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Bilingual Processing on French Verbs: Lexicon Organization and Morphological Structures

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Abstract: Word recognition is mediated by morphological processing. It has been argued that dual-mechanism models with rule-based and whole word routes explain the behaviour in late bilinguals, accounting for the differences between declarative and procedural memories. Nevertheless, the combinations between stems and inflectional suffixes in Romance verbal systems present great consistency; thus, bilinguals who speak two Romance languages might recycle their L1 mechanisms for L2 processing. We investigated L2 French speakers who have Brazilian Portuguese as their L1 by using two experiments with visual lexical decision task, one with surface and cumulative frequency effects and another with morphological violations in verbal structures. Experiment 1 showed that advanced L2 speakers are sensitive to the surface and cumulative frequency effects, while beginner speakers are not. Experiment 2 established that late L2 speakers have a similar behaviour as native French speakers when processing pseudoverbs. Our results present differences between beginner and advanced L2 speakers regarding their lexicon organization, but no differences were found considering word processing.

Keywords: Bilingualism, Morphological Processing, Psycholinguistics, Verbal Inflection, Word Recognition.

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I. INTRODUCTION

Word recognition is mediated by morphological processing and the activation of morphemes as meaningful units for lexical access. It has been argued that late bilinguals would never acquire the same competence than early bilinguals or native speakers because they are restricted to shallow processing in second language (L2) [1]. However, it seems that L2 language experience and proficiency, which is poor compared to native speakers as well as to first language (L1), influence the L2 processing and suffices to explain the differences in grammar processing between L1 and L2 [2], [3]. The Declarative/Procedural (DP) model states that late bilinguals first acquire language knowledge through declarative memory and later, when proficiency and competence is greater, transfer this knowledge to procedural memory [4].

This study investigated the morphological processing in late bilinguals who have similar L1 and L2 systems. We investigated the verbal morphological processing of French (FR) as L2 by speakers who have Brazilian Portuguese (BP) as L1. French and Portuguese are Romance languages which inherit their verbal system from Latin, presenting a large overlap in the verbal structure and morphosyntactic features. We carried out two experiments which had been already published with native French speakers [5], [6]. The participants performed two visual lexical decision experiments to track different aspects of the lexicon organization and the processing of verbal structures in word recognition [7]. Our results suggested a single-mechanism model with morphological decomposition for the recognition of all French verbs. Verbs are decomposed in stem and inflectional suffixes, then the morphemic representations are activated in the lexicon, and the morphemes are recombined for word verification [8].

Experiment 1 tested the surface and cumulative frequency effects on French verbs [6] and Experiment 2 investigated the morphological decomposition and morphemic activation on French pseudoverbs with morphological violations [5]. Late bilinguals present different grammar processing [1], language behaviour [9], and neural structure [10] than native speakers and early bilinguals. Thus, our objective was not to replicate the results found in the experiments with native speakers of French, but rather to analyse the data by itself and compare the bilinguals' results to the native speakers' results.

1.1 Morphological Models

Word recognition models can be differentiated between search and interactive-activation models, as well as between single- and double-mechanism models. Manelis and Tharp (1977) proposed the Whole Word

(WW) model based on the Full-Entry Hypothesis [12]; alternatively, Parallel Distributed Processing (PDP) models [13] propose associative-interactive networks between phonological, orthographic, and semantic information in hidden units. From a symbolic manipulation perspective, Taft (1979) proposed the Obligatory Decomposition (OD) model in which words are decomposed for lexical access.

By combining both kinds of word processing, dual-mechanism models consider one route for the associative whole word access and another route for the rule-based computations. The Augmented Addressed Morphology (AAM) model [14] proposes that high-frequency, non-transparent, and known words are accessed by the whole word route, while low-frequency, transparent, and unknown words are recognized by the combinatorial route; the Parallel Dual-Route (PDR) model [15] predicts the parallel activation of both routes, where the fastest one wins for lexical activation; the Word and Rules (W&R) model, supported by the DP model [16], proposes a procedural combinatorial route for regular words and a declarative associative route for irregular ones. Allen and Badecker (2002) propose a two level (TL) model where constituents from complex words first activate the lexeme level, and subsequently, activate the lemma level; along the same line, de Diego Balaguer et al. (2006) present a model in which lexical stems and functional suffixes are processed by different neural circuits. Finally, the Minimalist Morphology (MM) model [19] proposes whole word entries with post-lexical morphological processing based on a full symbolic productive route and another hierarchical semi-structured route.

In addition to the discussions about how morphological processing is performed, these various morphological models from theoretical and experimental perspectives suggest that there is no general consensus of how inflection is processed by native speakers in L1 [20]. Turning to L2 later speakers, contradictory and complex results in psycholinguistic experiments on inflectional morphology seem to blur the functioning of these models [21]. Nevertheless, these experimental results allow a better understanding of the L2 morphological acquisition and the interaction between L1 and L2 in the grammar system in the mental lexicon organization.

1.2 French and Portuguese Verbal Morphology

French and Portuguese are Romance languages inherited from Latin during the Middle Ages. Both languages descend from the Gallo-Iberian family, but French evolved from Gallic while Portuguese evolved from Iberian families. Brazilian Portuguese (BP) evolved from European Portuguese in the 16th century, presenting differences in syntax, orthography, phonology, prosody, semantics, and borrows from Amerindian languages. French and Portuguese are inflectional languages with rich morphology, where verbal inflection is described as a stem (v), formed by the root (√) and the theme vowel (Th), merged with a tense node, formed by the tense suffix (T) and the agreement suffix (Agr), according to [[[√][Th]v][[T][Agr]T]TP], adapted from [22] (e.g., French: $[[[\text{aim}]_{\surd}[\text{e}]_{\text{Th}}]_{\text{v}}[[\text{r}]_{\text{T}}[\text{ons}]_{\text{Agr}}]_{\text{T}}]_{\text{TP}}$, BP: $[[[\text{am}]_{\surd}[\text{a}]_{\text{Th}}]_{\text{v}}[[\text{re}]_{\text{T}}[\text{mos}]_{\text{Agr}}]_{\text{T}}]_{\text{TP}}$ 'we will love').

