveolar stop.
2. Only the absolute VOT data were measured for this work, and we understand that this is a limitation of this proposal. However, previous studies on VOT changes in immigration contexts demonstrate that there are no statistical differences between the results of inferential analyzes with absolute and relative VOT values (Kupske, 2016).
3. In BP, words such as "poça" (puddle) are usually produced like [ˈpɔ.sə] with a low-mid back vowel. However, in some regions, the item might be produced like [ˈpo.sə] with a high-mid back vowel.

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