Considering cross-linguistic differences between French and Portuguese, Estivalet and Margotti (2014) presented a comparative analysis of the inflectional suffixes and verbal formation in both languages. In sum, there is a large and consistent formal overlap between both verbal inflectional systems. More than the inflectional system correspondence, both languages also present great similarities concerning stem morphophonology and allomorphy (e.g., FR: *adorons/adɔre* BP: *adoramos/adɔro* 'we adore/I adore', FR: *disons/dit* BP: *dizemos/digo* 'we say/I say'). Moreover, these systems exhibit large syncretism in many morphemes. Moving to a more abstract analysis of the morphosyntactic features expressed by the productive inflectional suffixes in French and Portuguese, and considering the feature underspecification hypothesis, we reduced the clusters available and represented each inflectional suffix with only its positive morphosyntactic features [24] for the main tenses in French and Portuguese, as shown in Table 1.

	Node	Tense						Agreement																	
	Suffix.	I		II		III		IV		V		VI		VII		VIII		IX		X		XI		XII	
	Lang.	FR	BP	FR	BP	FR	BP	FR	BP	FR	BP	FR	BP	FR	BP	FR	BP	FR	BP	FR	BP	FR	BP	FR	BP
	Feat.	ai	va	i	a	r	r	s	s	ai	ei	as	ás	t	u	a	á	ons	mos	ez	is	ent	m	ont	ão
Tense	Imp.	+	+	+	+																				
	Fut.					+	+				+		+				+							+	+
	Cond.	+		+		+	+																		
Person	1			+				+		+	+							+	+						
	2			+				+	+			+	+							+	+				
	3													+	+	+	+					+	+	+	+
Number	Sg							+	+	+	+	+	+	+	+	+	+								
	Pl			+														+	+	+	+	+	+	+	+

Table 1 – French and Portuguese tense and agreement suffixes with underspecified and only positive morphosyntactic features. Grey features percolate from different morphosyntactic nodes.

Default morphemes are not feature marked: a) class: 1st, b) mood: indicative, c) tense: present, d) person: 3rd, e) number: singular. We point out the similarities in the FR/BP suffixal forms and morphosyntactic features, with the agreement suffixes showing higher overlap and regularity than the tense ones. The future and conditional tenses, and the plural agreement morphemes are the most regular and similar across the two verbal systems. While the indicative simple past and subjunctive imperfect past tenses are widely used in Portuguese, they are obsolete tenses in French, and they were replaced by the *passé composé* and subjunctive present, respectively, which have different uses in BP [23], [25].

Table 1 shows a series of inflectional suffixes expressing specific morphosyntactic features; if we reverse this logic, we have a series of morphosyntactic features expressed by specific morphemes [22]. Then, there is more than just the phonological/orthographic resemblance between French and Portuguese inflectional suffixes, there is a large overlap in the morphosyntactic features activated by the inflectional suffixes, allowing a direct mapping from the Portuguese verbal system to the French one in a deep and abstract level of representations and processing.

1.3 Bilingual Processing

L1 and L2 processing differ from each other in four main aspects: 1) relevant grammatical knowledge, 2) influence from the L1, 3) cognitive resource limitation, and 4) neural maturation [1]. Early and late bilinguals can be distinguished regarding the age they acquire their languages. The critical period for L1 acquisition is considered to be around the age of seven years, and for L2 around the age of 12. However, the critical period and the neuroplasticity that underlie language acquisition has been widely discussed [10], [26]. More importantly, early bilinguals acquire their languages during babyhood through natural and massive stimulation, communication, and task requirements for all purposes, while late bilinguals acquire their L2 during adulthood through artificial and poor stimulation, in language courses, explicit instruction, and non-required purposes.

Thus, native and early bilingual speakers unconsciously encode productive procedures in morphological acquisition. In contrast, late bilinguals explicitly acquire declarative knowledge about language. Ullman (2001b) proposes that linguistic forms which depend upon procedural memory in L1 might be largely dependent upon declarative memory in L2, and a shift from declarative to procedural memory is expected according to L2 exposure and proficiency.

Imaging and lesion studies have not provided evidence for neuronal separation between L1 and L2, on the contrary, Perani and Abutalebi (2005) showed that bilinguals recruit at a comparable level areas associated with grammatical tasks in L1 and L2 (i.e., Broca's regions and basal ganglia). Additional activation for L2 in extending areas related to L1 grammar was found only in bilinguals with low proficiency or late acquisition. Hernandez, Li, and MacWhinney (2005, p.222) complement the computational explanation for age-of-acquisition effects, "because the bilingual child retains greater plasticity and faces somewhat lesser L1 entrenchment, the model predicts a slow but continual reorganization of lexical space. For the young adult, on the other hand, movement on the lexical map may be no longer possible".

In this sense, there should be a large transfer and interference of lexical and grammatical knowledge between L1 and L2, especially between closer typological languages. We propose three basic mechanisms involved in the cross-linguistic interaction and L1 knowledge recycling for L2 acquisition and processing: 1) L1 rules which can be generalized in L2, 2) L1 rules which have to be inhibited in L2, and 3) L2 rules which have to be acquired. For example, BP speakers as L1 who speak French as L2 1) can generalize the use of $[\text{-ons}]_{FR:1pl}$ for $[\text{-mos}]_{BP:1pl}$, 2) inhibit the use of the indicative simple past and subjunctive imperfect past tenses, and 3) acquire the allomorphy between $[\text{-ai-}]_{imp,\ sg/3pl}$~$[\text{-i-}]_{imp,\ 1pl/2pl}$ for the French indicative imperfect past tense. Estivalet and Mota (2010) found that native speakers of BP who speak French as L2 have significantly larger working memory capacities than those who speak English as L2, whose findings were based on the interaction and recycling mechanisms between L1 and L2 in lexical overlap and stem allomorphic constraints.

Grainger and Dijkstra (1992) investigated two hypotheses in the bilingual lexicon, the language tag and the language network based on serial search and interactive-activation models, respectively. They observed that language decision latencies in English/French bilinguals were slower than lexical decision latencies, suggesting that there is no language tag activation for lexical decisions and the latter is prior than the former. They proposed the Bilingual Interactive-Activation model (BIA) in which language decision can be made once the lexical representation is isolated. Further, Dijkstra and van Heuven (2002) implemented the BIA+ that adds phonological and semantic lexical representations to the available orthographic ones, and assigns a different role to the language-nodes. Interestingly, words from different languages seem to compete during recognition, that is, the recognition of a word in one language is affected by word candidates in other languages, supporting the assumption of a shared bilingual lexicon [30].

Regarding the experiments conducted in the present study, frequency effects have not been largely explored in late bilinguals, and it is an open question whether their lexicon organization deviates from native speakers and corpora norms [31]. Pseudowords provide an interesting environment for the investigation of morphological processing in L2 because they avoid frequency and semantic effects [14]. The purpose of Experiment 1 was to verify the lexicon organization in beginner and advanced bilinguals of French as L2 in function of the frequency norms. We predict to find differences between beginner and advanced bilinguals, in which the latter are in line with native speakers and the former present only surface frequency effects based on whole word access in the declarative memory. The aim of Experiment 2 was to identify differences between beginner and advanced speakers in the processing of different violations in French verbal structure. We predict to find differences between beginner and advanced speakers in the verb types containing only stem and inexistent but morphologically legal forms.

Concerning the previously published results with native speakers, Experiment 1 presented cumulative frequency effects in fully regular and irregular verbs in both high and low surface frequencies. These results suggest that fully regular verbs are fully decomposed for lexical access and irregular verbs have different, but linked representations of allomorphic stems. Morphophonological verbs did not present any effect of cumulative frequency, but the effects of total cumulative frequency became clear in a *post-hoc* analysis, supporting the idea that morphophonological verbs have abstract underlying phonological representations [6]. Experiment 2 conducted with native speakers showed no differences between morphological illegal (MI) and only base (OB), and between existent morphological legal (EML) and only suffix (OS) verb types, but significant differences were found between OB and EML, and between OS and inexistent but morphological legal (IML) verb types. Furthermore, there were significant differences in the number of inflectional suffixes in OS and EML verb types [5].

II. METHOD

2.1 Experiment 1: Surface and Cumulative Frequencies

2.1.1 Participants

A total of 20 adult speakers of BP as L1 and French as L2 between the ages of 20 and 32 years (M = 25.9 years old, 11 women) participated in Experiments 1 and 2. Participants had contact with French as L2 between 2 to 14 years (M = 5.9 years). Most participants learnt English as L2 in high school (i.e., from 14 to 17 years), and started learning French later. All participants were right-handed, had normal hearing, normal vision or corrected by glasses or contact lenses, and had no history of cognitive or language disorders. Experiments 1 and 2 were performed in one session, with a break between them, in counterbalanced order between participants and lists in a Latin square. Participants did not know the research purposes and signed a written consent to participate in the experiment as volunteers.

2.1.2 Materials and Design

Experiment 1 used the same materials, design, and procedure described by Estivalet and Meunier (2015a). Participants performed a lexical decision task in visual modality. We investigated three variables: 1) verb type: a) fully regular (e.g., *parlons/aiment* 'we speak/they love'), b) morphophonological e/ɛ with orthographic mark (e.g., *appelons/appɛllent* 'we call/they call'), c) morphophonological o/ɔ without orthographic mark (e.g., *adorons/adɔrent* 'we adore/they adore'), and d) irregular (e.g., *buvons/boivent* 'we drink/they drink'); 2) surface frequency (high vs. low); and 3) cumulative frequency (high vs. low). We manipulated four different experimental conditions by verb type: two conditions with high cumulative frequency in high or low surface frequencies, and two conditions with low cumulative frequency in high or low surface frequency. Eighty stem pairs from the four verb types were selected, consisting of 20 pairs for each verb type. For each stem pair, we choose four different forms; for the fully regular verbs, we did not use a stem pair because they have only one stem; we used two different verbs with the same surface frequency. All experimental words were matched for number of letters, number of phonemes, number of syllables, and orthographic neighbours, as calculated by the Orthographic Leveinshtein Distance between the 20 closest words (OLD20) [32]. A set of 320 pseudowords was added to the 320 experimental words, totalizing 640 stimuli. Pseudowords were constructed by combining non-existent but possible stems to existent verbal suffixes in French. All words and pseudowords were selected and controlled using the French database *Lexique* [33].

2.1.3 Procedure

We used the E-Prime® 2.0 Professional (Psychology Software Tools, Inc., Sharpsburg, PA, USA) [34] to construct, apply, and collect experimental data. Each trial had the following sequence: first, a fixation point was displayed in the centre of the screen for 500 ms; after, the target word was presented in the centre of the screen in lowercases for 2,000 ms or until the participant's response; then, a blank screen was presented as inter-stimuli for 500 ms, and a new trial started with the fixation point. The stimuli were presented in the centre of a 15" LCD computer screen, in white 18-point Courier New font on a black background. Reaction time (RT) measurement began at the onset of the target screen and finished when the participants responded using a keyboard button. Participants were asked to perform a visual lexical decision task as quickly and accurately as possible using a computer keyboard. They had to press the 'green' button for words using the right hand and press the 'red' button for pseudowords using the left hand. The experiment started with an instructional screen followed by a practice phase with eight stimuli, one break was provided in the middle of the experiment. The entire experiment lasted approximately 22 min.

2.1.4 Results

Only experimental items were analysed. Responses faster than 300 ms and slower than 1,900 ms were considered out of task and removed (2.39%); two participants were excluded because they had error rates higher than 25% (9.96%); two experimental stimuli (i.e., *nomment* 'they name' and *vaillent* 'they worth') were removed because they had error rates higher than 60% (.92%). There were 12.61% of incorrect responses that were removed for the RT analysis.

For the proficiency factor, we equally divided the 18 remaining participants into two groups of French speakers (beginners vs. advanced) determined by time of French exposure, i.e., beginners (N = 9, M = 2.9 years) and advanced (N = 9, M = 9.9 years). In order to support this proficiency division, we verified significant differences between the two groups using one-tailed t-tests in proficiency ($t(8) = 6.881$, $p < .001$), error rate (i.e., beginner: 16.52%, advanced: 8.78%) ($t(8) = 2.713$, $p < .01$), as well as by-participant Pearson's correlation between proficiency and error rate ($r = -.609$, $t(16) = -3.072$, $p < .01$) [35].

The data were analysed using two mixed-effects models [36]. In one model, the normalized RTs (i.e., 1/RT * -1,000) were used as the dependent variable, participants and targets as random variables, and verb type, surface frequency, cumulative frequency, and proficiency as fixed-effect variables. In the other model, we used the logit ACC as the dependent variable and binomial family specification. Overall RT means and standard deviations (SD) are shown in Table 2.

		High Surface Frequency		Low Surface Frequency	
Profic.	Verb Types	High Cum.	Low Cum.	High Cum.	Low Cum.
Beginner	a) Fully Regular	911(260)	947(257)	948(287)	948(267)
	b) Morpho. e/ɛ	956(288)	977(303)	922(254)	1054(326)
	c) Morpho. o/ɔ	960(292)	915(273)	954(272)	977(280)
	d) Irregular	1021(321)	993(298)	968(274)	1028(295)
Advanced	a) Fully Regular	834(292)	860(290)	876(285)	879(329)
	b) Morpho. e/ɛ	872(310)	880(306)	857(302)	925(315)
	c) Morpho. o/ɔ	842(285)	866(317)	894(317)	937(350)
	d) Irregular	826(277)	892(319)	901(319)	982(348)

Table 2 - RT means and SDs by verb type, surface frequency, cumulative frequency, and proficiency.

The analysis of variance (ANOVA) in the mixed-effects model from RTs showed significant effects of verb type ($F(3,299) = 3.013$, $p < .05$) and surface frequency ($F(1,299) = 7.679$, $p < .01$), but no effect of cumulative frequency ($F(1,299) = .859$, $p = .355$) or proficiency ($F(1,16) = 1.292$, $p = .272$). Importantly, there was a significant interaction between proficiency and cumulative frequency ($F(1,4577) = 19.384$, $p < .001$) and a significant interaction between proficiency and surface frequency ($F(1,4577) = 8.193$, $p < .01$), but no other interaction (Fs < 1, ps > .1).

Moving to the planned comparisons from the effects of surface and cumulative frequencies in beginner and advanced bilinguals, we only present the significant results. Concerning the beginner speakers, it was observed a significant total cumulative frequency effect in morphophonological e/ɛ verbs with low surface frequency ($t(354) = 3.763$, $p < .001$) and high surface frequency ($t(353) = 2.505$, $p < .05$). Regarding the morphophonological o/ɔ verbs, it was found a significant total cumulative frequency effect in forms with low surface frequency ($t(357) = 2.083$, $p < .05$). In the advanced speakers, it was observed a significant surface frequency effect in fully regular verbs with low cumulative frequency ($t(330) = 2.354$, $p < .05$). For the morphophonological e/ɛ verbs, it was found a significant total cumulative frequency effect in forms with low surface frequency ($t(343) = 2.455$, $p < .05$), and a significant surface frequency effect in forms with low cumulative frequency ($t(345) = 1.997$, $p < .05$). For the morphophonological o/ɔ verbs, it was observed a significant surface frequency effect in forms with low total cumulative frequency ($t(346) = 3.391$, $p < .001$), and a significant surface frequency effect in forms with low cumulative frequency ($t(345) = 1.997$, $p < .05$) and high cumulative frequency ($t(335) = 2.162$, $p < .05$). For the irregular verbs, was found a significant surface frequency effect in forms with low cumulative frequency ($t(337) = 2.554$, $p < .05$) and a significant cumulative frequency effect in forms with high surface frequency ($t(338) = 2.306$, $p < .05$).

The analysis of deviance in the mixed-effects model from error rates showed significant differences for verb type ($\chi^2(3, N = 18) = 10.986$, $p < .05$), total cumulative frequency ($\chi^2(1, N = 18) = 17.712$, $p < .001$), and proficiency ($\chi^2(1, N = 18) = 8.012$, $p < .01$), but no significant interactions among these variables (*p*s > .1). The error rate means are shown in Table 3.

		High Surface Frequency		Low Surface Frequency	
Profic.	Verb Types	High Cum.	Low Cum.	High Cum.	Low Cum.
Beginner	a) Fully Regular	.394	.322	.394	.287
	b) Morpho. e/ɛ	.681	.431	.592	.646
	c) Morpho. o/ɔ	.592	.466	.789	.556
	d) Irregular	.502	.646	.431	.448
Advanced	a) Fully Regular	.197	.287	.215	.215
	b) Morpho. e/E	.215	.358	.378	.358
	c) Morpho. o/O	.233	.215	.466	.322
	d) Irregular	.126	.322	.631	.089

Table 3 – Error rate means by verb type, surface frequency, cumulative frequency, and proficiency.

2.1.5 Discussion

Experiment 1 showed significant differences in RT in surface frequency and verb type, with longer RTs for verbal forms with low surface frequency and for irregular verbs. The results also showed significant interactions between proficiency and surface frequency, and between proficiency and cumulative frequency, indicating that proficiency modulates the results from these predictors. The surface and cumulative frequency effects are mainly significant in advanced bilinguals, while beginner bilinguals present significant differences only in the total cumulative frequency for morphophonological verbs. The results reveal that the RTs for irregular verbs are the slowest, contradicting dual-mechanism models which state that irregular verbs are quickly recognized by the whole-word route, just as the W&R/DP [16]. This suggests that irregular verbs are also recognized by the combinatorial route where and RTs are slower due to allomorphic processes [37].

Interestingly, surface frequency effects were only observed in advanced speakers. Surface frequency is a robust effect in psycholinguistics which more frequent words are recognized faster than less frequent ones. These results suggest that the mental lexicon organization of advanced speakers, who are proficient and competent, is significantly different from beginner speakers, more in line with the corpora frequency norms and native speakers mental lexicon [27].

We found significant differences in cumulative frequency for irregular verbs in advanced speakers, supporting that they might have separated, albeit linked, stem allomorphic representations in their mental lexicon. In the fully regular verbs, only a significant effect of surface frequency was observed, which means that the stem representations in the mental lexicon of L2 speakers is probably different, such as observed in the irregular verbs, one only for the roots (e.g., *[jou]ons* 'we play') and another for the root combined with the theme vowel (e.g., *[joue]s* 'you$_{sg}$ speak') [38]–[40]. Perhaps the L1-BP/L2-French speakers tested did not acquire the full decomposition rule as French native speakers because most stems in Portuguese are clear combinations of the root with a theme vowel [23].

The results suggest that advanced L2 speakers are not faster than beginners, however, the mental lexicon organization of beginner and advanced L2 speakers is different due to surface and cumulative frequency norms exposure. Advanced speakers had more stimuli and interaction in L2, presenting a behaviour pattern similar to native speakers [41]. Differently, beginners had restricted L2 stimuli, thus the frequency norms are bad predictors for lexicon organization. This pattern is clarified by the error rate results in proficiency, supporting that advanced speakers significantly know more words than beginners.

Comparing these results with the study with native speakers, there are differences between native speakers, and advanced and beginner speakers of French as L2. Native speakers presented robust effects in the surface and cumulative frequencies for fully regular and irregular verbs, advanced bilinguals presented only some significant effects when compared with the native speakers, and beginner bilinguals presented a different pattern than native speakers and advanced bilinguals.

As expected, surface and cumulative frequencies are abstract and inconsistent when regarding how late bilinguals acquire and are exposed to L2 [42]. Therefore, Experiment 2 aims to overcome these frequency difficulties and limitations, exploring effects of morphological hierarchical structures in pseudoverbs [5].

2.2 Experiment 2: French Pseudoverbs

2.2.1 Participants

Participants in Experiment 2 were the same as those from Experiment 1. Participants did not know the research purposes and signed a written consent to participate in the experiment as volunteers.

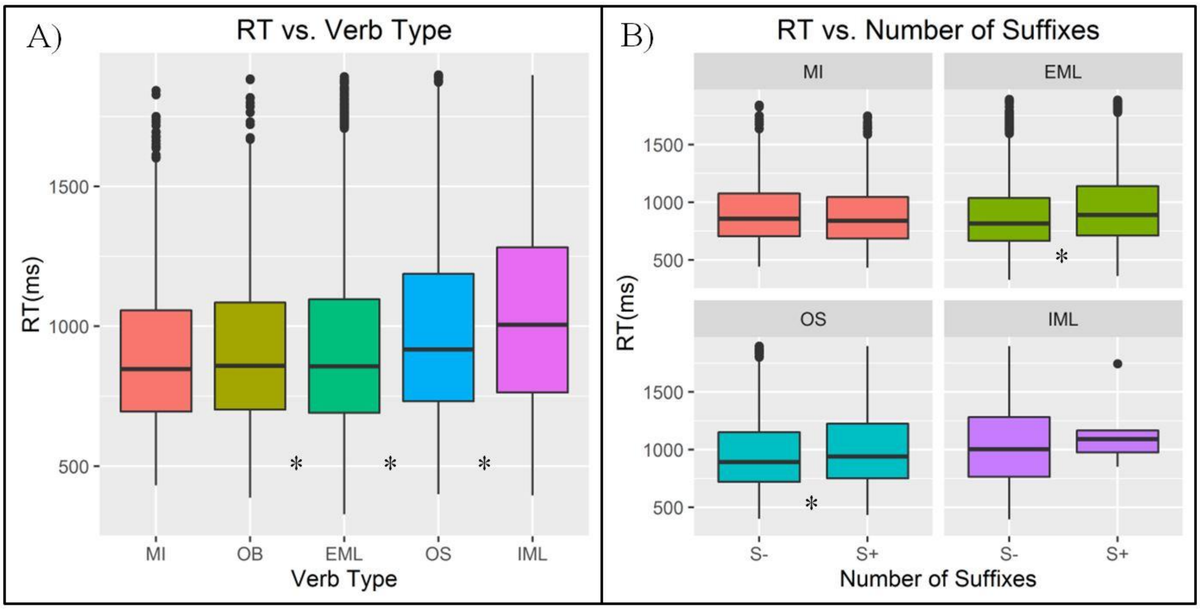
2.2.2 Materials, Design, and Procedure

Experiment 2 used the same materials, design, and procedure from Estivalet and Meunier (2016). Participants performed a visual lexical decision task. We tested two variables, 1) verb type: a) morphologically illegal (MI) (e.g., **abrou*), b) only base (OB) (e.g., **[aim]ou*), c) only suffix (OS) (e.g., **abr[ons]*), d) inexistent but morphologically legal (IML) (e.g., **[aim][ir]*), and e) existent and morphologically legal (EML) (e.g., *[[aim][ons]]* 'we love'; and 2) number of verbal inflectional suffixes: one inflectional suffix Agr (e.g., *aim[ons]* 'we love') vs. two inflectional suffixes T and Agr (e.g., *aim[i][ons]* 'we loved'). Two hundred and fifty words were selected as experimental items, 50 words for each verb type. The pseudowords were initially created using the pseudoword toolbox from the French database *Lexique* [33] and were then manipulated to fit the different verb types of interest. We controlled the number of letters, number of phonemes, number of syllables, and OLD20 [32]. A set of 250 fillers was inserted to counterbalance the responses, 200 words and 50 pseudowords, totalizing 500 stimuli. The experiment started with a screen of instructions followed by 10-word practice stimuli and the experimental trials. The experiment lasted approximately 28 minutes. The procedure in Experiment 2 was the same as in Experiment 1.

2.2.3 Results

Only experimental items were analysed. Responses faster than 300 ms and slower than 1,900 ms were considered out of task and discarded (2.96%); two experimental stimuli (i.e., **mouri* and **poudrent*) were removed because they presented an error rate higher than 60% (.21%). There were 19.63% of incorrect answers that were removed for the RT analysis. Overall RTs and significant differences are shown in Fig.1.

Figure 1 - RTs by verb type and number of suffixes. A) RTs by verb type. B) RTs by number of suffixes. S- for one suffix and S+ for two suffixes.



As in Experiment 1, we equally divided the 20 participants into two groups of L2 French proficient speakers (beginner vs. advanced). These groups were determined according to the time of French exposure (i.e., beginners: N = 10, M = 2.9 years; advanced: N = 10, M = 9.9 years), and verified differences by proficiency ($t(9) = 8.281$, $p < .001$), error rate (i.e., beginner: 24.33%, advanced: 14.02%) ($t(9) = 2.954$, $p < .05$), and the correlation between proficiency and error rate ($r = -.509$, $t(18) = -2.513$, $p < .05$) [35].

The data were analysed using two mixed-effects models [36]. In one model, normalized RTs (i.e., 1/RT * -1,000) were used as the dependent variable, participants and targets as random variables, and verb type, number of suffixes, and proficiency as fixed-effect variables; in the other model, the logit ACC was used as the dependent variable and binomial family specification.

The ANOVA in the mixed-effects model of the RT showed significant effects of verb type ($F(4,1043) = 31.118$, $p < .001$), number of suffixes ($F(1,2656) = 4.466$, $p < .05$), but no effect for proficiency ($F(1,17) = .557$, $p = .465$); a significant interaction was also observed between verb type and number of suffixes ($F(3,1129) = 4.101$, $p < .01$), but no other significant interactions (Fs < 1, ps > .1).

Mining the planned comparisons, MI and IML showed no difference in the number of suffixes (respectively, $t(795) = .451$, $p = .652$ and $t(2737) = 1.486$, $p = .137$) while EML and OS showed significant differences in the number of suffixes (respectively $t(875) = 7.577$, $p < .001$ and $t(976) = 4.321$, $p < .001$). OB differences in the number of suffixes was not analysed because it only has a base and no existent suffixes. MI showed no difference for OB ($t(800) = .551$, $p = .582$), but significant differences for EML ($t(803) = 1.982$, $p < .05$), OS ($t(811) = 2.238$, $p < .05$) and IML ($t(888) = 5.431$, $p < .001$). OB presented significant differences for EML ($t(822) = 3.531$, $p < .001$), OS ($t(837) = 2.191$, $p < .05$), and IML ($t(948) = 5.981$, $p < .001$). EML showed significant differences for OS ($t(902) = 8.559$, $p < .001$) and IML ($t(1038) = 10.494$, $p < .001$). OS presented significant differences for IML ($t(1059) = 5.274$, $p < .001$). It became clear that it is the EML verbs which yield the interactions between verb type and number of suffixes.

The analysis of deviance in the mixed-effects model of the error rates showed significant differences for verb type ($\chi^2(4, N = 20) = 179.975$, $p < .001$), number of suffixes ($\chi^2(1, N = 20) = 16.651$, $p < .001$), and proficiency ($\chi^2(1, N = 20) = 16.523$, $p < .001$), and a significant interaction between proficiency and verb type ($\chi^2(4, N = 20) = 61.312$, $p < .001$), but no other significant interactions (*p*s > .1).

2.2.4 Discussion

The RT order in Figure 1A is: MI = OB < *EML < *OS < IML, where 'less than' and 'asterisk' indicate significant effects of verb type and number of suffixes differences, respectively. OB is decomposed based on the stem information but it is immediately rejected because no existent suffix is found. EML and OB verb types are different because the former follows the whole process for word recognition, slowing down RTs. Furthermore, EML and OS verb types are different because more time is spent searching for the stem of the OS verbs, yielding longer RTs. Finally, IML verb type is different from the other verb types because its inhibitory processes in the later recombination phase for word rejection, which slows down RTs (Caramazza et al., 1988).
This pattern is the same as the one observed for French native speakers [5], with one single difference: the significant difference between EML and OS verb types in the present study. Considering the bilingual lexicon, it seems that L2 speakers have few stems stored and can quickly find the stems they know (EML); however, when they do not find a stem (OS), they still try to interpret the foreign stem and transfer L1 knowledge for interpretation [27].

The effect of the number of suffixes presented a similar pattern to those found for native speakers [5]. MI and IML verb types do not present any significant difference in the number of suffixes, while OS and EML verb types do. MI verb type is quickly rejected because of its idiosyncratic form and structure, with no place for word decomposition and morphemic activation. In contrast, IML verbs have existent morphemes but inexistent combinations of these morphemes, thus, IML verb type is rejected in a later verification of the word through inhibitory processes, slowing down RTs [15] and blurring the number of suffixes effect. Inversely, OS verb type is decomposed and its existent suffixes are activated; irrespective of the stem crash, the number of suffixes presents a significant difference because forms with two suffixes impose extra computation for word rejection. EML verb type presents the same processes, but result in well-formed lexical recombination and verification [8]. Finally, the error rate analysis is in line with the results of native speakers; importantly, there was a main significant effect on proficiency and interaction between proficiency and verb type, suggesting that advanced bilinguals made fewer errors because they know more words than beginners.

Experiment 2 showed that morphological investigation with bilinguals using pseudowords is valuable because it is possible to overcome frequency effects. It suggests that even beginner bilinguals might decompose verbs based on morphological information. Comparing these results with the native speakers' one, late bilinguals present almost the same behaviour. In addition to general higher RTs and error rates in bilinguals, the order of RTs and the significant differences in the number of inflectional suffixes to be processed are the same for beginner and advanced bilinguals, as well as for native French speakers. This suggests that the general morphological structure is equally processed in both populations.

III. GENERAL DISCUSSION

The present study consisted of two experiments which investigated the morphological processing and representation of French verbs in L2 speakers who have BP as their L1. Experiment 1 manipulated surface and cumulative frequencies in four verb types and Experiment 2 tested five different types of (pseudo)verbs. The present bilingual results are comparable to the previous native speakers' results in Experiment 2 while Experiment 1 yielded different results than native speakers. We analysed the difference between L2 French beginners and advanced speakers and we found a fast shift from associative to combinatorial processing in beginner and advanced bilinguals.

3.1 Morphological Processing and Proficiency

Based on our present results and large evidence on bilingual proficiency differences (Clahsen & Felser, 2006; Costa & Sebastián-Gallés, 2014; de Diego Balaguer, Sebastián-Gallés, Díaz, & Rodríguez-Fornells, 2005; Dijkstra, 2007; Hernandez et al., 2005; McNamara, 2006; Nation et al., 1993), it is clear that advanced bilinguals perform better in psycholinguistic experiments than beginner ones. Nevertheless, even if the results of advanced speakers are similar to those of native speakers, late bilinguals still present differences and limitations in morphological processing, lexical representations, and mental lexicon organization [1]. These differences between L1 and L2 speakers can be explained by considering the general low proficiency and language deficit in L2 speakers, as well as L1 influence [2], [44]. Even if grammatical processing of L2 speakers is sufficiently deep, L2 deficit and L1 interference modulate their behaviours.

A systematic difference in the error rates across experiments and experimental conditions can be observed, advanced speakers present on average the half error rates than beginners and native speakers present much fewer than the half error rates than advanced speakers. In contrast, RT means do not present differences between beginner and advanced speakers, but a large difference between native speakers and advanced ones [29]. We found significant differences in error rates between beginner and advanced speakers and significant correlations between language exposure time and error rates, but no significant RT differences or correlations to proficiency. Importantly, proficiency interacted with the other experimental variables, supporting the idea that proficiency directly affects speakers' performance [41].

Experiment 1 did not provide clear results regarding surface and cumulative frequencies differences in L2 French speakers because late bilinguals do not have the same mental lexicon organization as native speakers, as predicted by frequency norms [31]. Even if corpora present rich, valuable, and predictive information for native speakers' lexical decisions [33], this information does not fit the behaviour in late bilinguals and their lexicon organization. Late bilinguals have different language learning and exposure than native speakers, mainly through language courses, short and artificial didactic material, and language not required for communication purposes [27].

While beginners present an unclear pattern of frequency effects, advanced speakers present a pattern towards native speakers' behaviour. Advanced speakers were participants living in France for at least four years, who had been naturally exposed to language frequency norms and required communicative situations, thus, it seems that L2 proficiency tunes behaviour towards corpora frequency norm predictions.

Experiment 2 showed that when frequency and semantic knowledge is partially overcome, different results emerge from the processing of morphological hierarchical structures. There are no differences between beginner and advanced L2 French speakers, and most interestingly, their results are in line with the native speakers' pattern, suggesting the same kind of morphological processing for lexical access and word recognition [10].

It is important to note that adult participants in L1 psycholinguistic experiments had at least 18 years of massive language exposure since babyhood; differently, late bilinguals in the present experiments have had on average three years of language exposure for beginner speakers and nine years of exposure for advanced speakers, since adulthood. Thus, regarding native speakers, the mother tongue naturally sculpts, develops, and stimulates neural circuits which become specialized in the processing of specific language parameters; concerning late bilinguals, L2 is initially acquired through translation, associative relations to L1, explicit grammatical knowledge, and later, L2 redundancies are solved and formalized for language processing [4].

Our results suggest that this early phase with whole-word representation is very short in beginner bilinguals and only holds until the speakers have enough information to proceduralize grammatical redundancies [45]. Particularly, speakers whose L1 typological/grammar is close to L2 might recycle neuronal circuits and mechanisms for word recognition, resulting in a fast shift from declarative to procedural memories.

3.2 Frequency and Pseudoword Evidence

Lehtonen and Laine (2003) proposed that bilinguals explore combinatorial processes in low, median, and high word frequencies, while native speakers access high frequency words directly as whole forms. Our results are similar for L2 French speakers who, since early stages of language acquisition, explore the combinatorial processes for word recognition. Proficiency interacted with both surface and cumulative frequencies. However, there was no effect of cumulative frequency in fully regular verbs in advanced speakers probably because they did not tune their lexical access to corpora frequency norms to yield significant stem frequency differences. There were differences between fully regular and irregular verbs in both beginner and advanced speakers, which could suggest that allomorphic processes in irregular verbs take place, slowing down RTs [17].

Experiment 2 supports the idea that beginner and advanced speakers can decompose words for lexical access. These results can be directly compared with the native speakers' study and suggest that when frequency and semantic knowledge are alleviated using pseudowords, pure abstract combinatorial morphological processes are tracked [14]. Only real verbs (EML) presented interactions with the other verb types in the number of suffixes, thus, the behaviour of beginner and advanced speakers in rejecting pseudoverbs and recognizing real words cannot be differentiated [46].

3.3 Portuguese/French Interface

French 1st regular and 3rd irregular classes of verbs presented significant differences in Experiment 1 with the latter yielding longer latencies. These results are different from other Romance languages, such as Catalan (de Diego Balaguer et al., 2005), Italian [39], and Portuguese [38], in which differences in the morphological processing between 1st combinatorial class and 2nd/3rd whole word classes were found, in agreement with dual-mechanism models such as the W&R/DP [16] or the MM [19]. Differently, our results also seem to indicate morphological decomposition for French 3rd class verbs based on the systematic inflectional suffixes, with longer latencies in irregular verbs as a consequence of allomorphic processes.

We remark that in Romance languages, even if there are allomorphic representations or allomorphic rules in the lexical morpheme, mostly in the theme vowel and stems from the 2nd and/or 3rd classes, depending on language, verbal inflection almost always has inflectional suffixes in the word formation [37]. Functional morphemes have to be isolated to have their morphosyntactic features checked and processed, consequently, roots and stems are represented in the mental lexical. De Diego Balaguer et al. (2006) presented fMRI results that give support to a decompositional model in which different neural circuits process stem phonological information from the lexical morpheme and morphosyntactic features from the functional morphemes.

Regarding L1/L2 transfer, we remark that both the French and Portuguese languages have morphophonological processes driven by the prosodic system, thus, these computations can be easily transferred from L1 to L2 since speakers acquire the French prosodic system. Therefore, considering that L1-BP/L2-Fench speakers already have many circuits developed in their L1, they can largely transfer phonological, orthographic, syntactic, morphological, and semantic knowledge from L1 to L2, and a much more dynamic system for lexical representation and grammatical rule application may emerge [42]. Besides the specific French phonemes (e.g., /y/, /ə/, /œ/), orthography (e.g., <œ>, <è>, <ù>, <y>; diphthongs: <ai> → /ɛ/, <au> | <eau> → /o/, <ph> → /f/, <gn> → /ɲ/, /ɛ/ /_<ll> | <tt>), and semantic/pragmatic differences (e.g., FR: *émergence* 'emergence', BP: *emergência* 'emergency'; FR: *jouer* 'to play', BP: *tocar* 'to play'), it can be considered that speakers already have a large amount of grammar principles underlined and that speakers transfer linguistic knowledge between L1 and L2.

Finally, we suggest that the late acquisition of an L2 close to the L1 is mediated by a short declarative associative phase in lexical encoding, and since L2 speakers have enough accumulated information in their mental lexicon, there is a shift to procedural combinatorial processes [4]. These morphological processes become automatic and optimized according to the L2 speakers' proficiency and relation to L1. It is difficult to understand how PDP models could explain and/or simulate L1-to-L2 transfer, L2 competence based on language proficiency, and the fast shift from beginner to advanced speakers without posing language rules and symbolic manipulations.

IV. CONCLUSIONS

In the present study, we have presented evidence using two experiments of how French inflected verbs are processed in L2 by speakers who have BP as L1. In addition to the specific differences between beginner and advanced speakers, it seems that both groups are exploring the same decompositional mechanism for lexical access and word recognition [31]. Further research should deepen the analysis of inflection processing through auditory stimuli in French, given that this language has a great grapheme-to-phoneme inconsistency. It would also be interesting to test late proficient L2 speakers who have had at least 18 years of L2 exposure and compare the results with native speakers tested in psycholinguistic experiments.

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